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MARINE MAGNETIC SURVEYS ABOARD THE M.V. NELLA DAN, 1979/80 - OPERATIONS MANUAL

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INTRODUCTION

Every year the M.V. Nella Dan makes a series of voyages to Antarctica to resupply Australia's bases. These trips provide an opportunity to collect many thousands of kilometres of under way data at low cost and relatively little inconvenience to the supply operations. With the present stern configuration it is not practicable to collect seismic data on the Nella Dan, but the collection of magnetic data is feasible. This would provide a moderate but useful first step in the implementation of a marine geoscience program in Antarctic waters.

When it became apparent that the modifications necessary to allow seismic work would not be done in financial year 1979/80, BMR approached the Antarctic Division of the Department of Science and the Environment advocating that a magnetic data collection program should be implemented. With the three cruises to Antarctica this summer it would be possible to obtain six profiles in the Prydz Bay-Kerguelen Ridge area, which is believed to contain a significant thickness of sediments. Analysis of these profiles should provide a useful guide to the best place to start seismic work when the boat has been suitably modified.

To keep the manpower requirements at a level that could be supported by available staff in the Marine Geophysics Group at BMR, a computer-based data-acquisition system was considered essential. This was put together in two weeks by taking many of the software modules and hardware from our major data acquisition system previously used on the Cape Pillar. With the limited time available, the system has been restricted to the acquisition of time and magnetic data. The flexibility exists to expand this to include navigation and bathymetric data when time permits, probably for the 1980/81 summer.

The equipment was installed on the Nella Dan before its departure for Macquire Island on 19 October 1979. This trip was used to test out the data-acquisition system and study the best way of obtaining usable navigation and bathymetric data from systems already installed on the vessel. It appears straightforward to acquire this data, although in a somewhat cumbersome fashion, if watchkeeping can be provided from ANARE changeover personnel. As operations would need to be on a 24-hour day basis, a rostered shift system seems most appropriate, each shift lasting perhaps three hours. While the use of ANARE personnel avoids the requirement for extra staff to act as watchkeepers, maintenance of the magnetometer and data-acquisition system requires at least one skilled man with adequate training to be on board at any time.

At the present time (November 1979) the Marine Geophysics Group has been offered one berth on the second of the three voyages to Antarctica. It appears feasible to run the magnetometer on the outward leg of the first cruise and the return leg of the third cruise, using other BMR staff who will be on the *Nella Dan* for other purposes. The return leg of the first cruise and outward leg of the third cruise present a problem, and a possible loss of over 10 000 km of magnetic data. The help of the ANARE Scientific Coordinator has been suggested as an interim solution. In case a spare berth becomes available at the last moment, the geophysicist allocated to go on the second voyage is ready to go at 24 hours' notice. Should the opportunity occur, the next trained geophysicist will then undergo the ANARE medical examination.

The objectives of the work, and a basic outline of the navigation, magnetometer, and data-acquisition system requirements are given in the following chapters. The daily routines for each of the systems are given in the Appendices, as much as possible in a step-by-step explanation of the things the operator should do. These will be revised as experience dictates.

Compilation maps at 1:10 million and work sheets at 1:2.5 million of existing ships' tracks for which BMR holds data will be provided. The work sheets will be used to plan the best locations for ships' tracks to and from Antarctica, and for preliminary plotting of hourly positions. Bathymetric compilations by Scripps Institution of Oceanography and Lamont-Doherty Geological Observatory will be useful in deciding where deeper-water echo sounding should be attempted.

OBJECTIVES

The most obvious feature that can be seen from any compilation of geophysical work in Antarctic waters is the limited availability of data, with an almost total absence of data over the Antarctic continental margin itself. In the Southern Ocean the major contribution is the work done by the Eltanin but even that does not extend west of the Kerguelen Ridge. Therefore the main objective of the work proposed is the collection of data on a systematic basis to build up a useful body of data covering Australia's area of interest. This can be achieved with the co-operation of the ship's crew and the ANARE changeover personnel. There will be only a minor effect upon the operation of the Nella Dan supply voyages.

The event that has made the program feasible is the installation of the Tracor satellite navigation system by the Antarctic Division. Although it falls short of the standard required for precise survey work, the system provides position fixes with an accuracy of about 0.5 n.mile. With a reasonable allowance for propagation of error in the dead-reckoning mode, intermediate positions determined at sea should be good to 1 to 2 n. miles. On this basis it should be possible to navigate the ship within 5 n. miles of a specified traverse line, and to maintain an acceptable profile separation at a line spacing of 20 n. miles.

The ship's tracks to and from Antarctica should be designed to complement existing traverses with a line spacing at a suitable multiple of 20 n. miles. The effect such adjustment in the ship's tracks would have on travel time is trivial. The great circle path to Mawson would be extended by less than 10 n. miles if it was moved 240 n. miles to one side.

There are three main objectives:

(1) to obtain a series of magnetic profiles parallel to the continental edge at a 20 n. mile spacing in the Prydz Bay-Kerguelen Ridge region. Water depth data over the continental margin down to at least 3000 metres are needed to define the morphology of the shelf

and continental slope. This will provide a useful indication of whether or not the inferred sedimentary basin extends across the shelf. Actual achievement will depend upon pack ice and weather conditions, but a band 100 n. miles wide (the approximate width of the continental shelf) could be obtained in a single year. At the practical level it will probably take two years, with movements in and out of Mawson and Davis tying the east-west profiles together.

(2) to start a series of magnetic profiles at a 60 n. mile spacing along a band across the Southern Ocean between Australia and the Mawson region. It is unlikely that depth data can be obtained along much of these traverses. This would be built up over the years to help define the magnetic lineation pattern in the ocean basins, and to assist in the regional mapping of the Earth's magnetic field. As this is a longer-term objective, the actual tracks can be shifted considerably depending upon weather conditions as long as the required profile spacing is eventually built up.

(3) to provide a set of ties to the Eltanin magnetic profiles this coming summer. This will provide a statistical determination of the secular change in the Earth's magnetic field since the Eltanin cruises back in the late 1960s, and will provide a useful input to the determination of the International Geomagnetic Reference Field 1980.

BRIDGE WATCH-KEEPING

Navigation

If the magnetic data recorded are to be of practical use for interpretation, it is essential that the navigation data be of as high a standard as possible. Although the Tracor satellite navigation/DR system installed on the Nella Dan is somewhat rudimentary, reasonable positioning can be obtained by careful and frequent recording of the data. Because of the displayed accuracy of the system (0.1 n.m.), it is considered that position fix every 10 minutes is just suitable for our purposes. In addition, a position should be recorded at every change of speed or course, and all satellite fixes must be saved.

Bathymetry

Nella Dan is fitted with a 33 kHz Atlas echo-sounder that is capable of recording water depths of up to 3500 m. The echo-sounder should be turned on at any time that the water bottom can be recorded. The paper records from the echo-sounder should be saved for later scaling and incorporation with the navigation and magnetic data. To ensure that the data can be reliably integrated, it is essential that regular timing marks be placed on the record, together with annotated times, depths, and depth scales.

Daily Routine on the Bridge

The procedure for recording navigation and bathymetric data on the bridge is outlined below.

At 0000 GMT every day and at the start of recording

(a) remove the position listing from the satellite navigation terminal, make sure it is labelled with date, survey number, and Julian day number, fold it and place it in the folder supplied; advance the paper on the terminal, label it with date and Julian day number.

(b) advance the echo-sounder record by 30 cm and label it with date, survey number, Julian day number, and depth range; write depth value on record against the starting time.

Every hour on the hour

(a) at the satellite navigator:
write the survey number and Julian day number on the terminal listing

(b) at the echo-sounder:
write the survey number, Julian day number, and GMT time in form SS.DDD.HHbb against the time mark; scale the depth value and note on the record along with the depth range being used.

Every 10 minutes at the 10-minute time

(a) at the satellite navigator:
wait for the GMT time on the VDU to register zero seconds i.e. 00oo, 10oo, 20oo etc., then press MODE 32 to give a print-out of the ship's position; note that the print-out gives time only to the nearest minute so it is important that it is made exactly on the minute.

(b) at the echo-sounder
immediately you have started the position listing on the terminal, go and press the white event mark button on the echo-sounder; press long enough to record a complete vertical black line on the record.

At every course or speed change
at the satellite navigator:

(a) obtain a print-out of the DR position at the time of course or speed change using MODE 32

(b) note old and new course or speed on the listing and the exact time at which the change occurred.

Notes

(a) If the bridge is congested, it may not always be possible to press the event marker on the echo-sounder every 10 minutes. However, ensure that the record is marked whenever possible at a 10 minute time.

(b) Where possible, use a medium depth range on the echo-sounder to allow a fair degree of latitude in depth before it becomes necessary to change the range again.

(c) Note the new depth range on the record every time the range is changed.

(d) Try to keep the gain on the echo-sounder high enough to provide a sharp trace, but not high enough to scorch the paper.

(e) Acceptable satellite fixes are automatically printed out on the terminal.

SHIPBOARD MAGNETIC OBSERVATIONS

Magnetic data will be recorded in both digital and analogue form. The prime recording system is the computer-based digital data-acquisition system (DAS), but the reliability that can be expected in the severe operating environment of the rear hold is uncertain. It is therefore important that the strip-chart recording and annotated information are adequate for later data recovery if the need arises. All relevant data should be annotated on the strip chart (and DAS print-out) to minimise extra paperwork. All non-standard events should be clearly marked on the record (and print-out) at the time at which they occur. These would include: instrument problems and modifications, calibrations, changes in tuning, and clock corrections.

The analogue and digital systems are run in parallel and the daily routine should ensure that equipment malfunction or failure is soon detected. The complex digital system provides data in digital form that can be readily manipulated, displayed, and plotted in map form. However it is prone to hang-ups that must be speedily detected to avoid lengthy editing procedures. Hourly inspection of the system is considered essential to meet these requirements. At each visit the operator must ensure that necessary checks are methodically carried out.

The analogue system permits quality control and display of the data being recorded as well as providing a fail-safe backup. An electrostatic recorder has been chosen because it gives more reliable recording under arduous field conditions than a pen-and-ink recorder. The nominal paper speed of the strip chart recorder is 30 cm/hour. Two pens are used to record simultaneously at 100 nT and 1000 nT full-scale sensitivity. The 1000 nT trace has ten-minute time marks impressed upon it and the operator must identify the hourly time marks and absolute field levels during his visits. The calibration tests plus ten-minute time marks allow adequate definition of horizontal and vertical scales for later digitising of the data if needed.

When the magnetometer is functioning properly, the noise level is generally within 2 nT peak-to-peak ($\pm$ 1 nT). This may rise to more than 5 nT peak-to-peak in heavy rolling seas. Noise of this level is readily observed on the 100 nT trace when the magnetometer polarisation cycle is of 5 seconds' duration, which it should be at all times. Noise levels higher than expected can arise from a variety of causes. It will pay to start checking for the simplest possible causes and work to the more complex. The most useful steps when investigating excessive noise are:

1. Check that the tuning is properly set for the magnetic field being measured, and cross-check against the expected field value.

2. Vary the tuning and inspect the result on the oscilloscope (CRO); the amplitude of the precession signal should reach a maximum and should be clearest when the equipment is properly tuned, and the signal should last for a reasonable period of time.

3. Check for interference when the radio is operating and from other noise sources such as flickering fluorescent lights and other equipment on the same power supply.

4. Check the oscillator and any other electronic parts easy to get at: fuses, polarisation current, period of polarisation, cycle rate etc. Check that the console and sensor shield are properly earthed, as described in the manual for the magnetometer.

5. Check all electrical plugs carefully, particularly at the winch and sensor; clean or replace as necessary.

6. Inspect the cable between the console and winch and the sensor cable for damage such as broken wiring, broken shielding, and earthing.

7. Check the sensor casing for damage such as cracks, gouges, or metallic inclusions.

8. Clean the tuner switch and all circuit board contacts with Freon spray.

9. Replace each circuit card in the console one by one, replacing the original card if there is no improvement.

10. Check the sensor kerosene for water and other contamination by pouring it into a bucket and waiting for impurities to settle. Replace if necessary with clean household kerosene.

The procedures to be followed in launching and retrieving the sensor, initiating recording, and the daily routines are described below. Further background information is available in the manuals for the various pieces of equipment.

<u>Streaming the magnetometer</u>

1. Advise the watch officer on the bridge that you are about to stream the magnetometer.

2. Check that D.C. power to the winch is connected and turned on.

3. At the winch:

   (a) Unlash the cover and the sensor.
   (b) Unplug the deck leader and make sure the plug on the side of the drum cannot foul the winch frame.
   (c) Apply the brake and lift the sensor over the side.
   (d) Release the brake and press the lower switch on the control panel to unwind the cable.
   (e) Periodically release the switch to see if there is sufficient drag on the sensor to unwind the cable. When this can be done, leave the motor off and use the brake to prevent the winch racing.
   (f) When the innermost layer of the cable is completely exposed, pull the brake hard on to check its operation.

(g) Release the brake and continue running out the cable until one-third of the innermost layer has been run off, then pull the brake on with the drum in such a position that the deck leader can be reconnected without strain.
(h) Thread the chain through the holes in the drum and around the winch frame, and shackle it; release the brake.
(i) Plug in the deck leader and seal the plug join with insulating tape or sealant/adhesive such as 'Silastic'.
(j) Replace the canvas cover.
(k) Advise the bridge that the magnetometer has been streamed.

4. Winch maintenance.

(a) Keep the cover on the winch whenever the winch is not being operated.
(b) Keep the sensor cable connection greased with a non-conducting grease such as silicone.
(c) Keep the sensor head securely lashed when it is stowed.

Retrieving the magnetometer

1. Advise the bridge that you are about to retrieve the magnetometer, and ask them to slow the ship to about 6-7 knots.

2. Check that the D.C. power to the winch is connected and turned on.

3. At the winch:

(a) Unplug the deck leader and make sure the plug on the side of the drum cannot foul the frame.
(b) Turn the drum enough to take the strain off the chain and apply the brake.
(c) Unshackle the chain.
(d) Release the brake and press the upper switch on the control panel to wind in the cable. The cable should be directed onto the drum by an assistant.

(e) When the section of yellow insulating tape appears at the stern, the assistant should go to the snatch block to indicate to the operator when to stop the winch.
(f) Lift the sensor over the rail and secure it.
(g) Release the brake and reconnect and reseal the deck leader
(h) Advise the bridge that the magnetometer is on board.

Turning the equipment on

Magnetometer

(a) Turn D.C. power supply on, adjust output to 28 volts.
(b) Check all magnetometer switch settings (see manual, page 3-2).
(c) Turn on power switch on magnetometer.
(d) Monitor internal voltages, +12V, -12V, +5V using METER
(e) Turn MODE switch from STANDBY to NORM (Note: MODE switch must be turned to STANDBY before turning magnetometer off).
(f) Turn MONITOR switch to POLARISE and check the polarisation current drawn from the D.C. power supply.
(g) Turn MONITOR switch to SIGNAL and adjust coarse and fine TUNING to give maximum signal level on METER or on the CRO, if connected.

Strip Chart Recorder

(a) Check that the paper supply is adequate for 24 hours' operation; change if necessary.
(b) Check the switch settings (see manual).
(c) Turn on power and paper drive switches.
(d) Lower styli onto paper.
(e) Carry out zero and calibration adjustments.
(f) Check that the event marker is working properly.
(g) Ensure that the strip-chart recorder clock is synchronised with the DAS clock to provide correct 10-minute marks.

Daily routine for the magnetometer

1. At 0000 GMT every day and at start of recording:

   (a) Check that there is sufficient paper for the next 24 hours of operation; if not, remove the roll and replace with a new roll of paper.

   (b) Pull paper forward 0.5 m, label with date, survey number, Julian day number and time, and approximate location.

   (c) Reset zero and full-scale deflection on the strip chart recorder. Use the CAL-RUN-ZERO switch and the CALIBRATE/ZERO controls on the magnetometer; do not use the adjustment potentiometers on the strip-chart recorder; calibrate both 100 nT and 1000 nT channels; mark "recalibration" on record.

   (d) Read magnetic value from digital display at start of recording and write it on record against the starting time.

   (e) Check the clock setting against A.P.O. radio time signals, and record the difference from radio time on the record; do not adjust unless the difference exceeds 5 seconds; suspected abnormal clock behaviour should be checked promptly and monitored closely.

2. Every hour on the hour:

   (a) Zero both pens of the recorder momentarily using the ZERO of the CAL-RUN-ZERO switch on the magnetometer.

   (b) Label the resulting hour mark with survey number, Julian day number and hour in form SS.DDD.HHMM

   (c) Read magnetic value from digital display on magnetometer and write it on record against the hour mark.

   (d) Check the noise level on the record; in good weather it should be 2 to 3 nT peak-to-peak, rising to 5 to 10 nT in heavy rolling seas; investigate further if it is excessive.

   (e) Check the tuning of the magnetometer using the fine and coarse TUNING adjustment on the magnetometer observing signal amplitude on the METER provided and the CRO; mark record with new tuning value if it is changed.

3. <u>Every six to eight hours on the hour</u>

(a) Check zero and full-scale calibration of the strip-chart recorder using the CAL-RUN-ZERO switch on the magnetometer and mark "calibration" on record.

(b) <u>Only</u> if the error exceeds 2 mm should you recalibrate as in 1(c).

(c) Make sure a calibration check (<u>not</u> a recalibration) is made shortly <u>before</u> 0000 GMT (i.e. at the end of a day's record); similarly at the end of recording.

4. <u>Following any unusual event such as</u>

(a) after removing a roll of paper from the strip chart recorder: label <u>both ends</u> of the record with the start and stop times of the roll in form SS.DDD.HHMM, and the strip chart sequence number in form SS/NNN; log start and stop times.

(b) if a long break in work is anticipated: turn off recorder and mark the break clearly with the time and reason for break if known, then pull paper forward for next commencement of work as in 1 (a) to (d); for short breaks between work, continue recording and note cause of break on record.

(c) after any power failure: check the setting of the clock against A.P.O. radio time signals and adjust as necessary; the magnitude and time of all clock adjustments should be marked on the record.

THE DIGITAL DATA ACQUISITION SYSTEM

General Description

BMR has provided a data acquisition system (DAS) built around a Hewlett-Packard HP 2108 computer. This system acquires time and magnetic data every ten seconds and saves the information on cassette tape in blocks spanning two minutes. The DAS acquires the data as 4-bit BCD characters, checks for valid character transmission, and converts to internal HP floating-point word format before saving it on tape. To appreciate the advantages and limitations of the DAS, it is necessary to understand how the system works. There are three effectively independent programs within the system which communicate to some degree.

1. The acquisition program ACQ13: This program is written in assembly language and is driven by the clock. Every ten seconds on a multiple of ten seconds (i.e.),10,20,30,40,50) the clock time and magnetic value are acquired as raw data and placed in the input buffer; the input pointer is incremented. When the input buffer is full the pointer jumps back to the first line and the buffer is filled all over again. This continues blindly regardless of whether or not the data are extracted, processed, and saved.

The present software has an input buffer that will last for four hours. Hence it takes almost four hours before the acquisition over-runs the processing and a complete buffer of data is lost.

2. The processing program NELLA: This program maintains an output pointer marking the last data sample that has been extracted from the input buffer and processed. As long as input and output pointers differ it knows there are data to process and makes one pass through the processing loop. The cycle is repeated until the pointers agree, at which point it idles until the next acquisition cycle bumps the input pointer again. Should the input pointer catch up with the output pointer because of delays in processing, the program cannot differentiate between being up-to-date or four hours behind; hence the loss of four hours' data.

Within the processing loop, a sequence of steps is executed, from extracting the data from the input buffer to storing it in the output buffer. First the data are extracted and converted from 4-bit BCD code to internal HP word format. At this point a check is made to see if each character is valid in an effort to detect transmission errors or possible equipment malfunction. If an error is detected, a warning message is printed on the teletype. Should the erroneous value detected correspond to that seen by the computer when the magnetometer is off, the message is suppressed.

A check is made for jumps in time between consecutive samples to aid in detecting clock faults. A warning message is given at such times. As there is only one clock in this system, the program then proceeds on the assumption that the clock is showing the correct time. It is up to the operator to decide whether or not there is a clock malfunction. If the jump in time is negative, or positive and long enough to create an empty output block, the current output block is padded with 'unknowns' (10^{10}) and immediately written to cassette. A new output block is started and the current record inserted in the correct slot within it.

An output block spans a regular period of two minutes, i.e. 0000 to 0150, 0200 to 0350, 0400 to 0550, etc. The program ensures that each record is inserted in the correct slot to maintain this regularity. Should any slots be skipped because of time jumps, they are filled with unknowns. Whenever an output block is filled, it is output to the cassette drive and an informative message is printed on the teletype. The next record is then inserted in the appropriate slot in the output block.

Every 10 minutes on the ten minutes, the time and the previous 10 one-minute magnetic values are printed on the teletype. These are primarily provided as a simple digital back-up in case the cassette drive breaks down. These values should also be checked from time to time against the digital display on the magnetometer. This is important as a bit drop-out cannot be detected by any other method, in contrast with a bit lock-on, which will eventually result in a BCD error.

3. The operator system CHAOS: Once every processing cycle or at any time when the computer is not processing, the operator has the opportunity to intervene and modify key parameters. Most of the time the DAS is waiting for another acquisition cycle to occur, which will then be followed by a brief processing cycle. Therefore the operator will in general be able to intervene in the operation of the system within a fraction of a second. He does this by setting SWITCH bit 0 (zero) and at the appropriate time enters the number of the CHAOS operator program he wishes to execute.

The CHAOS system is effectively a third level of program to which the operator can rapidly gain access when required but which is otherwise dormant. When the operator has initiated CHAOS program, there is usually a series of questions he must answer. In general, termination of the operator program causes the request to be implemented. The operator should then preferably quit the CHAOS system by asking for program 0 (zero). Should the operator neglect to exit from CHAOS, it terminates itself after about 20 seconds.

It is most important to realise that if an operator program is not properly completed, e.g. by his not answering a question, then the DAS cannot return to the processing program. The acquisition program meanwhile is continuing to acquire data, and should the delay extend to four hours will cause overwriting of the input buffer data that have not been extracted and processed. It is therefore imperative for the operator to exit properly from the CHAOS system at all times.

System Messages

When the DAS is operating normally, only two messages should be printed on the teletype. These are:

(1) Every 2 minutes of processing time a block of data will be written to cassette tape; a message is printed giving the clock time at which the block was output, and the start and stop times of each block.

(2) Every 10 minutes of processing time, the time and the previous 10 one-minute values will be printed. The last of these values corresponds with the time printed. These values should be checked from time to time against the digital display on the magnetometer.

Other messages that may be printed include

(3) - TAPE PARITY ERROR
If this occurs frequently, use operator program 13 to eject the cassette, clean the recorder and insert a blank data cassette. NEVER insert a partially used cassette.

(4) - EJECT TIMED OUT ON LUN 7
If this message is printed, it means the recorder has taken too long to eject a cassette. This probably means the cassette is jammed in the drive.

(5) - BCD ERROR IN CLOCK - n
or BCD ERROR IN MAG. - n
This message means that an error has occurred in converting the data from the clock or magnetometer; 'n' is the number of consecutive times it has occurred. In either case the likely cause is a transmission error or instrument/cabling fault. If the problem is rare, it is probably best left alone. If the fault is permanent, the message will be printed every 10 seconds for one minute, then every 10 minutes thereafter.

(6) - TIME JUMP TO SS.DDD.HHMMSS
Warning that a time jump has occurred. The DAS automatically copes with these on the assumption that the clock face is showing the correct time. The operator must check the clock and correct or repair the clock if necessary.

(7) - OUTPUT BLOCK PADDED AFTER SS.DDD.HHMMSS
If a time jump occurs such that at least one empty output block would be generated, or the jump is negative such as after a clock correction, the current block is padded with unknowns (10^{10}) and output immediately followed by resynchronisation; see (8).

(8) - OUTPUT BLOCK RESYNCHRONISED AT SS.DDD.HHMMSS
At the start of recording or after a large time jump the output of data is resynchronised so that the current record is inserted in the correct slot in a regular two-minute output block. The leading part of the block is padded with unknowns.

Switch Register Usage

The SWITCH register on the front of the computer is used to access the CHAOS operator system, perform certain limited actions in case of emergency, and provide a simple visual display of the running of the DAS. The display contains much useful information that is not readily available in any other form. The SWITCH register display should therefore always be studied on any inspection of the system.

The main functions of the SWITCH register are:

Bit 0 - ACTIVE: allows access to the CHAOS system; this will stay on if an operator program is improperly terminated; make sure it is off after using CHAOS.

Bit 1 - DISPLAY : ON when processing is inactive, waiting for the next acquisition.

Bit 2 - DISPLAY : ON during data conversion.

Bit 3 - DISPLAY : ON during BCD error checking.

Bit 4 - INACTIVE

Bit 5 - DISPLAY : ON when teletype is printing.

Bit 6 - DISPLAY : shows when the program is waiting to output data to the cassette tape drive.

Bit 7 - DISPLAY : turns on and off alternately at each clock interrupt, showing that clock is functioning. If it freezes then the clock is not interrupting.

Bit 8 - DISPLAY : turns on and off alternately each 10-second acquisition cycle showing that data are being acquired. If it freezes then program ACQ 13 is failing to recognise that the next 10-second acquisition cycle should take place.

Bit 9 - DISPLAY : shows when data are actually being output to the cassette tape drive.

Bit 10- ACTIVE : allows emergency ejection of the tape if the program hangs up (shown by bits 6 and 9 being on for a prolonged period). The tape is ejected and the operator must insert a new cassette and clear Bit 10.

Bit 11- INACTIVE.

Bit 12- ACTIVE : causes the dump of a specified channel from the output block, which must be selected in response to a question on the teletype. The dump can be terminated by clearing Bit 12.

Bit 13- INACTIVE.

Bit 14- ACTIVE : causes the dump of a converted input record, with each word displayed in octal and BCD. The dump is terminated automatically.

Bit 15- ACTIVE : causes the dump of an input BCD record. The dump is terminated automatically.

Starting up the Data Acquisition System

The following procedure should be used to commence operation of the data acquisition system.

1. Turning the equipment on: If recording is intended, the magnetometer and strip-chart recorder should also be turned on at this stage.

Data acquisition system computer

(a) Turn on power switch on back of computer.

(b) Make sure both internal fans come on; if not, check fuses etc.

(c) Turn key on front of computer $\frac{1}{4}$ turn anticlockwise for one second (STANDBY to R), then $\frac{1}{2}$ turn clockwise (R to OPERATE).

(d) The computer should then carry out a short self-test program and end on HALT with the T-register displayed on the front switches.

NCE digital clock

(a) Plugging in the clock turns on the internal fan.

(b) Turn on CLOCK POWER switch.

(c) Set 100 kHz oscillator switch to EXT.

(d) Set clock face to the Julian day number and GMT time slightly in advance of the correct time.

(e) Carry the correct time from a radio time signal such as VNG.

(f) Start the clock when the correct time and clock face agree, by flicking the 100 kHz oscillator switch to INT.

KSR 43 teletype

(a) Turn on power switch at back of teletype.

(b) The following front switches should be set:

(i) PARITY-down (no parity checking)

(ii) DUPLEX-down (full duplex transmission)

(iii) CPS-up (30 cps transmission)

(c) Open teletype top, pull back print head from paper.

(d) Insert paper and wind through, making sure sprocket holes line up on both sides.

(e) Move print head forward, ensuring ribbon is correctly positioned.

(f) Close lid, make sure ALARM is off, press LOCAL.

(g) Check that teletype is printing properly by holding down PRINTER TEST for several seconds.

(h) Press TERM READY, when DATA light should come on and all others should go out; the teletype is now connected to the computer.

Facit cassette tape recorder

(a) Turn power switch on front panel ON.

(b) Press EJECT, and cassette panel should spring open.

(c) Insert timing test cassette, close panel, and wait for cassette to load.

(d) Press READ, and time how long it takes to read test tape; this should be 180 $\pm$ 5 seconds.

(e) Eject cassette; the recorder is now ready for use.

2. Loading the program:

(a) Insert cassette tape containing binary absolute copy of the DAS into the cassette recorder with the manufacturer's label to the front, and close the door. Check that after about two seconds' delay, the tape moves forward to load point and then halts after 5 to 7 seconds.

(b) Using the register select switch, select the S-register. Set the contents to 141000B then - with the computer on HALT -

press STORE
PRESET
IBL
RUN

The program will now be loaded into memory from the cassette - this is accompanied by distinct clicks from the recorder at about half-second intervals, and will take about two minutes to complete.

(c) If the program loads successfully, the computer will HALT with 102077B displayed in the T-register. If any other number is displayed (typically 102033B or 102011B) a fault has occurred. In such cases eject the cassette, clean the recorder, and try again with the same cassette. Should this fail, try again with another cassette copy of the program.

(d) Following a successful load of the program, eject the cassette and insert a properly labelled blank data cassette with the manufacturer's label to the front. If the program casette is left in, the DAS will hang-up almost immediately it is initialised.

(e) Start program execution by using the register select switch to select the P-register, set the contents to 2B then -

press STORE
PRESET
RUN

The DAS program will then print the following message on the teletype

PROGRAM NELLA - VERSION OF OCTOBER 1979

At this point turn the operator key on the front of the computer to LOCK - this prevents the DAS from being accidentally halted.

3. Initialisation of the data acquisition system: Following successful start-up of the acquisition system, the computer will type a series of messages including four questions that the operator must answer. After each answer make sure that both RETURN (CR) and LINEFEED (LF) are pressed to indicate end of transmission, otherwise the system will hang-up waiting for the message to be completed.

(a) After the starting message
PROGRAM NELLA - VERSION OF OCTOBER 1979
the data acquisition system will type
TYPE 'GO' TO START DAS
You must then type
GO CR/LF

(b) The DAS will then wait for the next 10-second clock interrupt before typing
HHMMSS - ACQUISITION STARTED

(c) It will then ask the four questions to which you must reply
The questions are

(i) SURVEY NO =
Reply with the appropriate survey number
31 CR/LF - during 1979
32 CR/LF - during 1980

(ii) TURN CASSETTE RECORDING OFF -
If data are to be recorded on cassette, answer
NO CR/LF
Only if the Facit cassette recorder has broken down
should you answer
YES CR/LF

(iii) - NEW MAG. CHECK VALUE =
You must give the value the computer sees when the
magnetometer is turned off
16665 CR/LF

(iv) - MAGNETIC VALUE =
Type in the value currently being displayed on the
magnetometer. Before doing so ensure that the
magnetometer is giving valid field values as the DAS
uses the number you supply to determine the tens of
thousands digit of the magnetic field value
"value" CR/LF

(d) At this point the DAS starts normal program execution. Note that acquisition of data commenced before the computer went into the question-and-answer phase. You will almost immediately be informed that data are correctly slotted into the output buffer beginning at the time of start of data acquisition, by the message
- OUTPUT BLOCK RESYNCHRONISED AT SS.DDD.HHMMSS

(e) It is important to verify that the system is functioning properly. You should wait at least ten minutes to verify that data blocks are being written to cassette tape every 2 minutes and that the 10-minute listing of magnetic values is produced.

Operator Intervention

Six sub-programs allow the operator a certain amount of intervention in the running of the DAS. These sub-programs are accessed by setting SWITCH bit 0 (Zero) on the front of the computer. When the

DAS has completed its current processing cycle it will print :

- CHAOS PROGRAM

Answer with the number of the operator program you require. The first four programs are identical to those used in system initialisation.

The operator program numbers are:

1 - <u>Change survey number</u>

This will not normally be used. It needs to be called at the start of a new year, e.g. transition from 1979 to 1980, 31.365.235950 to 32.001.000000.

2 - <u>Turn cassette recording off/on</u>

Recording will only be turned off if the cassette recorder breaks down for more than four hours. After its repair, reinitiate recording using the same operator program.

3 - <u>Change magnetic check value</u>

This will not normally need to be varied from 16665.

4 - <u>Set magnetic value</u>

Once initiated, this program should not need to be entered unless there is a break in recording of magnetic data with a corresponding large jump in the observed field value.

13 - <u>Eject cassette tape</u>

The DAS will ask

- EJECT CASSETTE TAPE?

Answer YES if you want to change cassettes; otherwise answer NO.

14 - <u>Operator terminal message</u>

This program allows the operator to type in any useful informative message on the teletype for permanent recording in the DAS printout. It does <u>not</u> affect program execution.

<u>Notes</u>

(i) After each operator program is completed, the DAS will ask for the next CHAOS program required. Use of the CHAOS system is ended by typing in a program number of 0 (Zero). Alternatively if the operator does not reply within about 20 seconds, the CHAOS system terminates itself to prevent the processing bogging down.

(ii) It is important to realise that if an operator program is not completed, e.g. by not answering a question, then the processing program is halted at that point. Meanwhile the acquisition program is continuing to blindly acquire data.

(iii) In most cases where the DAS is hung-up (e.g. if the read-only program cassette tape is left in the Facit drive), the processing cycle is held up and hence the CHAOS operator system cannot be entered.

<u>Daily Routine for the Data Acquisition System</u>

1: <u>Daily cassette tape changing</u>: The cassette tape should be changed at 24-hour intervals to avoid the possibility of parity errors developing and to restrict the amount of data contained on a single tape. The following procedure must be used <u>without fail</u>:

(a) Take a blank cassette, label with the next sequential tape number (SS/NNN) and approximate start time only (SSDDDHHbb).

(b) Use CHAOS program 13 to eject the cassette in the recorder.

(c) Immediately the cassette is ejected, remove it and <u>turn the read/write tabs inwards so that it cannot be written on again</u>; place it in its protective box.

(d) Clean the cassette recorder using Freon and a lint-free cloth (a linen handkerchief is best); make sure the recording head and pinch rollers are cleaned, particularly to prevent oxide build-up on the left-hand pinch roller.

(e) Insert the labelled new cassette and close the panel; wait until at least two blocks of data have been written onto the new cassette before departing.

(f) Write the actual start and stop times of the old cassette onto its label (SS.DD.HHMMSS) and seal the cassette in its box.

(g) Log the actual start and stop times of the old cassette, and enter the new cassette sequential number and approximate start time.

2. <u>Every hour on the hour:</u>

   (a) Check that the magnetic values printed on the teletype agree with the values displayed on the magnetometer.

   (b) Ensure that the clock is interrupting properly (switch Bit 7 turns on and off alternately every second) and that acquisition is taking place (switch Bit 8 turns on and off alternately every ten seconds).

   (c) Check for any unusual messages on the teletypes including

      (i) tape parity error

      (ii) BCD error in clock/BCD error in Mag.

      (iii) time jumps/padding and resynchronising of blocks.

      (iv) write rejected.

   (d) Ensure that data are being successfully written to tape by waiting while two or more blocks are output; check that switch Bit 6 comes on while the DAS waits to write, and Bit 9 when data are actually written.

Computer Input/Output Configuration

Only the lowest four I/O slots (10B to 13B) of the computer are used by program NELLA to communicate with the peripheral equipment used. The following interface cards must be placed in the specified I/O slots.

I/O slot	Instrument	Interface card
10B	Facit cassette recorder	Modified ground true I/O (Grd True I/O)
11B	NCE or GED clock	HP 32-bit data source (HP Data)
12B	KSR 43 teletype	High speed terminal/Buffered TTY (HS Term)
13B	Magnetometer	Ground true I/O (Grd True I/O)
14B	-----	Terminator * (Term)

* This last card, which is not connected to any instrument, is not essential; however, its use is recommended.

THE CLOCK AND TIMING CONTROL

A crystal-controlled clock provides the basic timing for the data acquisition system and magnetometer recorder. It may be a GED or NCE model, but both have identical characteristics as far as timing control is concerned. The setting of this clock must be initiated and checked by reference to the Australian Post Office time signals on radio station VNG, or equivalent overseas stations such as WWVH in Hawaii. Time signals generated by the A.P.O. standard are accurate to about 100 microseconds, but the received signal may jitter by roughly 1 millisecond owing to ionospheric effects.

The clock has a one-second reading precision and can be set to within one second of the radio time signal by the simple technique of carrying the time from the radio to the clock using an intermediary clock or stop-watch. The specified drift rate for the clock is better than 1 in 10^7, or the equivalent of one second in four months. Clock error should not therefore be significant during a cruise, and time signal error is negligible by comparison.

The magnetometer is read every 10 seconds, and a drift in the clock of up to even half of this would not greatly affect the accuracy of the data. (This would correspond to a positional error of about 25 metres at 10 knots). Under normal conditions a timing error of 5 seconds would be excessively high considering the drift rate mentioned previously, and would most probably indicate abnormal operation requiring close attention. However, operational conditions in the hold on the <u>Nella Dan</u> are far from ideal, and a more flexible approach is considered appropriate.

After synchronisation of the clock with VNG, the drift should be determined and logged on a regular daily basis. As long as the drift rate is fairly steady and close to linear, no adjustment should be made until the clock error exceeds five seconds. At that point the clock should be resynchronised with VNG and the adjustment logged. The operator should watch for abnormal clock behaviour indicated by erratic or abrupt changes in drift. Such events should be checked promptly; if necessary, clock drift should be monitored closely until the problem is resolved.

The navigation data are derived from another system that has independent timing control. Keeping the BMR clock within 5 seconds of GMT will maintain equivalent positional errors at a trivial level considering that the navigational accuracy available is 0.1 mile.