PROJECT GP/MG/74.4

TITLE: MGU Shetland Survey

SHIP:	NAME	MV Briarthorn
	OWNER	S William Coe and Co Ltd chartered from Wimpey Laboratories Ltd
	LENGTH	81 metres
	TONNAGE	1503 tons gross

SUMMARY OF SHIP'S MOVEMENTS

27 July	Sailed from Leith
1 August	Short call at Lerwick
6 August	Project 74/5 suspended; start of project 74/4
8-10 August	Port call at Lerwick
22-24 August	Port call at Lerwick
4-6 September	Port call at Lerwick
19-24 September	Port call at Aberdeen
3-5 October	Port call at Aberdeen
5-18 October	Project 74/5 continued and completed
18-19 October	Port call at Aberdeen
23 October	End of survey
23-26 October	Demobilisation of equipment. End of charter.

		ON	OFF	ON	OFF
T Rooney	Hunting Surveys Ltd	27 July	23 Aug.		
K Cameron		27 July	23 Oct.		
S Smith		27 July	8 Aug.	5 Sept.	23 Oct.
M Brown		8 Aug.	5 Sept.		
P Kimber		23 Aug.	25 Oct.		
A Cummings	IOS Barry	27 July	9 Aug.	4 Oct.	19 Oct.
T Fitton		8 Aug.	23 Aug.	5 Sept.	19 Sept.
					25 Oct.
R Powell		19 Sept.	4 Oct.		
W Merrill	Magnavox	27 July	8 Aug.		
B Wilkinson		27 July	8 Aug.		
O Meinlein		22 Aug.	26 Aug.		
J Black		22 Aug.	26 Aug.		
R Harouard	Sodera	27 July	8 Aug.		

SURVEY PERSONNEL AND PERIODS ON SHIP

		ON	OFF	ON	OFF
M Bacon	MGU	1 Aug.	9 Aug.	22 Aug.	26 Aug.
A S Mould	MGU	27 July	5 Sept.		
R A Floyd	MGU	19 Sept.	4 Oct.		
M C Tully	MGU	4 Oct.	26 Oct.		
P R Roberts	MGU	27 July	9 Aug.	4 Oct. 22 Aug.	19 Oct. 5 Sept.
J A Chalmers	MGU	1 Aug.	23 Aug.		
Miss S E Arnold	MGU	8 Aug.	19 Sept.		
N Kenolty	MGU	22 Aug.	5 Sept.	19 Sept.	4 Oct.
A J Davies	MGU	19 Sept.	4 Oct.	18 Oct.	26 Oct.
A Dobinson	MGU	8 Aug.	23 Aug.	5 Sept.	20 Sept.
R Gillanders	MGU	18 Oct.	24 Oct.		
J Donato	MGU	5 Sept.	4 Oct.		
D K Smythe	MGU	4 Oct.	23 Oct.		
R Scrutton	IGS/University of Edinburgh	27 July	22 Aug.		
C Ramos	ECAFE/PHILLIPINES BUREAU OF MINES	5 Sept.	4 Oct.		
E Ariate	ECAFE/PHILLIPINES BUREAU OF MINES	4 Oct.	23 Oct.		
C Deegan	CSU II	8 Aug.	23 Aug.		
Mrs O Petrie	CSU II	8 Aug.	22 Aug.		
D Evans	CSU II	22 Aug.	5 Sept.	19 Sept.	4 Oct.
N Ruckley	CSU II	22 Aug.	5 Sept.		
J Chesher	CSU II	5 Sept.	19 Sept.		
A Rochester	CSU II	5 Sept.	19 Sept.		
Mrs S Paterson	CSU II	19 Sept.	4 Oct.		
R Holmes	CSU II	4 Oct.	24 Oct.		
R Sutherland	CSU II	4 Oct.	24 Oct.		

CONTENTS

AIMS

The project was designed to complete regional geophysical surveys over the following areas, as per attached sketch map.

Priority 1 - NW of Orkney
Priority 2 - E of Shetlands
Priority 3 - N Minch
Priority 4 - W of Butt of Lewis

By August 16 when the extension of the 1974 charter on Briarthorn was confirmed, priority 4 was rerated as equal priority 2 and priority 3 was shelved for bad weather periods.

The "NW of Orkneys" and "W of Butt of Lewis" areas extend and infill the areas previously surveyed by MGU off NW Scotland. The E of Shetland area was chosen principally because of current engineering interest in this area (pipelines etc). The N Minch survey was designed to provide shallow seismic coverage along deep seismic lines and to cover the area methodically using more accurate navigation than was available for previous surveys.

Equipment mobilised for these surveys were:-

S G Brown/Askania GSS 3 gravitymeter system/latterly Anschutz platform.

Barringer magnetometer

Bolt airgun

Sparker

MS 47 Transit Sonar

ORE pinger/side scan

Decca data logger

Decca MK 21 main chain receivers

Magnavox integrated sat. nav./doppler sonar/Loran C navigation system.

27 July-8 August

On August 6, further work on project 74/5 (north of 62°N) was postponed. Seven lines totalling approximately 175 nautical miles were run in the E of Shetland (priority 2) area in the period August 6-8.

These lines were run using equipment and methods as described for the subsequent legs (see following). Results were in general good.

LEG 1

SURVEY REPORT: MGU SHETLANDS SURVEY

DATES: 10 AUGUST-22 AUGUST

PARTY CHIEF'S REPORT

WEATHER

During the early part of the leg weather conditions were good. These deteriorated later and the second half of the leg consisted of marginal survey weather.

LINES RUN

A total of 48 lines were run in the Priority 1 area to the NW of the Orkneys. Although no time was lost due to weather or equipment failure, the majority of lines were in areas sheltered from the south and west, ie along the N coast of Scotland and east of the Orkneys, were completed. Extra and extended lines were run NE of the Orkneys and around Fair Isle to define the Walls Boundary Fault and the associated basin to the west of this fault. Approximately 1450 line miles were run, of which approximately 1200 were of the original programme, 150 were requested by N Fannin and 100 were unscheduled.

CHIEF SURVEYOR'S REPORT

DATES: 10 AUGUST-22 AUGUST

Lines 8 to 48 were completed on leg 10. The plotting of charts was done using Decca Main Chain which functioned well except for a few occassions of the decometers swinging at night and also trouble with the lane identification malfunction; in the latter case the data logger lane counter was used. The fault righted itself but the cause was unknown.

In general the geometry of lane intersections for chain 6c was good, however, on some long traverse lines which cross several sheets we were forced to change from using red and green lanes to red and purple. Because there were no Decca corrections applied this caused a jump or a shift in the traverse line.

The satellite navigation printout was illegible and made proper monitoring of the system impossible.

SAT NAV REPORT

DATES: 8 AUGUST-22 AUGUST

At the end of the last leg the satellite navigation system was still without an operating Doppler Sonar to provide dead reckoned position but the Loran C receiver had been successfully interfaced. However, shortly after docking in Lerwick on the 8 August the system stopped running and it was not possible to restart the program within the computer. Attempts to reload the program failed since the paper tape reader would not read in the entire program without a series of premature halts. The data sheets supplied for the reader were inadequate for fault finding and it was not certain whether the problem lay with the reader or the computer. A Hewlett Packard engineer (Mr Casserlay), who had already been called to Lerwick on another job, was located and checked out the system's HP 2100 computer. He replaced one of the 8k core memories but had a faulty core location and also fitted a new power supply unit which was causing spurious power failure halts. He also corrected a memory configuration diode link that had been incorrectly inserted. An intermittent fault on the tape reader was confirmed but by manipulating the signal cable this problem could be overcome. The reader and cable were inspected but no cause was obvious. By the evening of the 9 August the system was functional again with the gyro compass and Loran C providing D/R position. It was decided to delay the reconnection of the Doppler Sonar until the system had been tested further in case the problems with the computer reappeared.

During the survey none of the above faults recurred and there was little prolonged down time of the system, however, certain problems did arise and these are mentioned below. The printout from the Silent 700 teleprinter became progressively less distinct due to a faulty print head. By 13 August it became so bad that it was impossible to assess in detail the quality of the satellite fixes or to output regular survey fix positions although the CRT still enabled manual logging of the current position. After the paper tape reader had been switched on for one period of about 12 hours the sprocket drive would not pull the tape through the reader. This was probably due to overheating as after switching off for 10 minutes the tape was read in correctly. It therefore became necessary to switch the reader off after use. In addition a disturbingly high number of program halts occurred, averaging about one per day. These halts were inevitably associated with a rapid winding forward of the magnetic tape. Some of these halts could be corrected by a general reset of the system or restarting the program in care but the majority, such as attempts to address the protected area of memory necessitated a program reload from paper tape. This involved loss of data because of the lengthy parameter initialisation, the Loran filter setting time and the magnetic tape repositioning that was required.

The dead reckoning using Loran C in range-range mode has been relatively successful. An average of 14 satellite passes per day were used to automatically update the Loran derived positions, the mean update being about 3% of the distance run. The dead reckoned position at each 10 minute survey fix was logged manually on the survey log sheets and magnetic tape records were obtained using a 1 minute data rate. It was found that good results could be obtained with the Loran only if the receiver was carefully monitored to ensure any weak signals were discarded and any necessary re-searching initiated. Of the slaves in the SL3 chain the Norwegian C station was used continuously with little interference and was combined with either the Icelandic Y or German W stations which were generally less easy to track. The Loran C software was used with a response time of 15 minutes to reduce noise and this required a run in at the start of the line to let the velocity filters settle down before the first fix of the line.

TECHNICIAN I/C's REPORT

DATES: 9 AUGUST-22 AUGUST

SPARKER: 9 candle array - Insulation breakdown on two of the elements of one of bank of 3. Temporary repair effected, two new elements to be available at Lerwick.

Trig Units 1) Large electrical discharge upon switch, aft bleed resistor blown and evidence of discharge between terminals of a capacitor (back left). New resistor to be available at Lerwick. Connecting bolts (discharge gap to array) sheared/temporary repair effected: replacement at Lerwick.

Trig Units 2) Intermittent firing - electrodes and trigger wire replaced.

MESS Tow cable extended.

9 Candle To be extended.

MAGNETOMETER: No faults to report since last cruise report.

HUNTEC: Fuse 701 (1 amp) continually blowing (drawing 1 amp plus intermittently); individual circuits monitored and checked okay. When reassembled total drain on circuit was 650 Milli Amps (800 Milli Amps on triggering). Loop electrode drive motors stopped. Loop electrode replaced and the one available spare motor fitted: unit now running on one motor only. Defective motors repaired; one to be fitted as soon as possible. Paper rolling through unevenly; pressure of left hand fastener lightened by removing three washers.

GENERATORS: Two failures - supply wires changed over. One failure apparently due to shipping water - fuse holders burnt out; replacements to be available at Lerwick.

FOR INFORMATION Plotting container lighting fitted to run from 13 amp plug and socket in geophysics container.

GEOPHYSICS REPORT

DATES: 10 AUGUST-22 AUGUST

Instruments used:
- Gravity meter - see below
- Magnetometer - Barringer
- Sparker - see below
- Air gun - see below
- MS 47 Transit Sonar

GRAVITYMETER - The S G Brown platform was faulty throughout this leg, causing jerks and constant dislevellment of the Askania GSS3 meter. Gravity traces at sea were of variable quality depending upon the movement of the ship, particularly of the pitch axis where serious jerking of the platform was regularly observed. A total of 24 hours on 8/9 August was spent by J Price working on the platform to no avail. At 0300 on 10 August a variable dislevellment of the platform causing variations in the meter reading of 10-15 mgals over five minute periods prevented a base connection being made. A base connection was achieved on 22 August and subsequent calculations showed that good crossovers were achieved on smoothing the trace.

AIR GUN - Trials with the Bolt gun in water of around 100m showed there to be no significant penetration through the first multiple and a significant degradation of resolution owing to bubble pulses. Subsequent use was confined to shelf edge areas with water depths over 300m. Here good penetration of over 500 msec was achieved using the 20 cu. in. chamber, 1600 p.s.i. working pressure and a 2 sec firing rate. Bubble pulses were minimised by towing the gun shallow (c. 4-5 feet below surface). In this way only one bubble pulse occurred but great care had to be taken to ensure that the gun did not fire out of the water. This is not a procedure to be recommended in heavy swells.

SPARKER - Good results were obtained using 2½Kjoules and a 2 sec firing rate. 1000 joule power gave no significant penetration when attempted. The Huntec recorder and Geomecanique hydrophone were used exclusively.

TRANSIT SONAR - Good results obtained. Used as source of water depths.

MAGNETOMETER - Good results throughout.

ORE PINGER - Non-operational.

GEOLOGY REPORT

OATES: 10 AUGUST-22 AUGUST

Gravity High A (Watts, 1971) has been delimited. The NW contact appears to be faulted and is closely followed by a change in magnetic character. Within this high, "basement" rocks are outcropping or present at shallow depth. There may be more than one type of "basement" rock in the high since there are at least two topographic styles evident: Lewisian rocks may pass eastwards into ?Oalradian/Moine rocks (East of the extension of the Moine Thrust) which have different topographic and magnetic characteristics. Consequently the SE boundary of high A is not very clear. To the SW the high becomes indistinct. This survey shows that it bifurcates into 2 main "horns" with a sedimentary sequence between them. Further SW the "horns" pass below the sedimentary rocks occurring between Basin C and the Orkneys.

To the SE of the high a well bedded sedimentary sequence occurs. According to Watts (1971) and Bott and Browitt (in press) this is Old Red Sandstone. The present survey has shown this to be extremely well bedded and structures within it can be traced quite long distances. Our records appear to be better than those of previous workers in this area, and in places the material seems too well bedded for Old Red Sandstone so another sequence may be present here. East of this there is some evidence of the basement ridge known by Watts (1971) (but this could be just a non-reflecting facies within the Old Red Sandstone since it does not have much topographic expression).

Further east, most of the sedimentary basin reported by Bott and Browitt (in press) has been outlined. Our survey broadly confirms their basin configuration but indicates that the presumed Mesozoic rocks extend further south than they envisage. Also within the basin it is possible to recognise 2 sedimentary groups by their acoustic characteristics. The extension of the Walls Boundary Fault on the east side of the basin has been mapped.

To the NW of gravity high A, Basin E (Watts, 1971) has been mapped. A well bedded sedimentary sequence dipping to the SE is seen, overlain unconformably by a thick development of Quaternary sediments.

The Shelf edge ridge (magnetic anomaly R of Watts, 1971) is not seen since calculations by Watts indicate that the structure causing the anomaly is at a depth of 1.5 to 2 kms. To the west and north-west, lines passing across the shelf edge and onto the slope show thick sequences of flat bedded (Tertiary and Quaternary) sediments containing a number of onlapping unconformities. Individual unconformities can probably be mapped over large areas when the survey is complete.

A long line towards Thurso has confirmed the existence of sedimentary Basin C and also the basement ridge around Sule Skerry. An additional line along the North Scottish coast has delimited the boundary between the sedimentary sequence occupying gravity low H and the Moine rocks of the adjacent coast. The nature of the contact is not clear (due to sea bed multiples in shallow water) but it's position can be mapped. The contact is probably an unconformity as the gravity does not suggest a fault.

LEG 2

SURVEY REPORT: MGU SHETLAND SURVEY

DATES: 23 AUGUST-5 SEPTEMBER

PARTY CHIEF'S REPORT

WEATHER

Early in the leg weather conditions were bad. No productive work was done in the period 23-26 August although extensive tests on refraction and doppler sonar equipment were carried out at anchor and in sheltered water near Lerwick. No further interruptions were experienced and sea conditions were generally favourable.

LINES RUN

Twenty lines totalling 1082 nautical miles were run in the period 26 August-4 September. Most of these lines were situated in the exposed N-W part of Priority 1 area.

RESULTS

Results were on the whole good. The simultaneous recording of air gun and sparker on the shelf edge was most successful and is a technique worth developing and refining. Development of simultaneous recording of lowand high energy sparker is not yet complete but could be most advantageous.

SAT NAV

No practical progress was made on the doppler sonar although the fault was extensively investigated by Magnavox personnel. The Magtape unit and peripherals were removed ashore for further laboratory work.

REFRACTION (PROJECT 74/5)

A total of 2½ days was spent working on refraction equipment. No success was achieved and technical suspicion now centres on possible faults in the sonobuoys. The experiment was again postponed until further equipment checks could be carried out ashore.

CHIEF SURVEYOR'S REPORT

Initially it was planned to spend part of this leg on the area north of parallel 62^{0} running refraction lines, this however was abandoned due to malfuntion of the refraction equipment and all productive work was carried out in the designated area west of Orkney. Position fixing was by Decca Navigator only, using chain 6C. The sat nav was not used due to continued malfunction of the Sonar Doppler transducer unit although a test run was attempted at the beginning of the leg with the 2 American Magnavox technicians aboard.

As stated earlier the position fixing was by Decca Navigator only although the sat nav was run using a manual speed input between sat fixes and although not used as a position fixing method, it functioned well. The accuracy of the Decca fixes was generally good and probably better than 1½ cables in most cases. This accuracy did however worsen somewhat in the western section of the area due to lane expansion and worsening hyperbolic geometry of the Decca lanes.

SAT NAV REPORT

A replacement teletype printhead was delivered on 22 August 1974 and no further trouble has been experienced from that source.

Messrs Don Heinlein (field engineer, also designed RDL tape interfacing) and Jerry Black (Ex-Magnavox, designed 150KHz sonar, now freelance) arrived on 22 August 1974 carrying sonar spares including a complete new electronics drawer and a new transducer preamplifier.

The transducer was lifted and the head and preamp changed on 23 August 1974. The head which was removed had apparently been manufactured from an incorrect quality of metal. The head which was fitted was the one originally supplied with the system in June. At the same time the Ecko paper tape reader was found to be definitely faulty and a spare was located at S G Brown and despatched by train from London and by air from Aberdeen. The expected delivery time of 1900 on 23 August 1974 was delayed by cancelled flights and it was eventually picked up from the Lerwick pilot boat at 0830 on 25 August 1974.

By the evening of 24 August 1974, no progress had been made on the doppler sonar. The suggestion was made that the transducer might not be protruding enough below the hull or that it was vibrating as a result of looseness in the bottom of the sea well. It was decided to engage the services of a diver to determine this. On the same evening two long link calls to California resulted in the following information:-

(a) The crystals in the transducers probably have an incorrect resonant frequency owing to a manufacturing fault on the part of Magnavox's suppliers. The resonant frequency is probably 166KHz as against the normal 150KHz. This problem will take at least a month to solve since it means obtaining correct crystals and manufacturing and testing a new transducer from scratch.

(b) Some doubts were expressed about the hardware efficiency of the RDL deck. It was decided to ship the deck with associated interface cards, control cards, Daconics etc to S G Brown where an RDL engineer could check it and Heinlein could work under laboratory conditions on the interface problems using S G Brown's system.

A further call to Magnavox on 25 August 1974 revealed that Magnavox were aware that the Ecko paper tape reader was inadequate for the job and were actively considering replacing all customers' units with HP 2748s (NB HP 2748 is 60Hz operation and is liable to overheating unless switched off when not in use).

The Eeko reader was fixed by the replacement of a bad chip and the connection cable/plug being wired straight into the reader. No further trouble was experienced with this unit. The temporary replacement for S G Brown was returned.

Problems of no heading input to the computer from the gyro compass were solved when it was found that the 36:1 synchro output had been disconnected while John Price was removing the faulty gravity meter platform units.

On 26 August 1974 the transducer was inspected in situ by a diver at Lerwick. The bottom of the transducer was 10½ below the hull with the Teflon spacer plate 12" up the sea well, ie 20½" above the transducer. The transducer could be flexed, there appeared to be a gap of approximately ¼" all around the spacer plate.

Since no further progress could be made with the doppler sonar and laboratory conditions were more favourable for fault-finding on the magtape system, Magnavox personnel left on 26 August 1974 taking the following items with them:-

(1) RDL 105DO deck with cables.

(2) Daconics control board and data board.

(3) 4 doppler sonar tracker cards.

(4) 1 Master control card (sonar?).

(5) 1 Transducer assembly (Magnavox property).

(6) 4 Software tapes.

J Black promised that a new, slightly larger Teflon spacer would be supplied along with the new transducer.

For the remainder of the trip the system ran with a manual speed input. Unfortunately the CRT and Loran C interfaces were inoperable owing to the components which were removed with the decks. No problems were experienced apart from those caused by human error.

TECHNICIANS REPORT

Data Logger	Although we are able to record data on the synchronous deck the incremental deck is still inoperative. The printlog is giving incorrect display on nixies - printout okay. The printlog printer needs repair and unless the system can be closed down for a few days these long outstanding faults can not be repaired.
Magnetometer	Working well. The chart recorder drive motor gearing was not driving paper and since the gravity chart recorder was faulty - awaiting spares - the two were combined to give a functional unit. Barry have been informed and new recorders are to be delivered.
Gravity	System closed down on previous leg.
Air gun	Functioning, but seemed to be giving a reduced energy output. A complete service has been carried out and all worn parts changed - subject to availability. Barry have been informed of spares used and of spares still required to bring gun back into first class condition.

Compressor — Is still as troublesome as ever. It is in need of new starter motor and solenoid and diesel injectors. The unit can be started quite easily but stalls within a few minutes. Barry have been informed of urgent need of fitter to give the unit a complete overhaul.

Seismic System — Faulty MESS array changed. All parts of seismic system now fully functional.

EPC recorder and Huntec recorder have been synchronised by the construction of an interface-frequency converter, the EPC being slaved from the Huntec. This interface permits the system to be run in the dual recorder mode and also by keying the air gun from one recorder and sparker from the other it can be so synchronised to give a dual trace record on the EPC.

Further work was carried out in order to attempt to key a high energy sparker and low energy sparker (9 candle and MESS) alternately.

Two main problems were encountered, those being:-

(a) pick up on trigger leads, and

(b) in overcoming (a) above back emf induced in twin core screened cable from sparker units destroyed keying circuits

(a) Can be overcome by using twin core screened cable - earthing the screen of the trigger plug in case.

(b) Can be overcome by isolating the keying pulses from the associated trigger lines by incorporating relay action, ie contact closure via a relay.

It was not possible to conclude this project - end of leg - but feel that to perfect it about another 4 or 5 days needed to be spent on it.

POWER SUPPLIES Although three generators are installed in a system which makes switching from one generator to another easier one of the generators can only supply 215v and cannot be used.

The second generator has a fuel tank leak and is to be repaired at Lerwick.

Generators 2 and 3 are marginal in that they are able to supply approximately 225v-230v on a load of approximately 7kva. Further loading (ie switching on air conditioner) results in the voltage supply falling to around 220v and less.

Changing generators

I strongly recommend that when changing generators the major items of equipment be turned off.

The voltage regulation at the generator is being tested, possibly to its limits, when presented suddenly with a heavy load. In view of our past experience I do not think that we can be too careful in the switching of the main supplies and stand to loose the service of very expensive equipment for the saving of a few minutes.

REFRACTION Again because of very noisy signals being presented at the Video and Audio outputs of both receivers used it was impossible to carry out these experiments.

Both receivers on board (Eddystone 990R) gave the same results when tuned to the sonobuoys - several used - indicating that there is probably some other weakness in the system. Without a high frequency generator (ie 100-200MHz) it is difficult to pinpoint the fault or eliminate the receivers.

From my own experience I would say that although both receivers have faults their basic operational ability is such that they are capable of reproducing fairly good signal levels free of the excessive noise which becomes apparent when tuned to the sonobuoys.

Since three independent aerials have been used in the course of these experiments - the same results being obtained with each - it would seem to point to poorly transmitted signals from the sonobuoys. Again in the absence of a known good reference signal, in the frequency range in which we are interested, it is not possible to accurately assess these signals.

To determine the fundamental cause of the difficulties experienced, both receivers and two sonobuoys are being taken ashore for further investigation. In any event new sonobuoys have been ordered for the continuation of this experiment.

GEOPHYSICS REPORT

Initially, the intention had been to carry out refraction programme in area north of 62°N. Due to malfunction of the equipment, this experiment has been postponed until later in the year. We returned to area NW of Orkney to continue the programme started on the previous leg.

The instrumentation employed was Barringer magnetometer, Kelvin Hughes MS47 transit sonar, a sparker and Bolt air gun systems.

The magnetic records are good, mainly flat except in the areas of possible Lewisian basement where the trace is irregular with an amplitude of the order of 100 gammas.

The transit sonar gave excellent results on the 600 metre range in water depths of up to 120 metres. Since we have no means of changing the angle of the transducer, the records became poorer the deeper the water. The sonar was used all the time to give soundings, down to 550 metres as there is no operational PDR on board.

At the beginning of the leg 2500 joule sparker records were obtained which were rather noisy. Since the same equipment, operated on the same settings, had given excellent results in the previous leg and later on on this leg, the noise was probably due to the choppy sea state. Most of the work was carried out over the continental slope, in water depths varying from 80 metres to over 1000 metres. In the areas between 80 and 150 metres, 2500 joule sparker was used, and in the deeper water areas a 20 cubic inch Bolt air gun and/or 4500 joule sparker. A system was devised whereby 4500 joule sparker was recorded on the Huntec and the air gun on the EPC recorder, the sparker and air gun firing alternatively. This proved a satisfactory system with greater penetration from the air gun and better definition from the sparker - one system complimenting the other. This system was used on several lines until the compressor broke down. Then

4500 joule sparker was used over the slope recording with 500 msec and 1 sec sweep on Huntec and 3 sec sweep on EPC. The sweep on the Huntec was such that it was only recording to just below the 1st multiple whereas on the EPC it was possible to pick up reflectors below the 1st and sometimes below the 2nd multiple at the top of the slope (penetration of 700 to 800 msec).

The gravity meter was inoperative for the whole leg. Gravity data collected prior to the beginning of this leg has now been reduced in the area NW of Orkney with 84 cross-overs, the average cross-over error is 3 mgals.

Profiling Equipment

As mentioned, the versatility of the profiling system has been significantly increased. Synchronisation of the Huntec and EPC recorders has been obtained following the construction of a circuit board which extracts the 64KHz reference frequency from the Huntec, divides it by ten, and shapes it to give the required external reference frequency of 6.4KHz, for slave operation of the EPC recorder. Thus the two recorders are locked together while still allowing flexibility of sweep parameters to suit each . In practice, this means for example, that with a two second repetition rate for each source, an airgun and 2.5KJ 9 candle sparker may be fired on alternate seconds, triggered by the EPC and Huntec respectively. The phase control is used to fix accurately the relative positions of the two sources. Additionally, the wide paper display of the EPC allows for the whole of the two second cycle to be printed on one recorder, while the sparker, in this case, is still being recorded completely independently on the Huntec. A wideband seismic signal is taken after the Huntec preamp, to independent filters, then to the print amps. Thus dual trace and dual recording facilities are available. We are almost at the position of recording 1500 J MESS and $2\frac{1}{2}$ KJ 9 candle array together, but well screened trigger leads are required to prevent sympathetic firing. This should be most effective as the present MESS is giving a very short pulse, and completion of the installation should be some time during the next survey legs of the people involved.

Examples of air gun (20 cu. in.) and sparker 2.5 KJ are available.

The implementation of these ideas was the product of the untiring enthusiasm and expertise of P Roberts, MGU, amongst other things, and was carried out during normal survey working, a feat in itself.

GEOLOGY REPORT

As this leg has concentrated chiefly on the deeper water areas near or beyond the 200m isobath, the main problem has been the interpretation of the Outer Shelf and continental slope sediments. Other lines run nearer land have however provided additional coverage of the solid geology.

On the Outer Shelf Tertiary deposits have been tentatively identified as a somewhat transparent layer of weak horizontal reflectors, individual reflectors being traceable for distances of over 20km. This identification does however require positive borehole control. These Tertiary beds are often found below an irregularly undulating strong reflector which is uncharacteristic of the Tertiary sediments and is not thought to represent the top of these deposits, but rather to be part of the Quaternary succession above. Accurate delineation of the supposed Tertiary has not always been possible, for at only a few localities (eg line 41, fix 42) is the feather edge overlap located. This is due to the considerable thickness of supposed Quaternary deposits (often known to be up to 150m thick) which necessitates inference of Tertiary sediments over much of the outer shelf. At least three horizons have been identified in the Quaternary.

On the continental slope some excellent records on the EPC recorder show over 1 second of well bedded, generally seaward dipping deposits of supposed Tertiary and Quaternary age. The geological situation here is clearly complex, but a meaningful study should be possible on completion of the survey.

On the inner shelf a number of features have been more clearly delineated on this leg. These include the Walls Boundary Fault and its associated basin (Bott and Browitt, in press), the southern extension of the eastern 'horn' of high A, and an area of particularly well bedded sediments (possibly Mesozoic) in the Old Red Sandstone of Watts (1971) to the south-east of High A.

LEG 3

SURVEY REPORT: MGU SHETLANDS SURVEY

DATES: 6 SEPTEMBER-19 SEPTEMBER

PARTY CHIEF'S REPORT

The aim of this leg of the survey was to run sparker, magnetic, transit sonar and pinger traverses in the areas NW of the Orkneys and E of the Shetlands completing earlier IGS work in the areas. The weather during the survey period was good with the exception of only the last day, enabling completion of the program. Unfortunately the ORE pinger was inoperable at the start of the leg and attempts to rectify the system failed. Therefore no pinger information was obtained. The other equipment proved very reliable with the exception of the sparker hydrophone and recorder. Standby units were available so no time was lost due to equipment failure but some of these lines were not up to the standard of earlier records.

Nine lines totalling 503 nautical miles were run in the NW Orkney area and 24 lines of total length 753 nautical miles were completed in the E Shetlands area.

CHIEF SURVEYOR'S REPORT

The first section of this leg was an extension of the previous leg for the purpose of completing the area west of Orkney and any relevant comments concerning navigation or position fixing have been made in the previous report. The latter half of the leg was carried out in the area E. of Shetland using Decca chain ØE. Decca navigator was the prime means of navigation in this area, although the satellite navigation system was interfaced with the Loran C and run experimentally until it failed due to an electronic fault. Throughout the leg the

Decca functioned well and due to good lane geometry the accuracy of fixing was good, probably within 200 metres on average. This figure could possibly be improved by applying Decca corrections but this has not been requested by IGS and is probably unnecessary in this particular area in any case.

Observation of the Loran C showed that it was particularly subject to error during the periods of sunset and sunrise, probably due to skywave effect. Generally its reliability and accuracy was not such as to recommend it as a prime means of navigation for survey purposes. This may however have been partially due to the developing fault which finally caused its failure at the latter end of the leg.

SAT NAV REPORT

On 5 September D Heinlein visited the ship at Lerwick to modify the system to enable the Loran C and the CRT display to be run on line. The Pertec tape deck and the controller had not yet arrived and so he replaced the Daconics DATA board and a speed/heading interface board in the HP2100 A computer to complete the interface chain. It was also necessary to modify some of the program steps to allow for this modification.

Upon sailing from Lerwick the system comprised the Loran C receiver interfaced to the satellite receiver to give D/R positions. No magnetic tape recording was possible nor was doppler sonar fitted. The survey was run in an area well covered by Decca Main Chain so although the system was carefully monitored and D/R positions recorded on the teletype at every fix the primary navigation aid was Decca Main Chain.

In general the Loran C set functioned well, using the SL3 chain and slaves X and W. Over the period of a week commencing

8 September the mean update between the Loran dead-reckoned position and the satellite fix was just over 2% of distance travelled, equivalent to .2mm. However, on three occasions the signal was lost at about 2000 GMT and it was not possible to retrack again until 0400. There were indications that the signal/noise ratio was low, but this did not appear to correlate with proximity to the Decca Main Chain transmitters in the area, which was one source of interference. The survey area is on the fringe of good Loran reception and it appears that Loran C suffers from some night interference effects here. On 16 September the Loran set developed a fault which prevented it from searching any of the station signals. It could not be used in either the hyperbolic or range/range mode. S G Brown were informed of the failure and through Magnavox intend to rectify the fault in Aberdeen on 19 September.

The overall system performed well with typically 16 usable satellite passes per day. One software problem which came to light is that the program corrupted if an attempt to recompute a previous fix is made, using the RCMP command during computation of the next satellite fix.

TECHNICIAN I/C'S REPORT

Equipment State: Barringer Magnetometer, no problems; recorder failed on slow speed rectified by S.S.

Side scan MS47, Bolt hydrophone, EPC recorder, E G & G Sparker equipment no problems.

Huntec and Geomecanique Hydrophone, weak and noisy signals - noise cleared. Signals weaker than normal but readable.

Faults developed in timing and control circuitry (report to P Roberts via Eric). Make shift repairs affected due to unavailability of correct transistors. Suggest a full overhaul as soon as possible.

ORE upon final installation did not work due to an intermittent break in an earth buss bar. After rectification of this fault, the equipment was tested for approximately 5 hours. However, the following day it was again out of action and repair was deferred until a Huntec fault was rectified. High voltage was found to be out of control; transmitter and drive DC Boards repaired and tested with fish on deck. After a few hours testing during which time spare boards were being repaired it failed again. I suggest that it be returned to Barry. The main problem with this piece of equipment, like all our older equipment, is that due to extreme shortage of staff at Barry it cannot get the technical attention it requires.

Generally a difficult trip due to heavy rolling and working on one half of the Huntec while the other half was still in use. Invaluable help was given by the MGU temporary assistant, Eric McKie.

GEOPHYSICS REPORT

This leg was a continuation of regional marine geophysical surveying in the areas NW of Orkney (Priority 1) and East of Shetland (Priority 2), both commenced on a previous leg.

NW of Orkney: Instruments used in this area were Barringer magnetometer, Kelvin Hughes MS 47 transit sonar, sparker system and data logger. Magnetometer worked well with fish towed at 350' astern of ship. Transit sonar gave good records on 600m scale except for lines 77 and 78 which were poor due to excessive rolling of the ship in heavy swell. Sparker records are reasonable in spit of several problems with the equipment. There was a general deterioration in input signal to the recorder from Geomecanique hydrophone. The Bolt one was used for part of line 74 and most of lines 75 and 76, but the signal to noise ratio was very bad. It was eventually decided to continue using the Geomecanique with the impaired input signal and the gain on the recorder turned up high. 2500 joules were used on lines 70 to 76 and part 77; 4500 joules on part 77 and 78. Huntec recorder was used on lines 70 to part 77, then changed to EPC as Huntec paper drive motor went down. Fault was repaired but the recorder would then only trigger on 1 sec of 1. With completion of line 78, this area was finished.

East of Shetland: The same instruments were used as NW of Orkney. The magnetometer gave good results on all but two lines. There is a large discrepancy between cross-overs of these two lines and the rest, for which there doesn't appear to be an obvious reason other than there were magnetic storms at the time - this can be checked with magnetograms from Lerwick Observatory. Transit sonar gave good records except on line 101 which was very poor due to the rough sea state. 2500 joule sparker was run over the whole area firing from the 9 candle array. Geomecanique hydrophone was used but still has poor input signal. EPC recorder was used on lines 79 to 90, Huntec on 91 to 102. Seismic records were reasonable on most lines, notable exception was line 101, with penetration to the first multiple in areas where there were reflectors. Better definition on Huntec trace than that on EPC. This area is now completed. In both areas water depths were taken from transit sonar.

Gravitymeter inoperable for the whole leg.

GEOLOGY REPORT

NW Orkney area

Basement

The main feature of the area consists of a prominent ridge trending NNE-SSw from 59°N to north of 60°N, and centred about 3° 30'W. The ridge is some 30km in width at it's widest extent and consists largely of probable Lewisian strata with associated high irregular magnetic anomalies, but to the south and west it appears to consist of less magnetic strata characterised by low undulating anomalies of less than 200γ. This may represent Dalradian strata.

The western margin of the ridge is marked by a prominent normal fault which separates Lewisian basement from a Mesozoic basin to the west. The eastern margin is in part faulted, and is separated from Mesozoic or Old Red Sandstone to the east. To the south-west a graben-like feature is present within the basement ridge. To the south the basement increases in depth and is overlain by sedimentary strata.

Devonian

The Devonian deposits, well exposed on the Orkneys, continue offshore as a unit of apparently massive strata with only rare traces of bedding. This massive strata can be traced for some 10km offshore to the east and west of the Orkneys but continues north for a distance of 30-40km.

To the north the massive Devonian passes into more well bedded strata characterised by fairly strong reflectors and dips ranging from 5-15°. Synclinal and anticlinal fold axes can be traced for several kilometres within this strata. This bedded strata is considered to be Devonian in age on geophysical characteristics, but may in part pass into overlying Mesozoic.

Mesozoic

To the west of the basement ridge is a prominent Mesozoic sedimentary basin downfaulted against the basement by a prominent normal fault. Strata within this basin are arranged in a prominent asymmetrical synclinal disposition with the axis to the west of the fault. This Mesozoic basin trends north-south, but its southern limit has as yet not been mapped with any degree of certainty. It appears to be continuous with the Mesozoic sedimentary basin in the south of the area.

Another prominent Mesozoic basin is present in the eastern part of the area between longitudes 1° 30'W and 2° 30'W and trending NNE-SSW. This basin conformably overlies Devonian strata to the west and is terminated against presumed Old Red Sandstone to the east by the Walls Boundary Fault.

Other minor Mesozoic basins may be present to the east of the main basement ridge but geophysical resolution has not been sufficient to form a conclusive opinion, and these occurrences may represent well bedded Devonian deposits.

Tertiary

A prominent gently north west dipping (c1°) reflector is present beneath the Quaternary in the NW of the area overlying the Mesozoic, and has been assumed to be the Mesozoic, and has been assumed to be the base Tertiary. The eastern limit of this reflector has been mapped trending NW-SE across the area.

Quaternary

A thin veneer of Quaternary sediments is present throughout the region except in the areas of basement, where rock outcrops are present on the sea floor. However, a boundary has been mapped for the Quaternary to the west of the basement ridge where thick Quaternary deposits are present. These horizontally bedded deposits form a gently undulating surface where they overlie the Mesozoic, but gradually form a more even base to the west where they unconformably overlie strata of presumed Tertiary age.

E Shetland area

The offshore geology consists predominantly of a near surface or surface basement complex comprised of massive strata with occasional traces of irregular bedding. The basement is characterised by gently undulating or flat magnetics with localised NNE-SSW trending highs. These highs probably represent axes of more magnetic material such as epidorite, hornblende schist or serpentinite. Between Fetlar and Unst a magnetic high may be directly correlated with onshore exposures of serpentinite, hornblende schist and epidorite. Due to the relatively homogeneous nature of the basement it has not been possible to make any direct comparison with the onshore geological setting of Shetland.

In the extreme SW of the area a small region of well bedded gently folded strata of Devonian or Mesozoic age is present overlying basement. These rocks are considered to be from the SE limit of a major sedimentary basin lying further to the NW. Similarly to the SE of the area strata is present that exhibits greater indications of bedding than is generally visible in the basement and for this reason these rocks are tentatively suggested as representing another sedimentary basin of Devonian or Mesozoic age. A small sedimentary Mesozoic or Devonian basin is also present between Whalsay and Fetlar lying unconformably on basement rocks.

The main feature of the area is a belt of very well bedded Mesozoic or Devonian sediments some 12km in width, trending NNE-SSW across the area, and widening to the NE. The presence of this belt of strata is marked by a prominent area of flat topographic relief well exhibited on the bathymetric map. These sediments have a regional dip to the SE and are folded into a series of gentle anticline and synclines trending NE-SW. In the NE of the area the sediments are affected to a high degree by minor normal faulting. The sediments thinly overlie basement in the south of the area and are not present south of 60° 15'N, but thicken to the NE. The western margin of this sedimentary belt consists of an unconformable contact overlying basement. This contact is partly faulted along its length. The eastern contact, however, is marked almost entirely by a prominent normal fault downthrowing to the NW. The presence of this fault is confirmed by a steep gravity gradient.

The Devonian strata present on land in the region of Lerwick appears to continue offshore for only a limited distance. Their eastern limit, where they unconformably overlie basement rocks cannot be mapped with any degree of certainty due to the lack of sufficiently distinguishable geophysical characteristics and this boundary has therefore only tentatively been shown on the map. The pronounced magnetic high SE of Lerwick has been attributed to possible Middle Devonian volcanics.

LEG 4

SURVEY REPORT: MGU SHETLANDS SURVEY

DATES: 21 SEPTEMBER-3 OCTOBER

PARTY CHIEF'S REPORT

The major objective of this leg was to complete the gravity coverage in the area west of the Orkneys. To this end an Anschutz GM platform on hire from Cambridge University was installed during the port call in Aberdeen (19-24 September) as a replacement for the S G Brown platform which was unserviceable. On completion of the gravity coverage it was planned to continue regional survey work to the west and south or in the Minch depending upon time available and weather conditions.

Throughout this leg weather conditions varied from poor to unworkable, three days were lost before sailing from Aberdeen and latterly shelter was sought in Kirkwall where the gravity meter was checked and in Loch Eribol. Fortunately the Cambridge platform performed well and acceptable gravity data was recorded in the priority areas. Due to the amount of time lost no other work was undertaken.

CHIEF SURVEYOR'S REPORT

This leg consisted mainly of a re-run of selected lines in the area west of Orkney using the gravimeter which was non-functional on the previous leg. These lines were run at 10 knots and navigation was by main chain Decca on chain 6C with sat nav/Loran being run experimentally. The accuracy of fixing was generally good as on the 2 previous legs due to good Decca lane geometry, which has been described in the previous reports. Also the higher speed made it easier to keep the vessel on line during the frequent periods of bad weather. Additional lines, using all the geophysical equipment were also run in the south and south-west of the area. These lines were run at 5-6 knots in an area where the Decca lane geometry and signal strengths were poor, and consequently the accuracy of position fixing was of a lower order. In fact to attempt survey navigation using Decca only, further south west is not really practicable from the reliability/accuracy point of view and the sat nav/Loran system is not likely to improve on this.

TECHNICAL REPORT

1. During the trip various trouble was encountered with the following equipment:
   (a) The data logging system.
   (b) The Geomecanique hydrophone.
   (c) The ORE Tx/Rx.
   (d) The air gun compressor.
2. The data logger problems were mainly confined to the "Data Monitor Unit." The faults here were various, ie I.C.'s blown, short circuits etc, in all, seven separate faults were discovered. The equipment was therefore unserviceable for the duration of the trip. A Watt visited the ship on 2 October 1974 and found three more faults, when he left the equipment working.
3. The Geomecanique hydrophone was giving no output at all. This was traced to dirty contacts inside the hydrophone connecting plug. All joints were resoldered and made good.
4. UOI technicians worked on the ORE Tx/Rx and made it serviceable again.
5. A fitter from RVB Barry joined the ship and replaced various drive belts in the air gun compressor.

GEOLOGY/GEOPHYSICS REPORT

The survey consisted essentially of a gravity survey only, to tidy up and enlarge the area surveyed in 1971. Regretably, this area did not cover areas of immediate interest to geophysicists of the Unit. Consequently, it has been necessary to complete interpretation of the West Shetland area without the detailed gravity coverage required. Following processing of gravity data on board, crossover errors were small within the 74/4 survey, but some interpretation will be required to integrate the data with that obtained during the 71/5 survey.

It should be noted that the reference building for the Blaikie Quay gravity base has been demolished!

For the duration of the survey, and with the assistance of A Davies efforts were made to develop a dual channel facility for profiling, using air gun and sparker. Unfortunately, the air gun system was defective and unsuccessful attempts were made to use two sparkers independently. I would point out again the difficulties of trying to develop new techniques while at the same time keeping the normal survey equipment running smoothly when only limited expertise is available.

LEG 5

SURVEY REPORT: MGU SHETLANDS SURVEY

DATES: 19-22 OCTOBER 1974

PARTY CHIEF'S REPORT

The aim of this leg was to survey a number of profiles in the North Sea at the request of Continental Shelf Unit II. These profiles were required to augment the data already available. Unfortunately very little surveying was done due to bad weather.

The ship left Aberdeen on Saturday 19 October and surveying continued until late on Sunday when bad weather forced a halt. At this time the gravity meter system was shut down and the weather and a faulty generator made it impossible to restart it. The survey was able to continue for another 24 hours but again bad weather forced the abandonment of the survey and severe gale conditions encountered late on Monday forced the ship to sail to the Tyne 36 hours ahead of schedule.

CHIEF SURVEYOR'S REPORT

The final short leg was run in the central North Sea and was restricted by gale force winds, only five lines being run, lines 122-126 inclusive. The general area of these lines was such that it was on the limits of 3 Decca chains, 6C, 3B, 9B. Consequently the lane expansion factor was high, the cut of the lanes poor, and signal strength low. Further, Decca chain coverage was not as good as it might have been necessitating the use of inappropriate chains at times. These factors led to a low standard of position fixing accuracy, particularly on lines 125 and 126. In some cases this necessitated using dead reckoning in conjunction with one Decca lane to obtain fixes. This situation was however ameliorated by the use of satellite fixes where possible (note the Loran C had been removed at the last port call).

The overall accuracy for the five lines was probably ± ½nm, the worst being on lines 125 and 126 (± ¾nm at times) with slightly better figures on the other 3 lines.

GEOLOGY/GEOPHYSICS REPORT

Introduction

The primary aims of this final leg aboard 'Briarthorn' for the 1974 season were shallow seismic studies with sparker, pinger and transit sonar equipment as complementary coverage to N-S lines run during GP/MG cruises 72/4 and 73/8. A very high priority line was also planned at 56°03'N from 1°30'W to 2°E with which it was intended to map for the first time rockhead and Quaternary strata on E-W sections south of 56°15'N. The programme was prematurely terminated due to force 8 gales, line 126 giving uninterpretable sparker records.

Description

1. North to south lines 122, 124, 125 were successfully run adding useful primary data to that already available, and thus decreasing N-S line spacing in those areas from 20km to 10km or less.
2. Line 123 was run west to east in poor weather conditions with a corresponding poor record resulting. The level of rockhead monitored in this area suggests there is a major difference of extrapolated levels of rockhead in areas to the north to those taken on this line.

Conclusion

In addition to the effects of NW-SE strike of rockhead level in this area, the significant drop in rockhead northwards is probably complemented by flexuring and/or faulting.

TABLE OF LINES SURVEYED

Key to Equipment:

- G = Gravitymeter
- M = Magnetometer
- TS = Transit Sonar
- S() = Sparker (power in kilojoules)
- A() = Air gun (capacity in IN^3)
- DL = Data logger
- DM = Decca main chain

Estimated Navigational Accuracy (ENA)

- A = $\pm$ 50m
- B = $\pm$ 100m
- C = $\pm$ 200m
- D = $\pm$ 500m
- E = $\pm$ 2km
- F $>$ 2km

TABLE OF LINES SURVEYED

Line No	Fixes	N.M.	ENA	Equipment Run					
1	1-30	30.0	C-D	G	M	TS	S(2.5)		DM
2	1-13	9.5	D	G	M	TS	S(2.5)		DM
3	1- 5	4.1	D	G	M	TS	S(2.5)		DM
4	1- 8	6.0	D	G	M	TS	S(2.5)		DM
5	1-36	30.8	C-D	G	M	TS	S(2.5)		DM
6	1-69	60	C	G	M	TS	S(2.5)		DM
7	1-36	35	C	G	M	TS	S(2.5)		DM
8	1-19	20	C	G	M	TS	S(2.5)	DL	DM
9	1-26	29	C	G	M	TS	S(2.5)	DL	DM
10	1-61	60	C	G	M	TS	S(2.5)	DL	DM
11	1-63	66.5	C	G	M	TS	S(2.5)	DL	DM
12	1-61	67	C	G	M	TS	S(2.5)	DL	DM
13	1-60	53.5	C	G	M	TS	S(2.5)	DL	DM
14	1-22	22	C	G	M	TS	S(2.5)	DL	DM
15	1-48	50	C	G	M	TS	S(2.5)	DL	DM
16	1-56	56.5	C	G	M	TS	S(2.5)	DL	DM
17	1-67	66	C	G	M	TS	S(2.5)	DL	DM
18	1-46	45	C	G	M	TS	S(2.5) (Fix 25-31) A(Fix 1-25, 31-46)	DL	DM
19	1-49	43	C	G	M	TS	S(2.5)	DL	DM
20	1-79	70	C	G	M	TS	S(2.5)	DL	DM
21	1-53	60	C	G	M	TS	S(2.5)	DL	DM
22	1-43	37.5	C	G	M	TS	S(2.5)	DL	DM
23	1- 6	5	C	G	M	TS	S(2.5)	DL	DM
24	1-31	34	C	G	M	TS	S(2.5)	DL	DM
25	1-18	16	C	G	M	TS	S(2.5)	DL	DM

Line No	Fixes	N.M.	ENA	Equipment Run					
26	1-12	14.5	C	G	M	TS	S(2.5)	DL	DM
27	1- 9	7.5	C	G	M	TS	S(2.5)	DL	DM
28	1-11	9	C	G	M	TS	S(2.5)	DL	DM
29	1- 5	4	C	G	M	TS	S(2.5)	DL	DM
30	1-19	17.5	C	G	M	TS	S(2.5)	DL	DM
31	1-18	16	C	G	M	TS	S(2.5)	DL	DM
32	1-19	17	C	G	M	TS	S(2.5)	DL	DM
33	1-18	16	C	G	M	TS	S(2.5)	DL	DM
34	1-24	25	C	G	M	TS	S(2.5)	DL	DM
35	1-14	16.5	C	G	M	TS	S(2.5)	DL	DM
36	1-12	14.5	C	G	M	TS	S(2.5)	DL	DM
37	1-36	33	C	G	M	TS	S(2.5)	DL	DM
38	1-62	59	C	G	M	TS	S(2.5)	DL	DM
39	1-45	40	C	G	M	TS	S(2.5)	DL	DM
40	1-27	23	C	G	M	TS	A(40)	DL	DM
41	1-99	94	C-D	G	M	TS	S(2.5)	DL	DM
42	1-12	12	C-D	G	M	TS	S(2.5)	DL	DM
43	1-18	18	C-D	G	M	TS	S(2.5)	DL	DM
44	1-22	18	C-D	G	M	TS	S(2.5)	DL	DM
45	1-16	14	C-D	G	M	TS	S(2.5)	DL	DM
46	1-47	58	C	G	M	TS	S(2.5)	DL	DM
47	1-48	55	C	G	M	TS	S(2.5)	DL	DM
48	1-57	65.5	C	G	M	TS	S(2.5)	DL	DM
49	1-28	23	C	G	M	TS	S(2.5)	DL	DM
50	1-28	26	C		M	TS	S(2.5)	DL	DM

Line No	Fixes	N.M.	ENA	Equipment Run				
51	1-50	52	C	M	TS	S(2.5)	DL	DM
52	1-77	53	C	M	TS	S(2.5)	DL	DM
53	1-97	75	C	M	TS	S(2.5)	DL	DM
54	1-48	52	C	M	TS	S(2.5)	DL	DM
55	1-87	84	C	M	TS	S(2.5)	DL	DM
56	1-37	42	C	M	TS	S(2.5 fixes 1-29) S(4.5 fixes 29-37)	DL	DM
57	1-39	38	C	M	TS	S(4.5)	DL	DM
58	1-19	17.5	C	M	TS	S(2.5)	DL	DM
59	1-19	16	C	M	TS	S(4.5)	DL	DM
60	1-22	22.5	C	M	TS	S(4.5)	DL	DM
61	1-35	39	C	M	TS	S(4.5 fixes 1-16) A(20 fixes 17-35)	DL	DM
62	1-48	44	C	M	TS	A(20 fixes 1-19) S(4.5 fixes 19-48)	DL	DM
63	1-38	42	C	M	TS	S(2.5)	DL	DM
64	1-55	41	C	M	TS	S(2.5) A(20)	DL	DM
65	1-38	41.5	C	M	TS	S(2,5 fixes 1-28 4.5 fixes 29-38) A(20 fixes 1-26)	DL	DM
66	1-121	110	C	M	TS	S(4.5 fixes 1-59 2.5 fixes 60-121)	DL	DM
67	1-81	86	C	M	TS	S(2.5 fixes 1-61 4.5 fixes 62-81)	DL	DM
68	1-77	79	C	M	TS	S(4.5 fixes 1-34 2.5 fixes 34-77)	DL	DM
69	1-18	19.5	C	M	TS	S(2.5 fixes 10-18)	DL	DM
70	1-48	39	C	M	TS	S(2.5)	DL	DM

Line No	Fixes	N.M.	ENA	Equipment Run				
71	1-22	25	C	M	TS	S(2.5)	DL	DM
72	1-82	72	C	M	TS	S(2.5)	DL	DM
73	1-58	57	C	M	TS	S(2.5)	DL	DM
74	1-52	56	C	M	TS	S(2.5 no record fixes 17-22)	DL	DM
75	1-57	53	C	M	TS	S(2.5)	DL	DM
76	1-59	62	C	M	TS	S(2.5)	DL	DM
77	1-76	70	C	M	TS	S(2.5 fixes 1-56 4.5 fixes 57-76)	DL	DM
78	1-72	70	C	M	TS	S(4.5 fixes 1-15 2.5 fixes 15-72)	DL	DM
79	1-59	61	C	M	TS	S(2.5)	DL	DM
80	1-60	61	C	M	TS	S(2.5)	DL	DM
81	1-56	61	C	M	TS	S(2.5)	DL	DM
82	1-72	61	C	M	TS	S(2.5)	DL	DM
83	1-32	33	C	M	TS	S(2.5)	DL	DM
84	1- 6	6	C	M	TS	S(2.5)	DL	DM
85	1-17	16	C	M	TS	S(2.5)	DL	DM
86	1-16	17.5	C	M	TS	S(2.5)	DL	DM
87	1-62	61.5	C	M	TS	S(2.5)	DL	DM
88	1-13	11.5	C	M	TS	S(2.5)	DL	DM
89	1-25	24	C	M	TS	S(2.5)	DL	DM
90	1-22	23.5	C	M	TS	S(2.5)	DL	DM
91	1-24	21.5	C	M	TS	S(2.5)	DL	DM
92	1-27	29	C	M	TS	S(2.5)	DL	DM
93	1-12	10	C	M	TS	S(2.5)	DL	DM

Line No	Fixes	N.M.	ENA	Equipment Run					
94	1- 8	8	C		M	TS	S(2.5)	DL	DM
95	1- 9	6.5	C		M	TS	S(2.5)	DL	DM
96	1-30	29	C		M	TS	S(2.5)	DL	DM
97	1-26	25	C		M	TS	S(2.5)	DL	DM
98	1-27	23	C		M	TS	S(2.5)	DL	DM
99	1-56	61	C		M	TS	S(2.5)	DL	DM
100	1-67	60	C		M	TS	S(2.5)	DL	DM
101	1-44	31	C		M	TS	S(2.5)	DL	DM
102	1-12	13	C		M	TS	S(2.5)	DL	DM
103	1-54	77	C	G		TS		DL	DM
104	1-24	41.5	C	G		TS		DL	DM
105	1-49	74	C	G		TS		DL	DM
106	1-10	11.5	C	G		TS		DL	DM
107	1-27	44	C	G		TS		DL	DM
108	1-24	41	C	G		TS		DL	DM
109	1-20	31	C	G		TS		DL	DM
110	1-19	30	C	G		TS		DL	DM
111	1-26	42.5	C	G		TS		DL	DM
112	1-27	41.5	C	G		TS		DL	DM
113	1-24	39.0	C	G		TS		DL	DM
114	1-11	17.5	C	G		TS		DL	DM
115	1-22	31	C	G		TS		DL	DM

Line No	Fixes	N.M.	ENA	Equipment Run		
116	1-67	56	C	G TS Pg S(2.5)	DL	DM
117	1-64	48.5	C	G TS Pg S(2.5)	DL	DM
118	1-81	74	C	G TS Pg S(2.5)	DL	DM
119	1-39	46	C	G M(from fix 11) TS Pg S(2.5)	DL	DM
120	1-18	20	C	G M TS Pg S(2.5)	DL	DM
121	1- 6	4.5	C	G M TS Pg S(2.5)	DL	DM
122	1-60	71	E	G M TS Pg S(1)	DL	DM
123	1-70	81	E	G M TS Pg S(1)	DL	DM
124	1-34	28.5	E	M TS Pg S(1)	DL	DM
125	1-61	71.5	E	M TS Pg S(1)	DL	DM
126	1-16	6	E	M TS Pg S(1)	DL	DM