



OPERATIONS REPORT  
HB77A MARINE SEISMIC SURVEY

BASS STRAIT

For

HEMATITE PETROLEUM PTY. LTD.

140 WILLIAM STREET

MELBOURNE VICTORIA 3000

BY

GEOPHYSICAL SERVICES INTERNATIONAL

P.O. BOX 106, NORTH RYDE, N.S.W. 2113

PARTY 2931 : M.V. "EUGENE McDERMOTT II"  
OPERATIONS SUPERVISOR : G. SHILLIDAY  
QUALITY CONTROL SEISMOLOGIST : R. THOMAS

DECEMBER 6 - DECEMBER 14, 1977

OR-017



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3	AIRGUN ARRAY
4	AIRGUN PULSE AND SPECTRUM
5	TAPE FORMAT



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SECTION 1INTRODUCTION

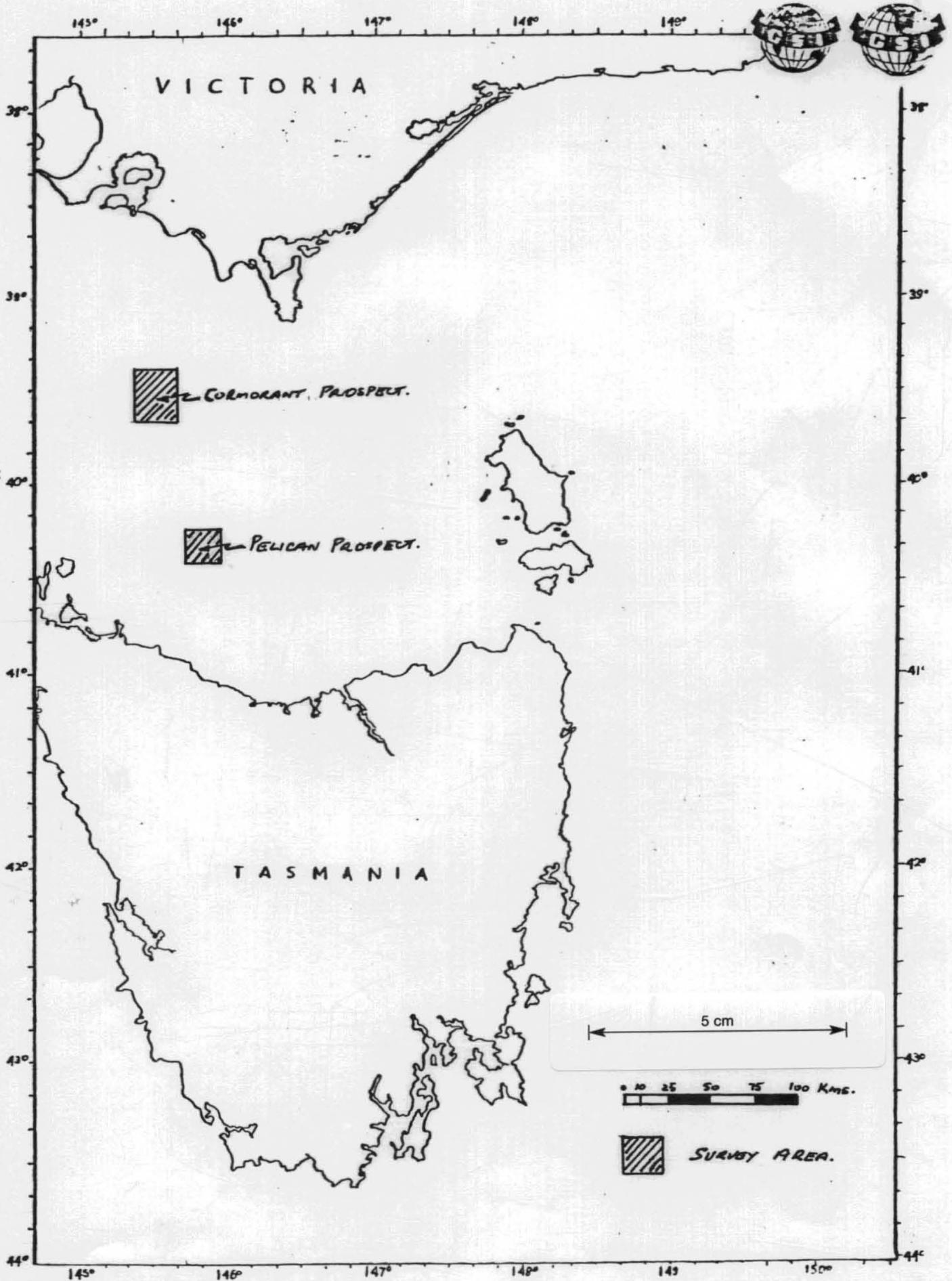
A marine seismic reflection survey was conducted by the m.v. "Eugene McDermott II" in the Cormorant and Pelican Prospects for Hematite Petroleum Pty. Ltd., between the 6th December and 14th December, 1977. (see plate 1)

651.425 kilometres of 48-fold reflection coverage were shot utilizing a 2400 metre streamer under continuous tow in conjunction with a Pneumatic Acoustic Energy Source (Airguns), generally operating 24 hours per day.

Recordings were made using two sets of DFS IV's\* with 4 tape transports recording on 12.7 mm magnetic tape in 9 track SEG B Digital Format. Record Length was 5 seconds. For Cormorant the sample rate was 2 milliseconds. For Pelican the sample rate was 4 milliseconds.

The ship's location was determined by Geonav\*.

\* Trademark of Texas Instruments Inc.



SECTION IIOPERATION PROCEDURESA. RECORDING:

2 Texas Instruments Digital Field System IV's (DFS IV) with 4 tape transports were used for all recording. Both of these instruments are identical but the traces were not recorded in the same channels for each system. For details see Appendix B Section a(4). A Servo Writer Profiler was utilised to obtain 100% (Near Trace Gather) subsurface coverage (uncorrected section) of 4 seconds duration, directly from monitor recording of trace 92.

Direct Read After Write (RAW) monitors were generated approximately every 40 shotpoints for quality control purposes. In making these displays the instantaneous gain was removed and programmed gain control applied so that relative amplitude variations between traces could be observed.

B. STREAMER:

The 2400 metre, neutrally buoyant, continuous tow streamer (refer plate 2) consisted of 48 live sections each 50 metres in length, each containing 2 x 25 metre live groups and 6 waterbreak/Depth Transducer sections each 4 metres in length, placed immediately in front of group 96 and between groups 80 and 81, 60 and 61, 40 and 41, 20 and 21, 2 and 3. Eight 50 metre nylon stretch sections were placed between group 96 and the recording vessel to attenuate ship-generated noise. Six Condep\*\* cable depth controllers were placed on the depth transducers on the streamer between live groups 2/3, 20/21, 40/41, 60/61, 80/81 and 96/stretch.

\*\* Trademark of Continental Oil Company





Only waterbreak transducers in locations stretch/96 and 80/81 were used. During initial ballasting operations a tap-test (consisting of striking each Geophone) on the 96 groups, was conducted at client request. This checked polarity of traces and to reveal any trace that did not come up to Texas Instruments specifications.

Tail-buoy bearings were checked at regular intervals to ensure the feathering angle of the streamer did not exceed 8 degrees during recording.

C. ENERGY SOURCE (AIRGUNS):

An Electro-Pneumatic Acoustic Energy Source known as "Airguns" was used for reflection work. The Airgun has basically two moving parts, the shuttle and solenoid. Compressed air is supplied to this unit at a pressure of 13789 kPa (2000 psi). The shuttle is forced to close on initial application of pressure. Compressed air fills the reservoir chamber through a central orifice in the shuttle. To discharge the gun an electrical current activates the solenoid and retracts a plunger, thus enabling compressed air to pass through a port hole to the underside of a flange at the top of the shuttle. The pressure difference above and below the shuttle then thrusts it open. The air from the chamber then escapes through four port holes near the centre of the gun and expands rapidly through the water, producing a single bubble and resultant shock wave. The air bubble collapses in a manner similar to that caused by explosives with one notable exception in that its period is controllable and is placed in the desired seismic frequency band.

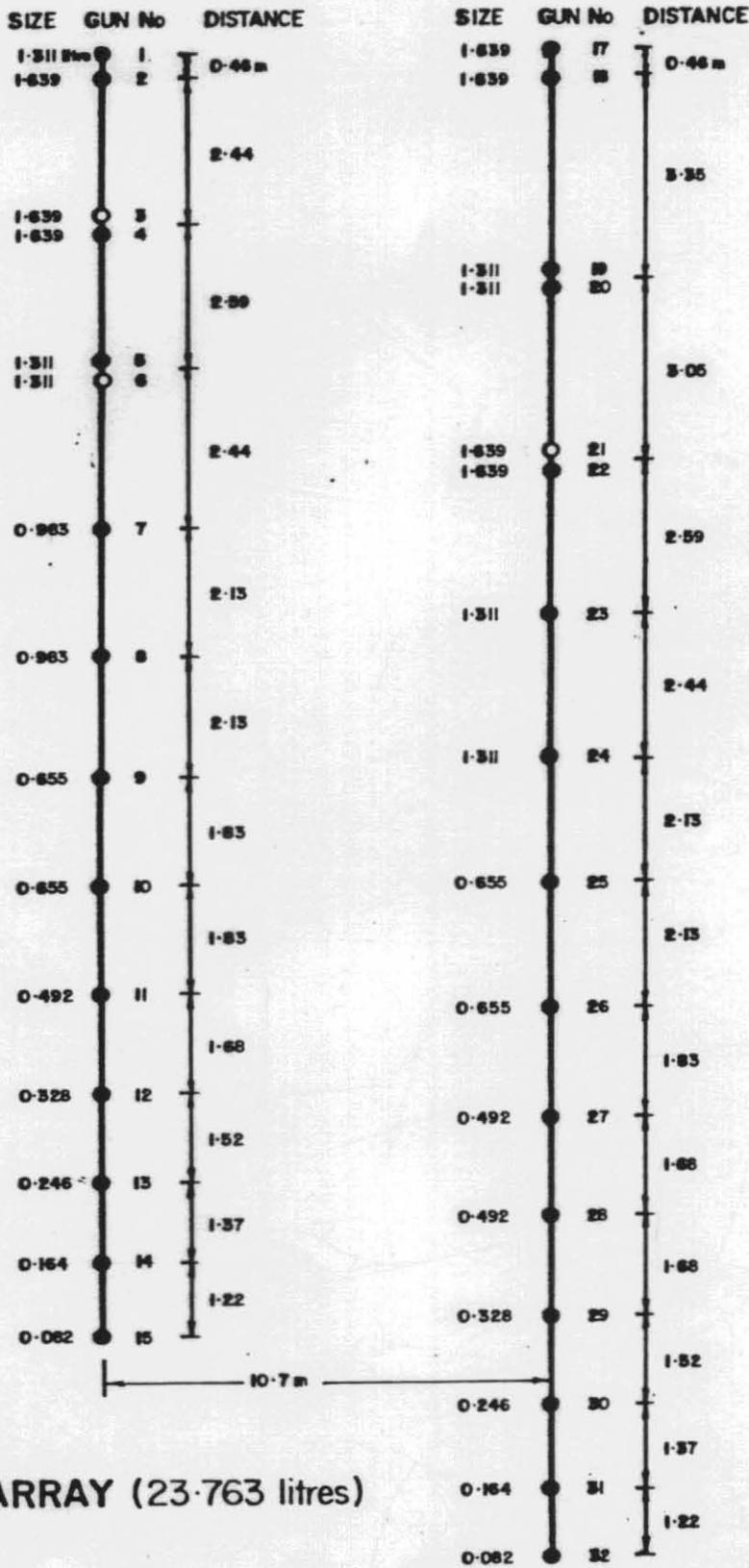
5 cm



Port

STERN OF VESSEL

Starboard



○ SPARE GUN

AIR GUN ARRAY (23.763 litres)



There are three variables used to control the frequency content of the shock waves. These are: -

- i) depth of the airgun in the water
- ii) pressure at which the gun is operated,  
and
- iii) size of the chambers used on the gun.

Using different guns of various chamber sizes broadens and flattens the frequency spectrum of the pulse (plate 4)

The depth of the airguns was 10 metres and they were operated at a pressure of 13789 kPa (2000 psi) with the pressure never falling below 12755 kPa (1850 psi)

The individual airguns were arranged to produce a 1450 cu. in. array. This array consisted of :-

- i) 4 x 100 cu. in. guns = 4 x 1.640 litres
- ii) 6 x 80 cu. in. guns = 6 x 1.312 litres
- iii) 2 x 60 cu. in. guns = 2 x 0.984 litres
- iv) 4 x 40 cu. in. guns = 4 x 0.656 litres
- v) 3 x 30 cu. in. guns = 3 x 0.492 litres
- vi) 2 x 20 cu. in. guns = 2 x 0.328 litres
- vii) 2 x 15 cu. in. guns = 2 x 0.246 litres
- viii) 2 x 5 cu. in. guns = 2 x 0.082 litres

These guns were arranged and spaced (see plate 3) so as to operate as a tuned array which yields a flat frequency spectrum.

N.B. 280 cu. in. (4.592 litres) of airgun volume was available in the form of spare guns.

1 psi = 6.8945 kPa

1 cu. in. = 0.0164 litres

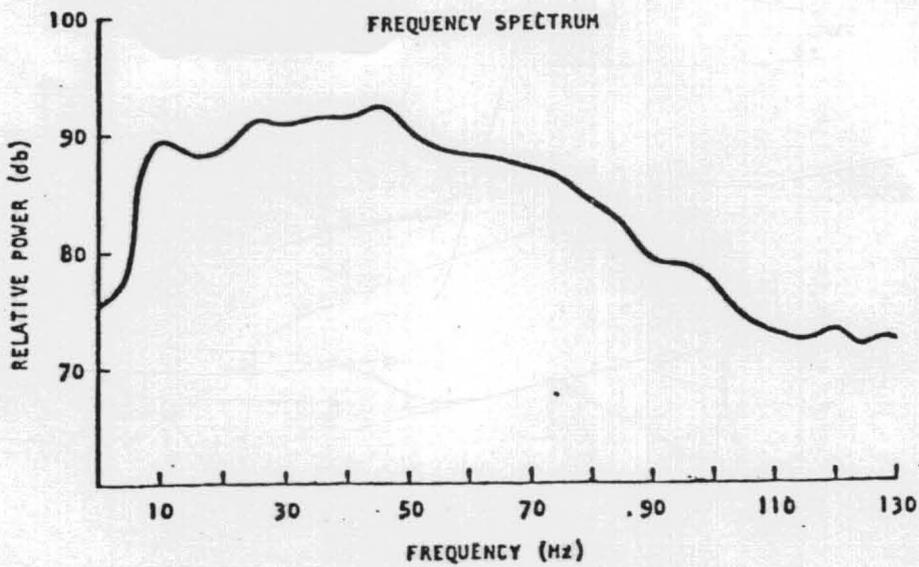
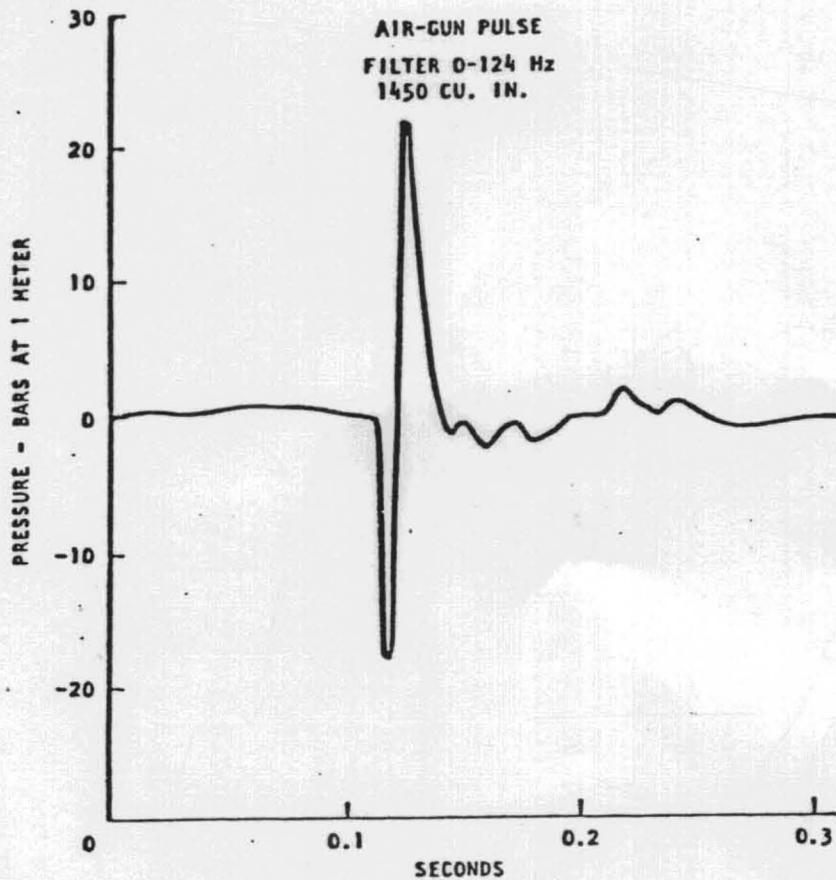


PLATE 4 Airgun Pulse Form and Frequency Spectrum

5 cm



The guns were fired every 25 metres giving 48-fold coverage. The airgun array was mounted on two Gun Strings, one port astern and the other starboard astern and towed behind the recording vessel.

D. INSTRUMENT AND NOISE TESTS :

Instrument tests were carried out each morning and the results were examined in an analog form in the field. These tests consisted of Dynamic Range Determination, Amplifier Noise Test and Automatic Gain Control (AGC) Test. Frequent checks on tape speed and skew were made. Tapes from each system were read on other transports as a check to confirm readability.

A set of monthly tests were carried out prior to commencement of operations. These tests included Harmonic Distortion, Gain Linearity, Periodic Calibration checks, skew checks, and the abovementioned tests. These tests were analysed in the Sydney, Australia Processing Centre using TIAC routine, and found to be up to Texas Instruments standards.

The Texas Instrument Automatic Airgun Controller (TIGER)\* can be controlled:-

- i) COMPUTER MODE
- ii) STAND ALONE MODE

\* Trademark of Texas Instruments



i) COMPUTER MODE :

In Computer Mode the CMS Navigation sets and monitors the last eight firing times of the individual guns in the array and keeps them to within 1ms.

The firing instant is sensed directly from the initial shuttle movement and the array is consistently tuned.

It is also noted that, there is a 51ms, delay from SOD, on tape, to the time that the airguns are fired.

ii) STAND ALONE MODE :

In this mode, which is independent of the CMS Navigation Computer, it sets and monitors only the last two firing times of the guns, and does essentially the same as in Computer Mode.

This detection system also provides a direct monitoring of the performance of each gun with an automatic display indicating a no-fire or self-fire for each individual gun.

A streamer noise analysis was made at the beginning and end of each line shot. All of these tests were recorded straight (unmixed) with the production recording filter (8Hz-62Hz) and it was required that the noise should not exceed 2 microbars RMS except for those groups within 200m of each end of the cable and within 50 metres of each depth control fin where up to 3 microbars would be allowed; all were found to be below these values (except for group 1 which was turned off at clients request from time to time).

E. FATHOMETER:

A Ross Model 400A fathometer and an Elac Deneb, Model LAZ-17DDI, AGN8 fathometer were used.





The Ross fathometer operated at 50 KHz and the Elac fathometer at 15.20 KHz. Each fathogram was identified by line number, direction shot, time and date of first shotpoint and scale. The fathograms were marked and labelled every 40 pops. The zero lines for the fathograms were recorded at the transducer position, 3.35 metres below sea level.

F. SURVEY :

The ship's position at each shotpoint was determined by Geonav\* (see Appendix E)

The distance from the primary antenna to the seismic source was 58.6 metres.

Auxiliary equipment used included 2 trace plotters and a thermal printer.

G. PERMITTING :

The Marine Operations Centre, Canberra was advised as to the ship's location throughout the survey to enable the necessary navigation warning to mariners to be issued.

SECTION IIIDATA QUALITY AND WEATHER

Data quality was maintained at or above G.S.I. standards.

Seastates between 4 and 6 were experienced resulting in some lines being reshot to hold to the required standards.



APPENDICES

APPENDIX AKEY PERSONNEL

G. SHILLIDAY	SUPERVISOR
I. TAYLOR	PARTY MANAGER
I. JONES	ADMINISTRATOR
R. THOMAS	QUALITY CONTROL SEISMOLOGIST
J. THOMPSON	INSTRUMENT ENGINEER
N. MCGOWAN	INSTRUMENT ENGINEER
C. ORR	INSTRUMENT ENGINEER TRAINEE
J. SCHMITZ	INSTRUMENT ENGINEER TRAINEE
S. MARTIN	AIRGUN MECHANIC
J. O'NEILL	AIRGUN MECHANIC
R. CAMPBELL	AIRGUN MECHANIC
C. GRUBBA	CAPTAIN
F. LASCASCIO	NAVIGATOR-GEONAV
M. BEECH	NAVIGATOR-GEONAV

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R. MARLOW )	CLIENT REPRESENTATIVES
P. SPRAGGON )	



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APPENDIX BEQUIPMENTa) RECORDING

## (1) 2400 Metre Streamer (Plate 2)

Type Cable A.C.H.	: 96 trace, neutrally buoyant, universal gland streamer.
Length of Live Section	: 50 metres
Length of Depth Transducer Section	: 4.00 metres
Distance Group 1 to 96 (Centers)	: 2375 metres
Group Interval	: 25 metres
Seismometer Type	: T.I. Flatpack Acceleration- cancelling
Seismometers per Group	: 15
Seismometer Interval	: Linear, 1.67 metres
Sensitivity	: 9.0 uV/uBar

a) (2) Recording Parameters - Two Systems (Cormorant Area)

Amplifiers : TI DFS IV

Gain Mode : IFP

Tape Speed : 41.88 I.P.S.

Record Length : 5.0 seconds

Sample Rate : 2 milliseconds

Gain Constant : 30 db

Final Gain : 114 db

Filter -

    Low Cut : 8Hz, 18 db/octave

    High Cut : 124Hz, 72 db/octave

a) (3) Recording Parameters - Two Systems (Pelican Area)

Amplifiers : TI DFS IV

Gain Mode : IFP

Tape Speed : 20.94 I.P.S.

Record Length : 5.0 seconds

Sample Rate : 4 milliseconds

Gain Constant : 30 db

Final Gain : 114 db

Filter -

    Low Cut : 8Hz, 18 db/octave

    High Cut : 62Hz, 72 db/octave



a) (4) Data Channel Allocations - 2400 metres Streamer

<u>FUNCTION</u>	<u>MONITOR TRACE NUMBER</u>	<u>SYSTEM</u>	<u>TAPE CHANNEL</u>
Timing		Both	
Traces 1-95 (Odd)	1-48	System I	1-48
Traces 2-96 (Even)	1-48	System II	1-48
Field Time Break	4	Both	Not recorded
D.F.S. Time Break	8	Both	Time word zero
Waterbreak 1	54 and 53	System II	Aux 1
Waterbreak 2	53 and 50	System II	Aux 1-2

b) Survey VesselM.V. "EUGENE McDERMOTT II"

Flag : Panama

Homeport : Panama

Trade : Foreign Going-Seismic Exploration

Owners : Geophysical Service Inc.

Call Sign : H0 9376

Length : 52.73 metres L.O.A.

Breadth : 12.19 metres

Depth : 4.27 metres

Draft : 3.05 - 3.24 metres

Official Number : 7062 - PEXT - 1

Gross Tonnage : 929.89 tonnes

Net Tonnage : 249.09 tonnes

Engine Power : 2 x 839.25 HP engines



APPENDIX C

OPERATION STATISTICS

<u>CORMORANT</u> <u>(HOURS)</u>	<u>FOR PERIOD 6TH-14TH DECEMBER 1977</u>	<u>PELICAN</u> <u>(HOURS)</u>
-	TRAVEL	14.75
3.92	CABLE HANDLING & FAILURE	2.75
-	SOURCE HANDLING & FAILURE	0.67
55.42	SHOOTING AND LINE CHANGES	63.16
13.00	EQUIPMENT FAILURE	2.75
12.34	NAVIGATION SYSTEM FAILURE	9.25
19.33	DOWN FOR WEATHER	14.08
<hr/>		
319.15	KILOMETRES RECORDED	332.28
12766	TOTAL SHOTPOINTS	13291

FIELD TAPES USED 467



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LIST OF FIELD TAPES AND SHOTPOINT NUMBERSSYSTEM I

DATE	TAPE NO.	LINE NO.	SHOTPOINTS
7 DEC. 1977	747609	HB77A-314	1-60
	747610	"	61-121
	747611	"	122-250
	747612	"	251-375
	747613	"	376-500
	747614	"	501-625
	747615	"	626-750
	747616	"	751-878
	747617	"	879-1004
	747618	"	1005-1077
	747619	"	1079-1115
	747620	HB77A-315	1-20
	747621	"	21-60
	747622	"	61-185
	747623	"	186-305
	747624	"	306-320
	747625	"	321-435
	747626	"	436-560
	747627	"	561-680
	747628	"	681-797
8 DEC. 1977	747634	HB77A-320	1-30
	747635	"	31-156
	747636	"	157-162
	747637	"	163-291
	747638	"	292-361
	747639	HB77A-321	1-70
	747640	"	71-169
747641	"	170-296	
747642	"	297-306	
747643	"	307-377	



LIST OF FIELD TAPES AND SHOTPOINT NUMBERS

SYSTEM I

DATE	TAPE NO.	LINE NO.	SHOTPOINTS
8 DEC. 1977	747650	HB77A-318	1-125
	747651	"	126-138
	747652	"	139-265
	747653	"	266-272
	747654	"	274-400
	747655	"	401-407
	747656	"	408-528
	747657	HB77A-319	1-126
	747658	"	127-132
	747659	"	133-262
	747660	"	263-275
	747661	"	276-327
	747662	HB77A-316	1-124
	747663	"	125-254
	747664	"	255-381
	747665	"	382-387
	747666	"	388-510
	747667	"	511-588
	747668	HB77A-317	1-120
	747669	"	121-245
	747670	"	246-370
	747671	"	371-443
	747672	HB77A-309	1-125
	747673	"	126-253
	747674	"	254-380



LIST OF FIELD TAPES AND SHOTPOINT NUMBERS

SYSTEM I

DATE	TAPE NO.	LINE NO.	SHOTPOINTS
8 DEC. 1977	747675	HB77A-309	381-478
	747676	HB77A-307	1-120
	747677	"	121-154
	747678	"	155-280
	747679	"	281-408
	747680	"	409-535
	747681	"	536-565
	747682	HB77A-308	1-120
	747683	"	121-245
	747684	"	246-370
	747685	"	371-470
	747686	HB77A-306	1- 60
	747687	"	61-185
	747688	"	186-313
	747689	"	314-429
9 DEC. 1977	747690	HB77A-305	1-75
	747691	"	76-203
	747692	"	204-332
	747693	"	333-460
	747694	"	461-590
	747695	"	591-628
	747696	HB77A-304	1-70
	747697	"	71-200
	747698	"	201-330
	747699	"	331-459
	747700	"	460-467
	747701	HB77A-303	1-70
	747702	"	71-200
	747703	"	201-329
	747704	"	330-460



LIST OF FIELD TAPES AND SHOTPOINT NUMBERS

SYSTEM I

DATE	TAPE NO.	LINE NO.	SHOTPOINTS
9 DEC. 1977	747705	HB77A-303	460-589
	747706	"	590-677
	747707	HB77A-302	1-70
	747708	"	71-198
	747709	"	199-327
	747710	"	328-443
	747711	HB77A-301	1-82
	747712	"	83-210
	747713	"	211-325
	747714	"	326-450
	747715	"	451-575
	747716	"	576-619
	747717	HB77A-300	1-125
	747718	"	126-250
	747719	"	251-375
	747720	"	376-419
	747721	HB77A-312	1-125
	747722	"	126-255
	747723	"	256-380
	747724	"	381-505
	747725	"	506-630
	747726	"	631-755
	747727	"	756-880
	747728	"	881-1009
	747729	"	1010-1124
	747730	HB77A-310	1- 60
	747731	"	61-185
	747732	"	186-310
	747733	"	311-436
	747734	"	437-564



LIST OF FIELD TAPES AND SHOTPOINT NUMBERS

SYSTEM I

DATE	TAPE NO.	LINE NO.	SHOTPOINTS
9 DEC. 1977	747735	HB77A-310	565-627
	747736	HB77A-313	1-128
10 DEC. 1977	747737	"	129-258
	747738	"	259-387
	747739	"	388-515
	747740	"	516-644
	747741	"	645-692
	747742	HB77A-311	1-72
	747743	"	73-200
	747744	"	201-328
	747745	"	329-455
	747746	"	456-466
	747747	"	467-593
11 DEC. 1977	747748	"	594-622
	747754	HB77A-351	2-200
	747755	"	201-458
	747756	"	459-463
	747759	HB77A-347	1-250
	747760	"	251-497
	747763	HB77A-349	1-250
	747764	"	251-500



LIST OF FIELD TAPES AND SHOTPOINT NUMBERS

SYSTEM I

DATE	TAPE NO.	LINE NO.	SHOTPOINTS
12 DEC. 1977	747765	HB77A-349	501-543
	747766	HB77A-345	1-200
	747767	"	201-458
	747768	"	459-628
	747769	HB77A-343	1-200
	747770	"	201-459
	747771	"	461-605
	747772	HB77A-341	1-200
	747773	"	201-455
	747774	"	456-561
	747775	HB77A-339	1-200
	747776	"	201-450
	747777	"	451-665
	747778	HB77A-358	1-200
	747779	"	201-300
	747780	HB77A-356	1-245
	747781	"	246-302
	747782	HB77A-354	1-251
	747783	"	252-382
	747784	HB77A-350	1-250
	747785	"	251-500
	747786	"	501-529
	747787	HB77A-352	1-200
	747788	"	201-388
747789	HB77A-346	1-250	
747790	"	251-500	
747791	"	501-560	
747792	HB77A-348	1-220	
747793	"	221-428	
13 DEC. 1977	747794	HB77A-361	1-200



LIST OF FIELD TAPES AND SHOTPOINT NUMBERS

SYSTEM I

DATE	TAPE NO.	LINE NO.	SHOTPOINTS
13 DEC. 1977	747795	HB77A-361	201-334
	747796	HB77A-342	1-200
	747797	"	201-455
	747798	"	456-708
	747799	HB77A-344	1-200
	747800	"	201-432
	747801	HB77A-331	1-200
	747802	"	201-346
	747803	HB77A-330	1-200
	747804	"	201-353
	747805	HB77A-332	1-210
	747806	"	211-376
	747807	HB77A-334	1-209
	747808	"	210-480
	747809	"	481-513
	747810	HB77A-336	1-250
	747811	"	251-490
	747812	"	491-513
	747813	HB77A-338	1-250
	747814	"	251-480
747815	"	481-555	
747816	HB77A-340	1-250	
747817	"	251-500	
747818	"	501-513	
14 DEC. 1977	747819	HB77A-333	1-200
	747820	"	201-283
	747821	HB77A-337	1-200
	747822	"	201-450
	747823	"	451-587
	747824	HB77A-335	1-200

LIST OF FIELD TAPES AND SHOTPOINT NUMBERSSYSTEM I

<u>DATE</u>	<u>TAPE NO.</u>	<u>LINE NO.</u>	<u>SHOTPOINTS</u>
14 DEC. 1977	747825	HB77A-335	201-450
	747826	"	451-505
	747827	HB77A-360	1-200
	747828	"	201-422



LIST OF FIELD TAPES AND SHOTPOINT NUMBERS

SYSTEM II

DATE	TAPE NO.	LINE NO.	SHOTPOINTS	
7 DEC. 1977	746906	HB77A-314	1-120	
	746907	"	121-195	
	746908	"	196-320	
	746909	"	321-445	
	746910	"	446-570	
	746911	"	571-700	
	746912	"	701-828	
	746913	"	829-955	
	746914	"	956-1079	
	746915	"	1080-1115	
	746916	HB77A-315	1-122	
	746917	"	123-245	
	746918	"	246-365	
	746919	"	366-490	
	746920	"	491-615	
	746921	"	616-740	
	746922	"	741-797	
	746925	HB77A-320	1-125	
	8 DEC. 1977	746926	"	126-253
		746927	"	254-361
746928		HB77A-321	1-125	
746929		"	126-260	
746930		"	261-377	
746934		HB77A-318	1-70	
746935		"	71-199	
746936		"	200-328	
746937		"	329-456	
746938		"	457-528	
746939		HB77A-319	1-70	
746940		"	71-199	
746941		"	200-327	



LIST OF FIELD TAPES AND SHOTPOINT NUMBERS

SYSTEM II

<u>DATE</u>	<u>TAPE NO.</u>	<u>LINE NO.</u>	<u>SHOTPOINTS</u>
8 DEC. 1977	746942	HB77A-316	1-70
	746943	HB77A-316	71-200
	746944	"	201-329
	746945	"	330-455
	746946	"	456-558
	746947	HB77A-317	1- 60
	746948	"	61-185
	746949	"	186-310
	746950	"	311-435
	746951	"	436-443
	746952	HB77A-309	1- 65
	746953	"	66-195
	746954	"	196-320
	746955	"	321-445
	746956	"	346-478
	746957	HB77A-307	1- 70
	746958	"	71-197
	746959	"	198-327
	746960	"	328-455
	746961	"	456-565
	746962	HB77A-308	1- 60
	746963	"	61-190
	746964	"	191-315
	746965	"	316-440
746966	"	441-470	
746967	HB77A-306	1-125	
746968	"	126-250	
746969	"	251-375	
746970	"	376-429	
9 DEC. 1977	746971	HB77A-305	1-127
	746972	"	128-255



LIST OF FIELD TAPES AND SHOTPOINT NUMBERS

SYSTEM II

DATE	TAPE NO.	LINE NO.	SHOTPOINTS
9 DEC. 1977	746973	HB77A-305	256-382
	746974	"	383-510
	746975	"	511-628
	746976	HB77A-304	1-128
	746977	"	129-258
	746978	"	259-388
	746979	"	389-467
	746980	HB77A-303	1-128
	746981	"	129-259
	746982	"	260-388
	746983	"	389-519
	746984	"	520-648
	746985	"	649-677
	746986	HB77A-302	1-124
	746987	"	125-253
	746988	"	254-382
	746989	"	383-443
	746990	HB77A-301	1-125
	746991	"	126-250
	746992	"	251-378
	746993	"	379-500
	746994	"	501-619
	746995	HB77A-300	1- 60
	746996	"	61-185
	746997	"	186-310
	746998	"	311-419
748609	HB77A-312	1- 70	
748610	"	71-195	
748611	"	196-320	
748612	"	321-445	



LIST OF FIELD TAPES AND SHOTPOINT NUMBERS

SYSTEM II

DATE	TAPE NO.	LINE NO.	SHOTPOINTS	
9 DEC.1977	748613	HB77A-312	446-575	
	748614	"	576-700	
	748615	"	701-825	
	748616	"	826-950	
	748617	"	951-1077	
	748618	"	1078-1124	
	748619	HB77A-310	1-127	
	7486201	"	128-255	
	748621	"	256-383	
	748622	"	384-510	
	748623	"	511-627	
	10 DEC.1977	748624	HB77A-313	1-70
		748525	"	71-200
		748626	"	201-331
748627		"	332-460	
748628		"	461-589	
748629		"	590-692	
748630		HB77A-311	1-126	
748631		"	127-256	
748632		"	257-384	
748633		"	385-510	
748634		"	511-622	
11 DEC.1977	748640	HB77A-351	2-252	
	748641	"	253-463	



LIST OF FIELD TAPES AND SHOTPOINT NUMBERS

SYSTEM II

DATE	TAPE NO.	LINE NO.	SHOTPOINTS
11 DEC. 1977	748645	HB77A-347	1-200
	748646	"	201-450
	748647	"	451-497
	748650	HB77A-349	1-200
	748651	"	201-450
	748652	"	451-543
12 DEC. 1977	748653	HB77A-345	1-255
	748654	"	256-511
	748655	"	512-628
	748656	HB77A-343	1-256
	748657	"	257-515
	748658	"	516-605
	748659	HB77A-341	1-250
	748660	"	251-500
	748661	"	501-561
	748662	HB77A-339	1-250
	748663	"	251-505
	748664	"	506-665
	748665	HB77A-358	1-250
	748666	"	251-300
	748667	HB77A-356	1-200
	748668	"	201-302
	748669	HB77A-354	1-201
	748670	"	202-382
	748671	HB77A-350	1-200
	748672	"	201-445
748673	"	446-529	



LIST OF FIELD TAPES AND SHOTPOINT NUMBERS

SYSTEM II

DATE	TAPE NO.	LINE NO.	SHOTPOINTS
12 DEC. 1977	748674	HB77A-352	1-250
	748675	"	251-388
	748676	HB77A-346	1-200
	748677	"	201-450
	748678	"	451-560
	748679	HB77A-348	1-250
	748680	"	251-428
	13 DEC. 1977	748681	HB77A-361
748682		"	253-334
748683		HB77A-342	1-250
748684		"	251-500
748685		"	501-708
748686		HB77A-344	1-250
748687		"	251-432
748688		HB77A-331	1-252
748689		"	253-346
748690		HB77A-330	1-263
748692		"	264-353
748693		HB77A-332	1-250
748694		"	251-376
748695		HB77A-334	1-250
748696		"	251-450
748697		"	451-513
748698		HB77A-336	1-200
748699		"	201-450
748700		"	451-513
748701		HB77A-338	1-183
748702	"	185-425	
748703	"	426-555	
748704	HB77A-340	1-212	

LIST OF FIELD TAPES AND SHOTPOINT NUMBERSSYSTEM II

<u>DATE</u>	<u>TAPE NO.</u>	<u>LINE NO.</u>	<u>SHOTPOINTS</u>
13 DEC. 1977	748705	HB77A-340	213-420
	748706	"	421-513
14 DEC. 1977	748707	HB77A-333	1-250
	748708	"	251-283
	748709	HB77A-337	1-250
	748710	"	251-500
	748711	"	501-587
	748712	HB77A-335	1-250
	748713	"	251-505
	748714	HB77A-360	1-250
	748715	"	251-422



## APPENDIX \* E

## GEONAV\*\* POSITIONING SYSTEM

A. INTRODUCTION

The GeoNav integrated marine navigation system records and displays continuous position computed from U.S. Navy navigation satellite, doppler sonar, gyrocompass, attitude control, and velocimeter data. The system performs automatic line and shot control based on distance-measured equal shotpoint spacing along the great circle path between the end positions of a seismic line.

B. FIELD OPERATION

The GeoNav system computes the great-circle path for a seismic line based on end points input as geographical positions by the GeoNav operator. While on-line, the vessel's deviation from the great-circle path is plotted on a pair of track plotters to a preset scale (normally 200 m/in). One of these plotters is on the bridge, where the helmsman steers the vessel to minimize deviations as they are plotted.

Automatic shot control is obtained by measuring the distance traveled on the surface. Each time the required pop interval is traversed the digital field system and the shot relay for the seismic energy source are activated automatically. The required pop interval is computed from group and coverage information input by the operator.

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\* This appendix is adapted from a paper entitled, "Self-contained Quality Control in Marine Satellite Navigation," by John M. Hughes and Rudolf Unger, presented at the 27th Annual Meeting of the Institute of Navigation, June 29, 1971 in Pasadena, California.

\*\*A Geophysical Service Inc. service mark.



The line and shot control module allows for extensions at either end of a line, line deflections (doglegs), and circling. In all these cases, continuity of shotpoint spacing along the great-circle path is preserved automatically. Subsurface coverage at the beginning and end of a line is guaranteed by taking into account possible position shifts due to satellite fix corrections and by computing the appropriate lead-in and lead-out. The track-plotters output a special lead-in display for each line and annotates line parameters, shotpoints, and satellite fixes.

All shotpoint positions, line parameters, position fixes, and other relevant navigation data are recorded on magnetic tape. Hardcopy redundancy of this recorded data is provided by teletype printout and track-plotter annotation.

#### C. POST MISSION PROCESSING

The navigation accuracy obtainable in real time is improved in post mission processing by infinite time smoothing of the recorded navigation data. Shotpoint and satellite fix positions are weighted against "past" and "future" position information using statistical filtering parameters based on satellite variance estimates and velocity and heading calibration factors output at each satellite fix.

Post mission processing also computes the position shift from satellite receiver antenna position to any desired offset position (seismic source, common depth points, etc.), and the position shift due to conversion from the APL\* satellite system reference ellipsoid to a given local datum.

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\*Applied Physics Laboratory, Johns Hopkins University.



The post mission processing end product is the computerized map and listing of transverse Mercator projected positions.

D. SYSTEM DESCRIPTION

1. General

The GeoNav system establishes its absolute geographical location from information transmitted by satellites of the U.S. Navy Navigational Satellite System. The vessel's continuous path of travel is computed by a dead reckoning system consisting of a velocity measurement system (VMS) and an azimuth measurement system (AMS). The VMS derives its values from four-beam independent doppler sonar velocity measurements compensated for the ship's pitch and roll, and for variations in the sound propagation velocity. The AMS consists of a gyrocompass externally compensated for the ship's dynamics.

At intervals averaging approximately 1.5 hours at the equator and less at higher latitudes, the dead reckoned position is corrected by a satellite position fix. Each satellite fix printout contains an estimate of fix accuracy and provides calibration factors for the dead reckoning system. In this manner, a self-contained quality control is established.

The Navy currently has five satellites in non-synchronous, circular, polar orbits of about 600 mi. altitude. A core memory onboard the satellite contains its orbital position information which is updated approximately every 12 to 18 hours from ground tracking and injection stations. The satellite continuously transmits this data as its navigation message phase encoded onto two carrier frequencies.

The vessel's satellite receiver automatically locks onto the satellite signals when it appears in sight. A satellite pass may have a



duration of up to 20 minutes during which period the satellite navigation message is redundantly received, and a number of integrated doppler frequency shift (doppler count) measurements are acquired. From the navigation message the satellite positions along its orbit are derived. The doppler counts yield measures of range difference between the vessel position and the satellite positions along its orbit. Comparing the doppler shifts of the two carrier frequencies permits elimination of the ionospheric refraction influence. Automatic data editing and an iterative process of fitting computed and measured range differences ultimately result in a correction to the dead reckoned position.

Besides the tasks of navigation and data quality control, the GeoNav computer performs the line and shot control as described in Section B.

## 2. Detailed Description

Figure 1 is a block diagram of the GeoNav system as configured for GSI. The system employs a Magnavox MX702CA satellite receiver configured for the transfer of doppler counts synchronized with the completion of each line of the satellite message (a line takes 4.6 sec of the 2-min cycle). This permits implementation of the so-called "short doppler" satellite solution whereby the doppler counts are integrated over segments corresponding to an integer multiple of satellite lines.

The satellite receiver also receives both of the two transmitted satellite frequencies, demodulates the signals, and organizes the demodulated bits into 12-bit data words for transfer to the computer. Each 12-bit data word is accompanied by three bits of code which identify the nature of the data being transferred. Also a part of the satellite receiver is a 5-MHz oven-stabilized crystal oscillator which is the reference oscillator for the

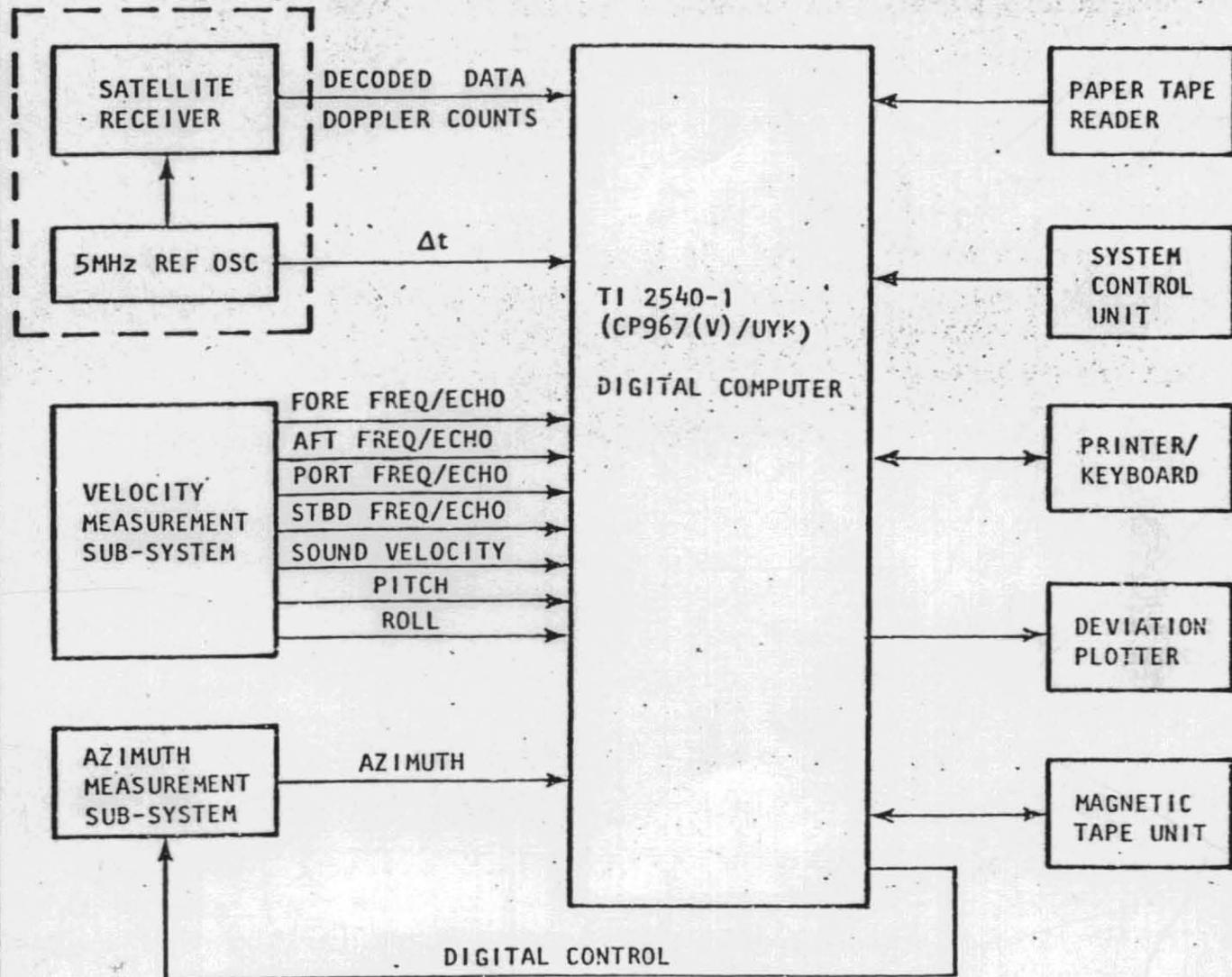


Fig. 1. GeoNav System Block Diagram.



satellite receiver in addition to being the relative time reference for the GeoNav system.

Figure 2 is a block diagram of the GeoNav velocity measurement subsystem. The sonar transducer and associated electronics are the Edo Western 435C pulse-frequency tracking system modified by Texas Instruments to yield only the frequencies of the four sonar beams (Figure 2 shows only one channel) and the time of arrival of their echoes.

The GeoNav velocity measurement subsystem provides parameters for computing the vessel's velocity in a plane tangent to the earth's surface. Components of this velocity are the projections of the ship's fore-aft and port-starboard axes on this tangent plane. To permit navigation from these data, these velocity vectors must be resolved into velocity components in northerly and easterly directions.

Figure 3 is a block diagram of the GeoNav azimuth measurement subsystem. Basic to it is the Sperry MK227-0 gyrocompass which provides X1 and X36 synchro outputs of vessel azimuth in addition to a 400-Hz reference, the amplitude of which is modulated by control from the computer, utilizing an amplitude modulator built by Texas Instruments. This external control from the computer is derived from an algorithm which compensates the gyrocompass for the effects of vessel dynamics on the compass.

A synchro-to-digital converter, Astrosystems A603-5-S149, translates the X1 and X36 information from the gyrocompass to digital form for transfer to the computer. Now available is the information necessary to resolve the data from the velocity measurement subsystem into components of velocity in northerly and easterly directions in the local earth-tangent plane. Basic instrument accuracies are shown in Table I.

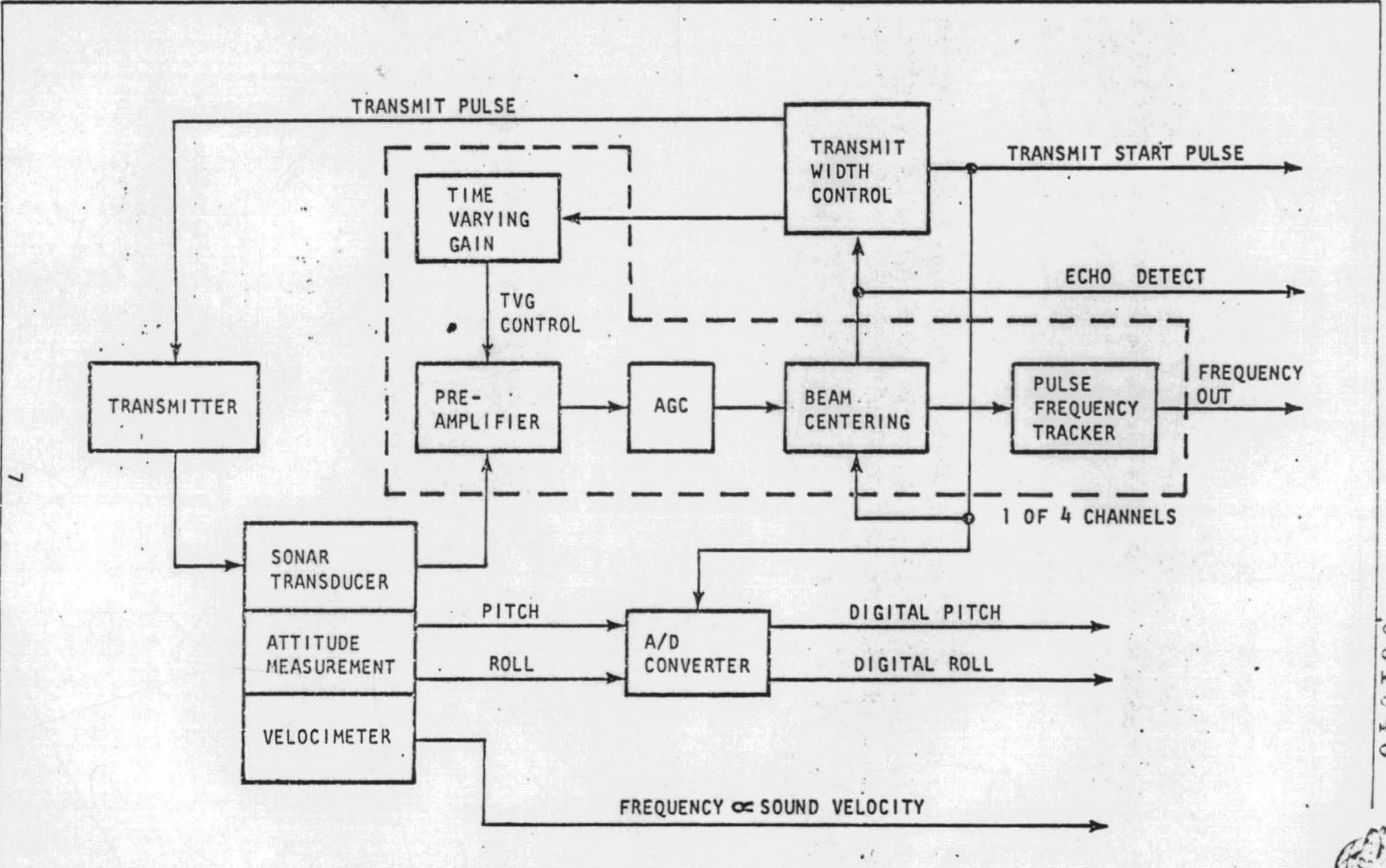


Fig. 2. Velocity Measurement Subsystem Block Diagram



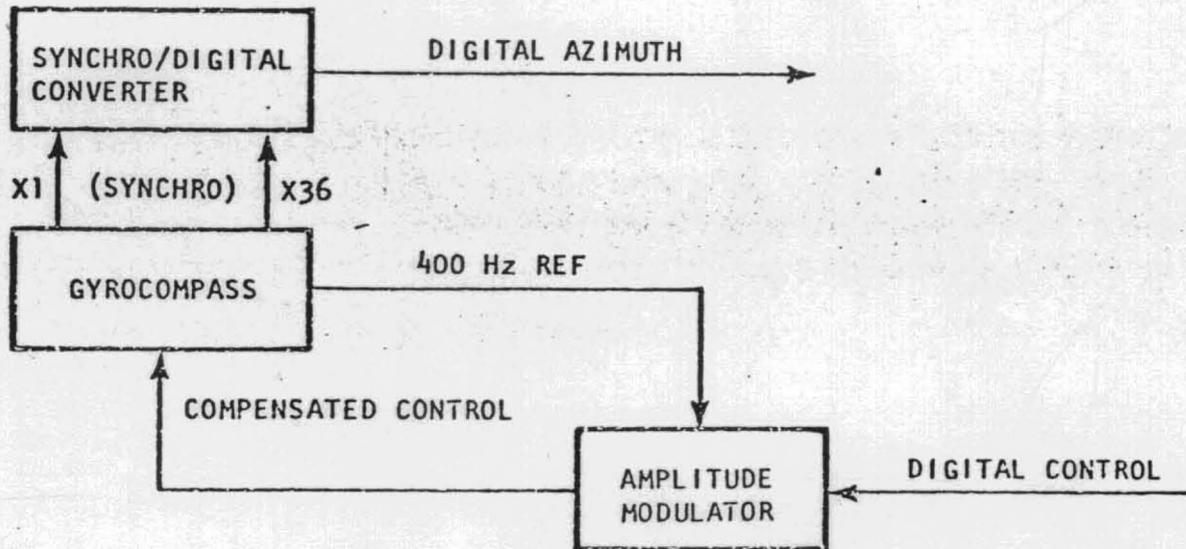


Fig. 3. Azimuth Measurement Subsystem Block Diagram.



Table I. Instrument Accuracy

Unit	Accuracy
Gyrocompass (with compensation)	0.2°
Doppler Sonar	
<100 Ftm	0.2%
100-160 Ftm	0.5%
Inclinometer	0.1°
Velocimeter	0.01%

Focal point of the GeoNav system is the TI 2540-3 (CP967(V)/UYK) digital computer; all sensor data must pass through the computer, and consequently, can be monitored by it. The GeoNav operating system software performs the satellite-fix solution and supplies velocity and azimuth measurement subsystem data to the dead reckoning system. The computer also performs position filtering, quality control of all sensors, and seismic-line and shot control. In this manner, data from all sensors are integrated to provide optimum continuous navigation, guidance, and shot control. In addition, data from the velocity measurement subsystem are used to compute the water depth for each sonar transmit/receive cycle. An extension of this technique permits using the system in bottom topography studies.

The system control panel, digital plotter, and printer/keyboard permit effectively using system outputs and system communications. A magnetic-tape unit is included for hardcopy data recording to permit post mission analysis.

The computer monitors the basic measurement processes of the various sensors. Anomalous measurements are noted and compensated for. The following paragraphs detail the techniques employed.



E. GEONAV SELF CONTAINED QUALITY CONTROL

1. Continuous Sensor Quality Control

The doppler sonar and associated parameters necessary for velocity measurement are of foremost importance. The basic sonar measurement provides a component of frequency from each of the four sonar axes (fore, aft, port, and starboard). These measurements are relative to the plane to which the sonar transducer is attached. Since this plane is normally free to roll and pitch with the vessel, vessel attitude must be measured. For similar reasons, the velocity of the vessel must be measured normal to the sonar transducer mounting plane. These sonar frequency measurements must be corrected for the velocity of sound in water. To complete the data set, the frequency of the transmitted sonar energy is required to resolve the velocity component normal to the sonar mounting plane.

In all cases, the basic measurement data are examined by the computer for reasonableness and rate of change; if found anomalous, the GeoNav operating system alerts the operator to the error condition. This is the most basic level of system quality control.

Another ancillary item of data measured by GeoNav is the time of arrival of the echoes from the four sonar beams with respect to the transmitted energy pulse. These measurements permit extension of GeoNav sonar quality control to include reasonableness of the locale of the sonar echoes. When combined with sound velocity data, these measurements extend GeoNav's usefulness as a depth-controlling device. The four sonar echoes per transmitted pulse also provide a powerful tool for bottom topography studies.

Likewise, data from the azimuth measurement subsystem are examined for reasonableness of magnitude and rate of change. The operator is informed of anomalies.



The value of this method of quality control is limited, however, since the rate of change of the variables can legitimately vary over a large range depending on the vessel's design and sea conditions. Hence, a wide range of variation must be permitted. Similarly, individual anomalous values are useful only in detecting obvious hardware malfunctions. What is required is an alternative means of verifying a sensor's performance by comparing its data with data from another source. The following paragraphs describe how GeoNav does this.

## 2. Quality Control on Satellite Position Fixes

Digital data received from the orbiting satellites are independent of the velocity and azimuth measurement subsystems comprising the dead reckoning system. Since the vessel's velocity and azimuth do affect the doppler count, fixes derived from the decoded data and associated doppler counts are not independent of the dead reckoning system. The following describes the quality control that verifies incoming satellite data, quality assurance during computation, and interpretation of results, all of which permits use of satellite fixes as independent references.

All data received from a satellite observation are preserved in the computer's memory. At the end of a satellite pass, the software performs a validation sequence verifying the quality of incoming data. Since the same data is received several times during one pass of the satellite, one validity test is to see whether repeated data bits actually appear identical in the computer. This bit majority voting is performed on like bits of like parameters over the entire range of redundant satellite messages stored in memory. In the event the bit error rate is excessive, the entire satellite observation is invalidated and the operator informed of the excessive error rate. When

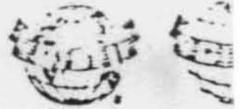


this occurs, it is highly probable that there is a noisy receiver channel requiring repair or, less likely, a bad satellite being observed.

The two frequencies transmitted by the satellite are received by GeoNav, and the doppler counts received from the two receiver channels are preserved in memory. These data are reduced to refraction counts and compared against preset limits to insure reasonable refraction data. In case the refraction counts are not reasonable, the pass is rejected and the operator alerted that the receiver should be verified for proper operation of the doppler counters. All data are validated automatically in preparation for entering the satellite solution.

The bit majority voting scheme is altered when a satellite injection is detected. In this instance, the system attempts to utilize only data received following the injection to insure that the most current data and the best prediction of the satellite's orbit is used in the position-fix solution. Data received before the injection is ignored and replaced as necessary by extrapolating back based on parameters received after the injection, using curve-fitting techniques. Similar techniques are used to interpolate for parameters which may have been missed due to poor signal quality, fade, etc., or for parameter points at the short doppler intervals selected by the software system. The choice of whether to extrapolate is based on whether the following conditions (arranged in decreasing importance) can be achieved.

- A data set of valid fixed parameters
- A minimum range requiring extrapolation of variable parameters yet still coinciding with the maximum range of good doppler counts



- Maximum range of valid variable parameters
- Most recent data

This concludes the preprocessing of satellite data. The resulting data set is free of erroneous message data and invalid doppler counts.

Further quality control of satellite fixes is handled as an editing function. Inasmuch as satellite doppler and, more especially, the refraction count are known to degrade when the satellite is near the horizon, doppler counts received below  $7.5^{\circ}$  are rejected.

Another quality control tool available to GeoNav operators is a constant which specifies the minimum number of short doppler intervals on both sides of the satellite's closest approach which the software (GNSDOP) will demand before computing a fix. This constant insures symmetry of the data (same number of short doppler counts on each side of closest approach) and is an indirect control of the minimum satellite elevation angle acceptable to the system. If, after checking the aforementioned editing criteria the system determines that there is the required symmetry but not enough data above  $7.5^{\circ}$  (at least 10 short doppler intervals), the editing software will accept just enough short doppler segments below  $7.5^{\circ}$  (maintaining symmetry) to meet minimum requirements.

Additional control permits rejection of an entire satellite observation if any portion of the data was collected while the observation angle exceeded some angle selected by the operator. This angle is typically  $70^{\circ}$  to  $75^{\circ}$  and is adjusted according to satellite alerts for the area of operation.

The preceding paragraphs describe some major elements of editing included in the GeoNav satellite software package. Together, all of these insure a high degree of quality for the data entering into a satellite-fix



solution and intermediate to the solution. To use the resulting fix effectively as a measure of the quality of the GeoNav sensor subsystem data, the quality of a given fix solution must be measured. The GeoNav system does this with a unique, proprietary algorithm that estimates statistical variances north and east for the satellite fix. These estimates are not derived from a priori statistics of satellite fixes versus elevation angle but from only the incoming satellite data set. Figure 4 is a bull's-eye of satellite-fix distribution from a set of 100 fixes received in GSI's Dallas laboratory. These data were recorded with a minimum requirement of five short doppler segments on both sides of closest approach and with a maximum elevation angle of  $75^{\circ}$ .

The foregoing discussion covers the condition in which the satellite receiver is stationary. To obtain experimental data, a week of satellite observations were recorded on magnetic tape using a GeoNav system operating with the standard operating software. The resulting satellite fixes were tabulated, and known velocity and heading errors were introduced into the dead-reckoning or navigator's estimates. The satellite fixes were then recomputed and compared with the previously tabulated data and plotted. The resulting curves are those shown in Figures 5 and 6. It is noteworthy that the major component of satellite-fix error versus velocity error is that previously published in numerous journals. However, the smaller component of fix error shows a tendency to split, depending on the direction of satellite travel with respect to the observer, e.g., clockwise or counter-clockwise. These errors are as shown for 1 knot north in Figure 5 and 1 knot east in Figure 6 at latitude  $32^{\circ}\text{N}$ . These curves would converge to zero at the equator and be in reversed orientation in the southern hemisphere. In either

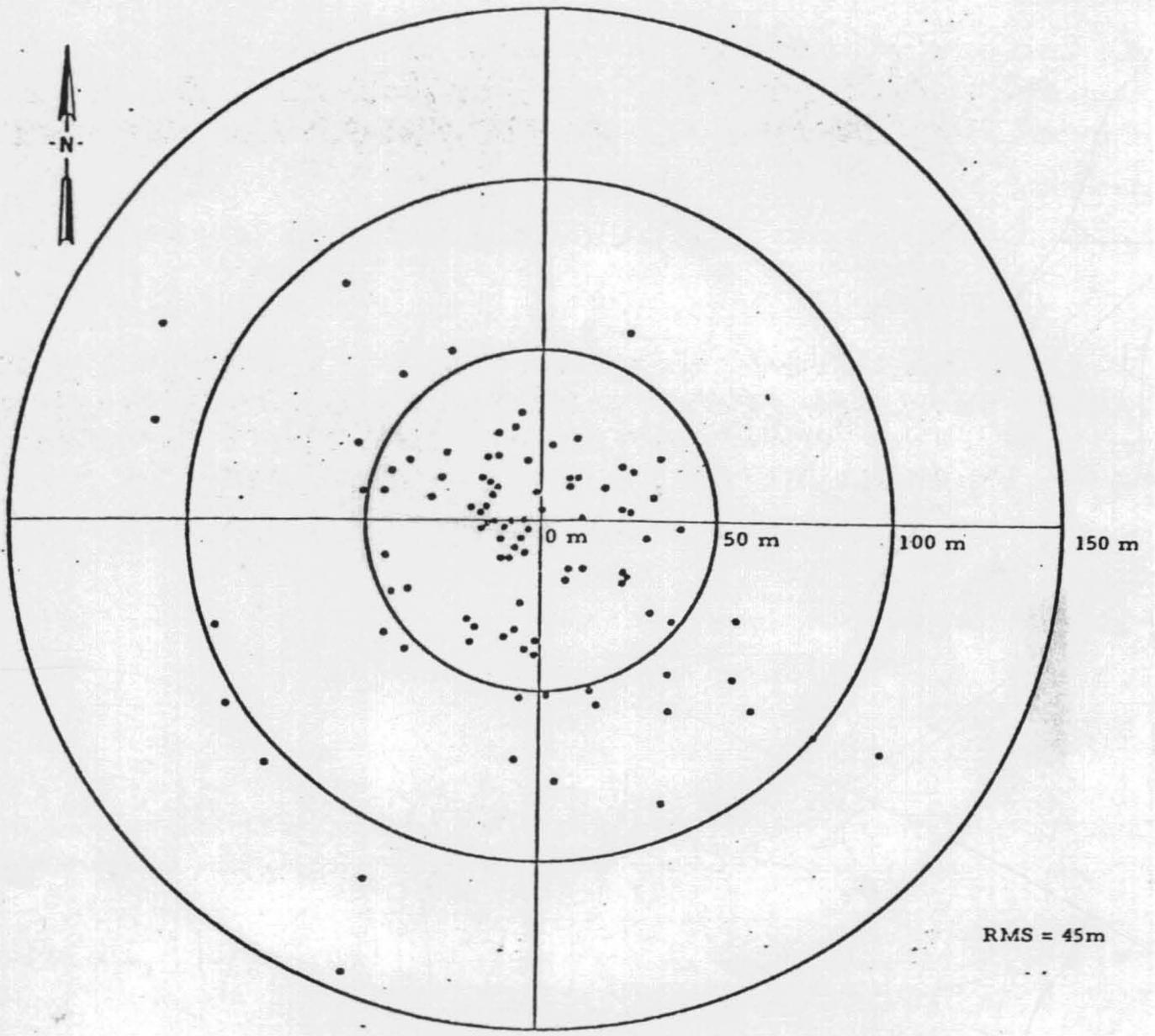
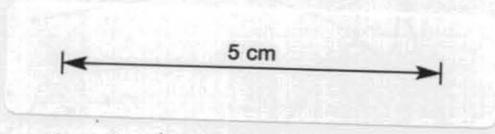


Fig. 4. Satellite-Fix Distribution.



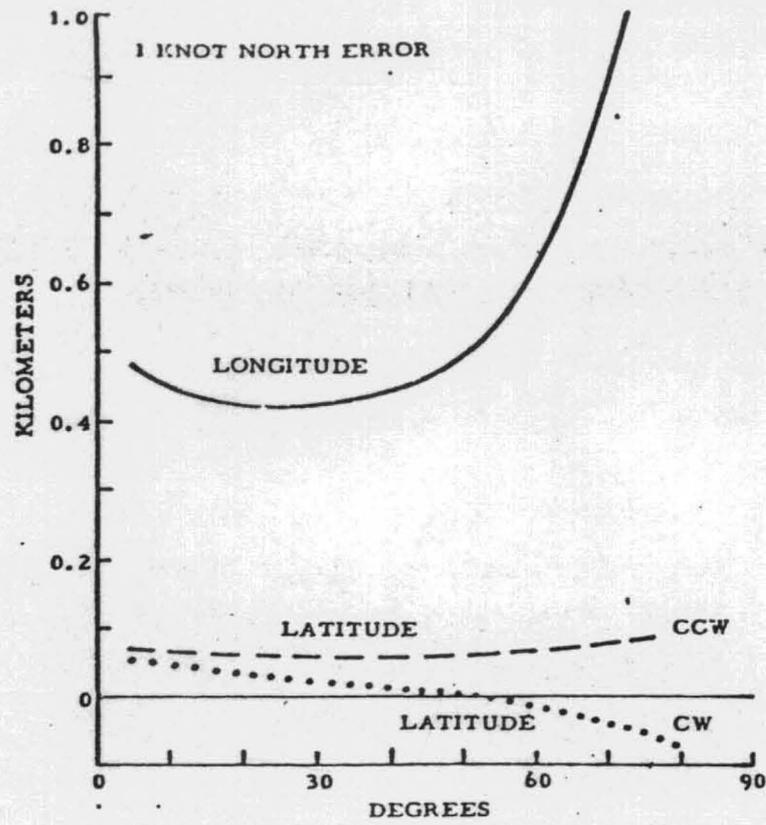


Fig. 5. Satellite Fix errors at Latitude 32°N, Due to Forced Dead Reckoning Errors.

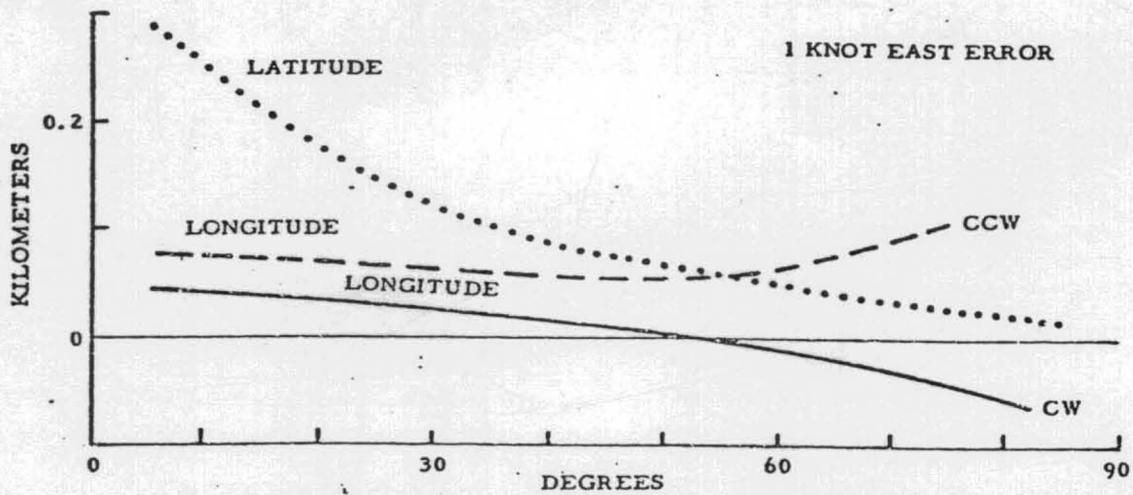
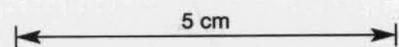


Fig. 6. Satellite Fix Errors at Latitude 32°N, Due to Forced Dead Reckoning Errors.





hemisphere, the magnitude of the error diverges as the pole is approached. In short, major satellite-fix errors are caused by dead-reckoning error, but the magnitude of these errors is such that they should be readily recognized. Hence, the problem reverts to one of identifying quality in a satellite-fix computation.

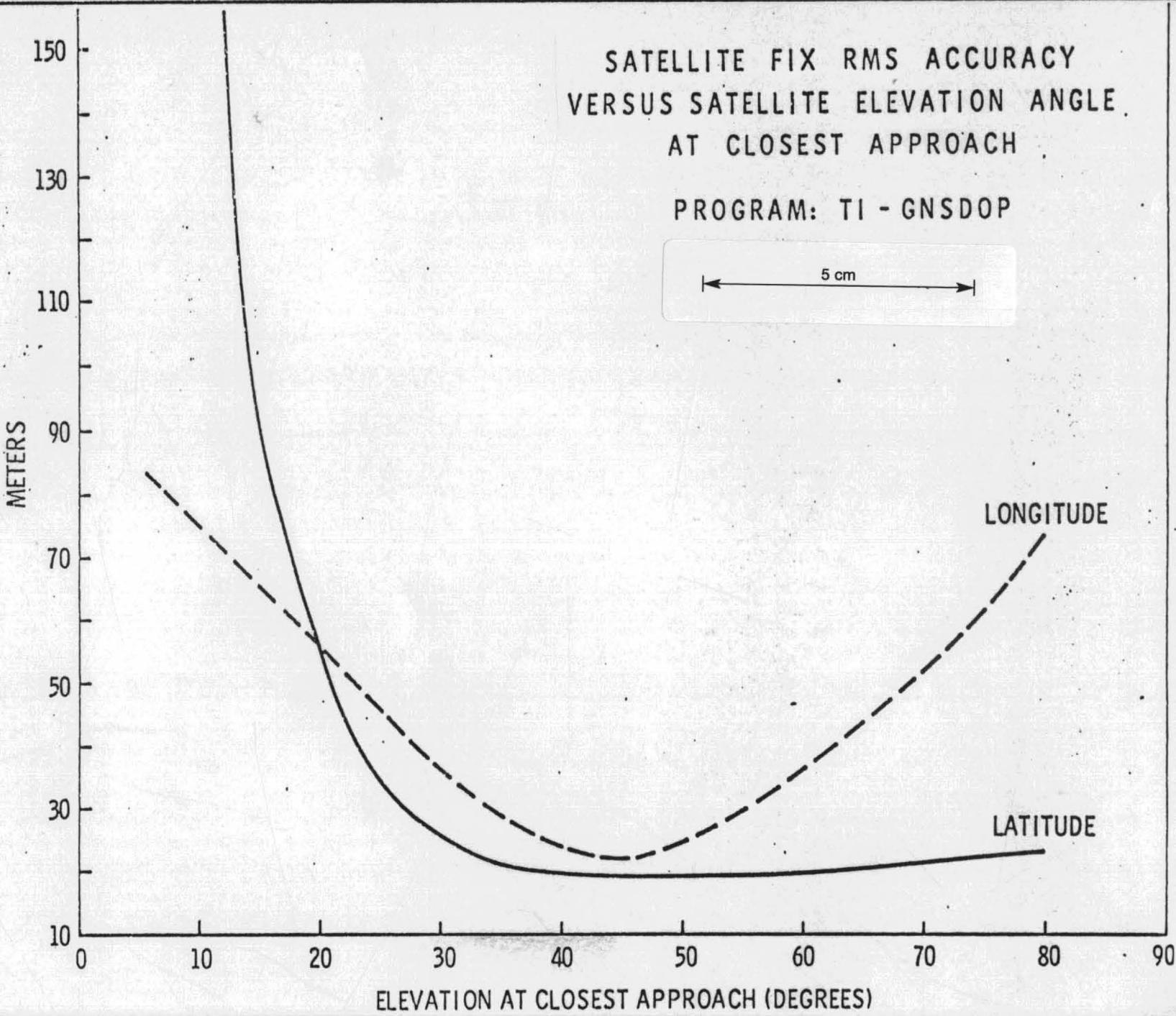
The previously described variances provided as part of the satellite-fix solution are independent of dead-reckoning error. To obtain a measure of the reliability of the variance computation, a set of satellite fixes was tabulated in the laboratory and each result and its variance estimates compared with the known antenna location. The curves shown in Figure 7 were obtained where the data were plotted as standard deviation versus satellite elevation angle. Figure 8 shows the same type of data recorded in the Far East while operating at approximately  $40^{\circ}\text{S}$  latitude. Figure 9 shows the difference between the variance estimate in the laboratory and the actual position error. This curve shows that the reliability of the variance estimate decreases at low elevation angles but that the estimate is reliable for satellites in the range  $15^{\circ}$  to  $70^{\circ}$ . Note that the error estimate tends to exceed the actual error, thereby avoiding an over-dependence on the satellite fix results. Hence, we have a reference with a reliable estimate of its accuracy which we can now use as a tool for verifying the quality of the velocity and azimuth measurement subsystems.

### 3. Velocity/Heading Quality Control

Velocity and azimuth subsystem performance can be evaluated by relating the position correction resulting from a satellite position fix to the distance between fixes. See Figure 10.

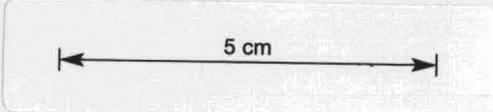
Fig. 7. Standard Deviation Versus Satellite Elevation Angle.

18



SATELLITE FIX RMS ACCURACY  
VERSUS SATELLITE ELEVATION ANGLE  
AT CLOSEST APPROACH

PROGRAM: TI - GNSDOP



LONGITUDE

LATITUDE

061057



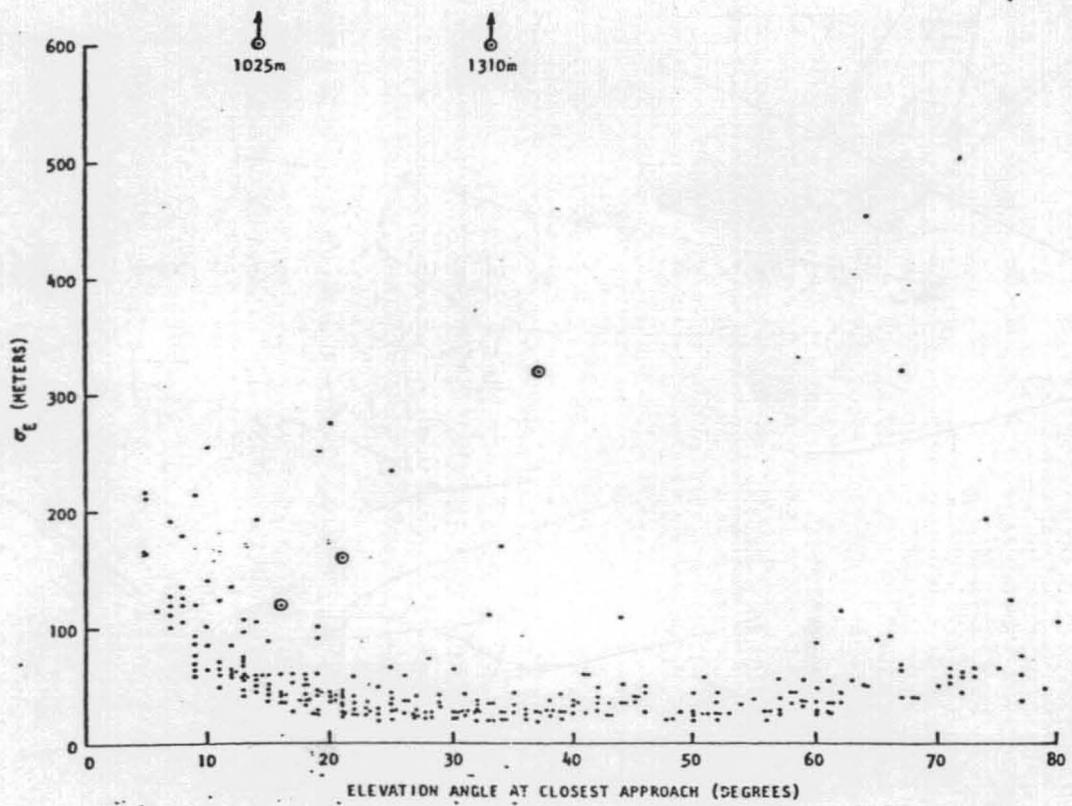
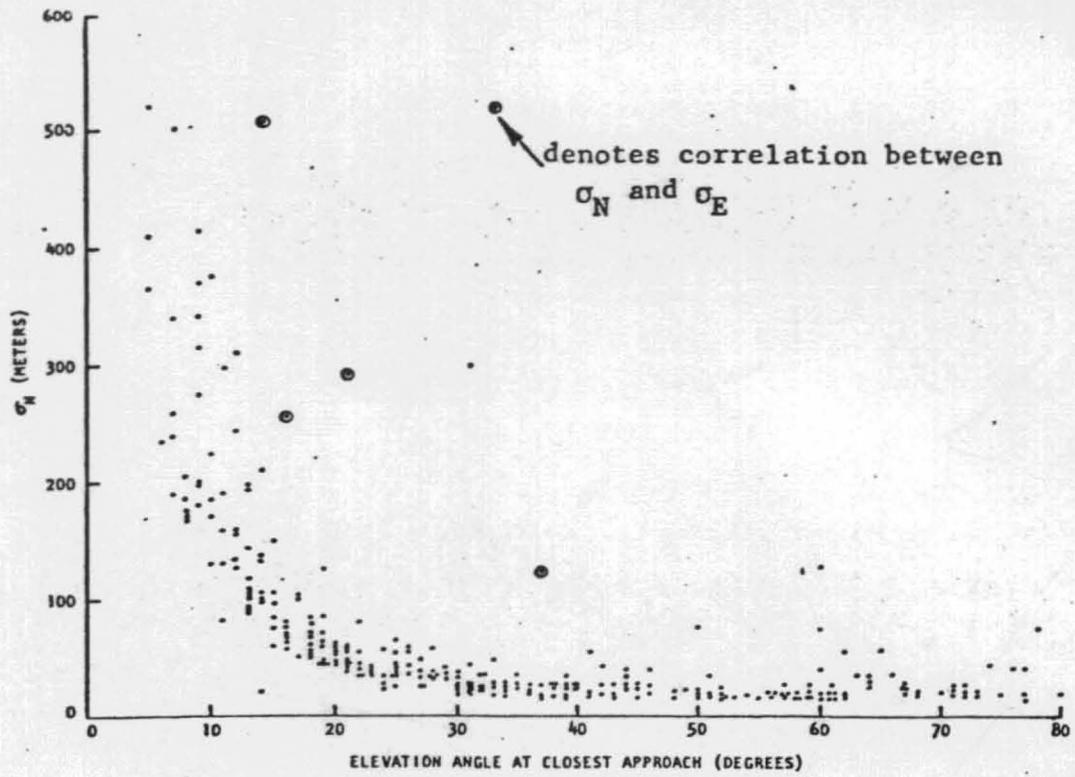
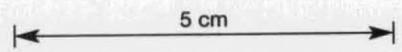


Fig. 8. Satellite-position Fix Standard-Deviation Estimate, Far East.



5 cm

CSI-708

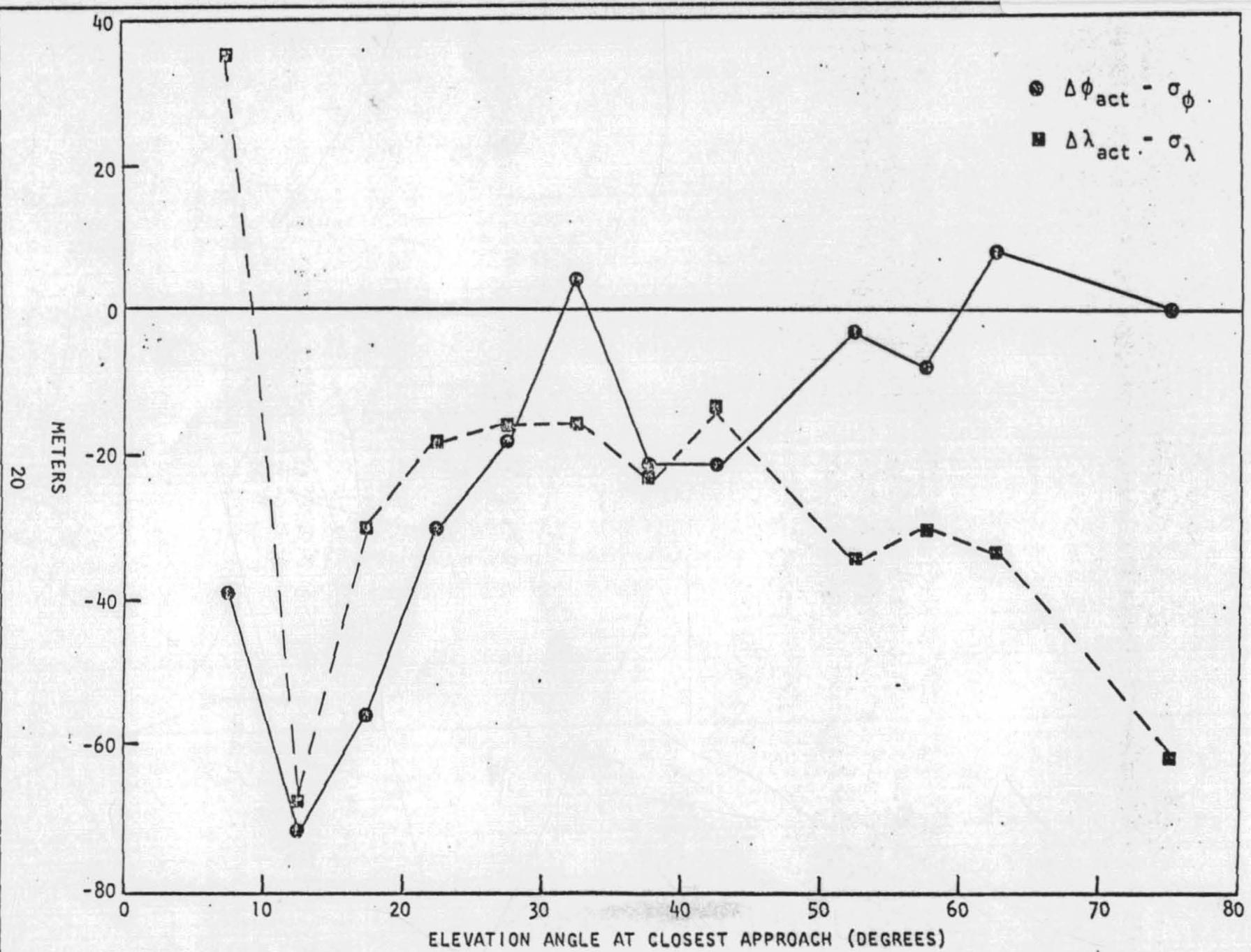


Fig. 9. Differences Between Variance Estimate In Laboratory and Actual Position Error.

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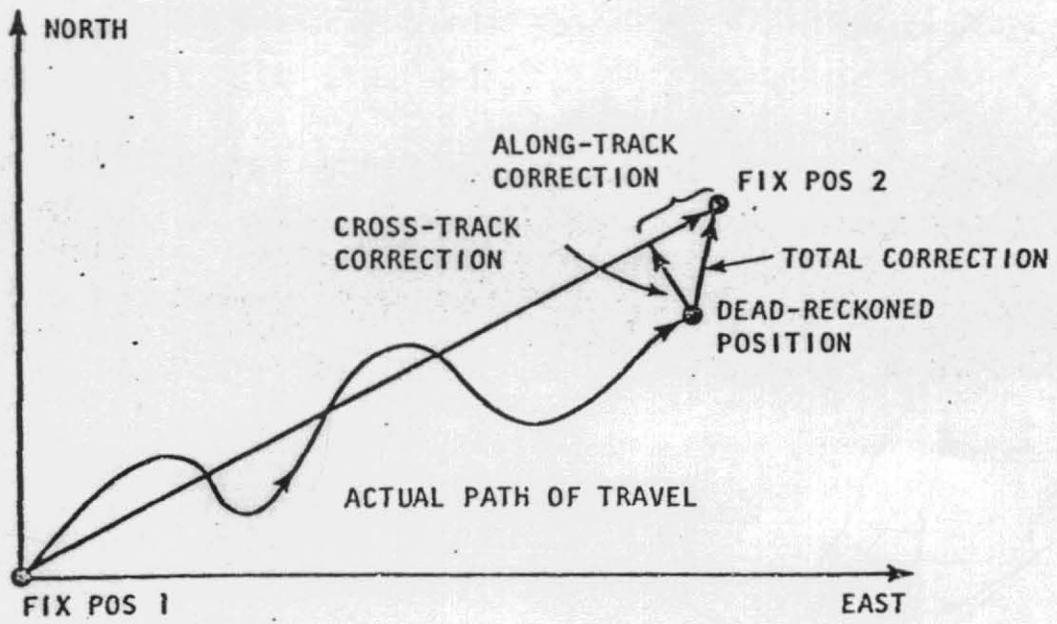


Fig. 10. Calibration Principle.



The total dead-reckoning error accumulated during the time between position fixes (fix interval) is a result of errors in along-track and cross-track velocity measurement and the error in azimuth measurement. Geometrically, this total error comprises two orthogonal error vectors. One vector is colinear with the direction of the shortest distance between each pair of position fixes. This component is basically the result of the error in the fore-aft or along-track velocity measurement. The orthogonal component combines the error in the port-starboard or cross-track velocity measurement and the error in measurement of the ship's azimuth. The heading error expresses any misalignment between the gyrocompass and the fore-aft direction as determined by the sonar beams. Thus, the error components are a direct and separate measure of average along-track and cross-track velocity errors. By prorating the vector magnitudes to the direct distance between fixes, we obtain relative or percent error factors.

Analytically, the total dead-reckoning error can be separated into total velocity error and heading error. In this, it is assumed that the relative errors in all velocity measurements are caused by the same sources, and higher-order cross-terms between velocity and heading error are ignored. The assumption is correct as far as the doppler sonar instrumentation is concerned and is plausible with respect to any environmental error sources.

Let

$K$  = relative error in velocity measurements

$\theta_e$  = absolute heading error

Then

$V_{\text{true}} = (1 - K)V_{\text{meas}}$  true velocity

$\theta_{\text{true}} = \theta_{\text{meas}} - \theta_e$  true heading



In dead reckoning, the fore-aft, port-starboard, and up-down velocities about the measured azimuth are resolved into velocity-north and velocity-east components, which are subsequently integrated over time:

$$\phi = \phi_0 + \int_T \frac{VN}{R_N(\phi)} dt, \text{ latitude}$$

$$\lambda = \lambda_0 + \int_T \frac{VE}{R_E(\phi)} dt, \text{ longitude}$$

where  $(\phi_0, \lambda_0)$  is an initial position, VN and VE are the velocity-north and -east components, and  $R_N$  and  $R_E$  are the radii of the earth's curvature in north and east directions.

Each velocity component contains an error which is a function of both the relative velocity error, K, and the heading error,  $\theta_e$ . Therefore, dead-reckoned latitude and longitude also contain errors which are (different) functions of the error parameters, K,  $\theta_e$ :

$$\phi_e = f(K, \theta_e)$$

$$\lambda_e = g(K, \theta_e)$$

A position fix, if sufficiently accurate, immediately yields the position error  $(\phi_e, \lambda_e)$ . By neglecting second- and higher-order cross-terms as mentioned, the error parameters or "calibration factors" K and  $\theta_e$  can be found directly.

Two requirements must be met for satisfactory calibration:

- The fixes at either end of the dead-reckoning interval must be sufficiently accurate
- The direct distance between fixes must be sufficiently large



For example, for a distance of 10 km between lines, a 100-m radial fix error causes an error of 1% in velocity calibration or  $0.01 \text{ rad} = 0.57^\circ$  in heading calibration.

The calibration method is independent of the actual travel path between fixes because deterministic errors compensate when traveling in opposite directions. In this respect, closed-loop navigation never reflects deterministic error, and the error at loop closure results from accumulated random errors. Thus, separate measurement of deterministic velocity and heading errors derived from position fixes of known accuracy have been established. At each satellite fix GeoNav prints out the estimated fix accuracy, the distance between fixes, and the calibration factors, plus all other necessary position update information, therefore providing continuous performance evaluation.

This velocity/heading calibration principle has been exercised extensively: first, in testing doppler sonar and gyrocompass instrument errors in the Gulf of Mexico in March 1970 by sailing between oil rigs, where the accurately known positions were substituted for satellite fixes; second, in the same period with a simulated seismic survey performed against electronic positioning; and third, by continuous data collection from actual worldwide field operations. Table II shows that the calibration factors obtained from the test run between known, fixed positions agree with the instrument errors specified.



Table II. Velocity-Heading Error Statistics

Distance Traveled (km)	Heading Error (m)	Velocity Error (m)	Total Error RMS (m)
24.1 (E→W)	-4.2	24	24
24.1 (W→E)	≈0.0	0	0
24.1 (E→W)	16.8	-24	29
24.1 (W→E)	29.4	0	29
24.1 (E→W)	4.2	-24	24
24.1 (W→E)	16.8	+48	51
44.5 (NE→SW)	96.0	-89	131
44.5 (SW→NE)	8.0	0	8



DATA PROCESSING  
FINAL REPORT  
BASS STRAIT  
HB77A-SEISMIC SURVEY

for

HEMATITE PETROLEUM PTY LTD  
GPO BOX 86A  
MELBOURNE. VIC 3001

by

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JULY 1978

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## SECTION I

### INTRODUCTION

A Seismic Reflection Survey was conducted by the M.V. "Eugene McDermott II" in the Bass Basin between 6th December and 14th December 1977.

Approximately 650 kms of reflection coverage were shot utilising a 96 trace, 2400 meter streamer under continuous tow. The recording system consisted of two sets of Texas Instruments DFS IV's. Data was recorded on half-inch tape, 1600 B.P.I. SEG B, with the odd and even groups being recorded separately.

Part of the survey was recorded to 5 seconds with 2 millisecond sampling, and part to a record length of 5 seconds every 4 milliseconds. A tuned array of airguns (23.76 litres) was the acoustic energy source.

Field operations report is under a separate cover.

Data processing was carried out in GSI's Sydney Processing Centre.

SECTION IIPRODUCTION PROCESSING

The data was recorded in the field as follows -

- a) Lines HB77A - 300 through 321:  
5 seconds/2 ms, subsequently referred to as  
PART A.
- b) Lines HB77A - 330 through 352, 354, 356, 358,  
360, 361:  
5 seconds/4 ms, subsequently referred to as  
PART B.

After basic experimental work was carried out to determine suitable deconvolution parameters, the processing sequences used were -

PART APre-Processing

1. True Amplitude Recovery
2. Correction for Air Gun delay
3. Resample 2 ms to 4 ms
4. Horizontal Mix 2:1
5. Pre-deconvolution ramp
6. Deconvolution
7. Common Depth Point (CDP) Gather
8. Annotation

Velocity Analysis

Static Corrections Applied

Continuous - centred every 1.125 kms.

Post Processing

1. Trace Editing
2. Normal Moveout Corrections
3. Static Corrections
4. Common Depth Point Stack
5. Deconvolution
6. Time Variant Digital Filtering
7. Plotter Displays

PART BPre-Processing

1. True Amplitude Recovery
2. Correction for Air Gun Delay
3. Horizontal Mix 2:1
4. Pre-deconvolution ramp
5. Deconvolution
6. Common Depth Point (CDP) Gather
7. Annotation
8. Demultiple

Velocity Analysis

Static Corrections Applied

Discrete over 9 depth points centred every 1.2 km.

Post-Processing

1. Trace Editing
2. Normal Moveout Corrections
3. Static Corrections
4. Common Depth Point Stack
5. Deconvolution
6. Time Variant Digital Filter
7. Plotter Displays



### SECTION III

#### Processing Details

Unless otherwise specified, parameters described in this section were applied to both PARTS A & B of the data.

#### Pre-Processing Module:

##### True Amplitude Recovery (TAR)

The TAR process is applied to digital field records in order to produce output records on which relative amplitudes of reflections on each trace are approximately true and traces evenly modulated. This consists of removing the gain imposed on the field record by the DFS IV Binary Gain Control System and correcting for inelastic attenuation and spherical divergence losses.

These may be expressed as -

$$S.D. = 20 \log \bar{V} T$$

Where S.D. = relative spherical divergence correction.

$\bar{V}$  is normally set at 1000 ft/sec., since the correction is quite insensitive to velocity variations.

T is the reflection travel time.

$$I.A. = B + \alpha T$$

Where I.A. = exponential gain rate which corrects the attenuation of reflection energy, remaining after the spherical divergence correction is applied .

B = gain factor computed by the program to give adequate modulation on the record

$\alpha$  = exponential gain rate

T = reflection time



The exponential gain rate  $\alpha$ , was 5.0 db/sec. applied from 0 to 3.5 seconds.

#### Correction for Airgun Delay

The recording system has an inherent delay caused by the TIGER\* system. This delay (52 milliseconds) was corrected for at this stage of the processing, effectively decreasing reflection times compared to the field recording.

#### Resample (PART A only)

The data was resampled from 2 milliseconds to 4 milliseconds. If the processing sample period is greater than the input sample period the appropriate antialias filter is applied to the data prior to time decimation of the trace.

Note that all data was preprocessed to a length of 4 seconds.

#### Horizontal Mix

The data had adjacent groups mixed i.e. 96 with 95, 94 with 93, ... 2 with 1. This output effectively reduces the data to a 48 trace, 48 fold system.

#### Pre-deconvolution Ramp

This was the application of a scaling function with one ramp to each trace preceding deconvolution. The ramp function was used to zero and attenuate first-arrival waves and thereby prevented amplification of these waves when deconvolution was applied to the traces.

#### Deconvolution

Deconvolution is accomplished by the application of one or more filters designed from data trace auto-correlation functions.

The type of deconvolution used was 2nd zero crossing.

\*Trademark of Texas Instruments



This was a single operator, non-whitening deconvolution designed from and applied to each trace over one gate. This has a gap equal to the second zero crossing on the auto-correlation function. The deconvolution parameters used on a particular line were a function of water depth, offset, and consequent available design gate.

#### Common Depth Point (CDP) Gather

All data output from the pre-processing stage is in a CDP format. Effectively, this means that each group of N traces (where N=fold) on these output records is common to the same depth point. Within one depth point however, each trace represents a different offset location.

#### Annotation

Auxiliary information is stored with the CDP records for use in further processing. This consists of water depth, offset, shotpoint location, receiver location, shot depth, cable depth, and multiplexor static for each trace in the gather.

The multiplexor static is a trace shift which compensates for field differences in the time of recording each individual trace.

#### Demultiple (PART B only)

After comparisons on line HB77A-342 it was decided that application of Demultiple would benefit definition of certain geological objectives.

Demultiple is a process carried out in the frequency domain, designed to use a multi-channel filtering technique to attenuate severe pegleg or interbed multiples.



Implied in the process is definition of a multiple velocity function. To determine this VELPS, (discrete, power-based pick type of velocity analysis along with stacked and single fold data displays), were run on line HB77A-342. Following the application of Demultiple, (CDP data is recycled through pre-processing to achieve this), VELPS were rerun with Demultiple inputs to check results. Finally stack comparisons were made on HB77A-342 for a more comprehensive appraisal.

To further check the lateral validity of this multiple function, 8 before and after Demultiple VELPS were examined, these being representatively located on PART B data. They were -

HB77A-331	SP. 16
-332	SP. 16, 165, 316
-334	SP. 416
-352	SP. 316
-361	SP. 16, 265



Velocity Analysis:

As part of any velocity analysis routine, static corrections to compensate for shot and cable depth, and multiplexor delays are applied.

Continuous (Supascat) - PART A only.

Every depth point is utilised in this process. The program reads every CDP gather record and performs the following :

- o Time variant filtering
- o Equalisation
- o Moveout and dip-scan building
- o Interpretation of moveout/dip scans to detect valid events with time, amplitude, moveout and dip information.
- o Output to magnetic tape the Pick/Event files for each space/time gate.

The initial phase was performed using spatial gates of 5 depth points. The next step consolidated consecutive pick/event files, accomplished via event correlation based on time, moveout and dip. A length attribute was calculated based on the smash rate and number of events that were correlated to produce the pick in the consolidated pick file . . Outputs of consolidated pick files contain attributes of time, moveout, dip and length. To produce the consolidated file, 9 Pick/Event files were smashed, giving an effective spatial coverage of 45 depth points per Supascat output. This output was displayed in scattergram form only, with no associated seismic data display.



To assist in the interpretations of the scattergrams, 10 VELPS from miscellaneous locations on PART A data were produced.

These were HB77A-304	SP. 1,
-307	SP. 1,
-310	SP. 1,
-313(2)	SP. 1, 547
-314(2)	SP. 1, 547
-315(2)	SP. 1, 547
-316	SP. 1.

Discrete(VELSCAN) - PART B only

GSI's VELSCAN Velocity Module is a discrete Velocity Analysis mode making use of advanced picking logic to generate events as functions of time, amplitude, moveout and dip. Analyses were centred over 9 consecutive depth points, every 48 depth points.

The event picking proceeds in the following manner :

- o NMO corrections corresponding to a series of moveout functions are applied to a set of depth point traces. For each moveout function, the NMO-corrected traces are stacked. The resulting traces consist of amplitudes as functions of time and moveout.
- o Identical operations are applied to adjacent depth points, adding the dimension of space.
- o Dip is applied and, for each value of dip, the traces are stacked across depth points. The result is a set of amplitudes as functions of time, moveout and dip.
- o An event is located by searching for an amplitude extremum in the time, moveout and dip domains. An extremum may be either a maximum or a minimum; that is both peaks and troughs are picked. The event attributes of time, amplitude, moveout, and dip are assigned to the centre depth point.



Prior to display, the events may be subjected to various sorting and classification. Display is in scattergram form.

As aids to interpretation, the VELSCAN module also generates and displays gathers, stacks and velocity functions. The specifications for this capability are independent of the specifications for event picking. The options used for each analysis were:

- o Number of velocity functions to apply -  
7 variable with time.
- o Display of gather traces.  
Display of centre depth point gather with application of each velocity function.

Also displayed are the stacks for all depth points for each velocity function, the centre depth point traces without NMO, and the velocity functions.

All velocity analyses were interpreted by GSI, with subsequent approval or modification by Hematite.

Non-consolidated velocity tapes generated in PART A were purchased by Hematite.



### Post Processing Module:

#### Trace Editing

At this stage of processing those traces were from the CDP gather records. The source of this edit was a preliminary display of stacked data which initiated investigation into spiked and noisy data.

#### Normal Moveout Correction

All velocity functions were submitted as 'water surface' functions. A linear interpolation was performed between the velocity functions which were applied at the points indicated on the final sections.

#### Static Corrections

Static corrections applied at this stage were -

- 1) Multiplexor statics annotated in the headers of the CDP records as described in Pre-Processing.
- 2) Shot and seismometer corrections -  
A static correction to compensate for the depth of airgun array and streamer below sea level, generally in the order of 12 milliseconds. This is a positive correction which effectively increases reflection time.

#### Common Depth Point Stack

Common Depth Point Stack was performed with a unity scaler being utilised. Thus scaling response can be expressed equal to -

$$\frac{\sum N}{T_c}$$



where  $N$  = sum of amplitudes of traces  
contributing to the stack

$T_c$  = number of traces contributing to  
the stack.

First break suppression ramps were derived from the  
CDP records as seen on the VELP velocity analyses  
displays.

The stacked records were output on magnetic tapes  
which were purchased by Hematite.

#### Deconvolution

Deconvolution (whitening) was performed on all the  
data after CDP stack.

#### Time Variant Digital Filtering

Filter analyses were carried out on stacked/deconvolved  
data. Locations of these analyses were -

HB77A-301	SP's	238-287
-307		267-317
-321		267-317
-333		188-238
-342		548-598

Interpretation of these yielded the following filters -

<u>PART A</u>	0	msec	25-80	Hz
	1000		15-60	
	2000		10-60	
	2500		7-50	
	3000		7-40	
	4000		7-30	



<u>PART B</u>	0	msec	15-60 Hz
	500		15-57
	1500		10-50
	2500		8-37
	3000		8-30
	4000		8-30

#### Plotter Displays

Initial displays of stacked data were on Gould paper. However these were replaced by a film display at 32 traces per inch, 3.75 inches per second, in the variable area/wiggle trace mode with 20% bias, and normal polarity (Positive values black).

Further, PART A data was replotted on film at an expanded scale of 20 traces per inch and 7.5 inches per second.

All velocity analyses, filter analyses, and stack comparisons (HB77A-342) were plotted on Gould paper only.

Side panels on final sections gives ready access to pertinent field and processing information.

061080



Respectfully submitted,  
GEOPHYSICAL SERVICE INTERNATIONAL

*K. Paine*

.....  
K. Paine

*I. McMahon*

.....  
I. McMahon.



APPENDIX A  
HEMATITE PURCHASE TAPE LOG INDEX

1. Velocity Files - Cormorant.

<u>LINE</u>	<u>TAPE NUMBER</u>
HB77A-300	37
301	327/328
302	37
303	327
304	209
305	331/333
306	339/341
307	330/333
308	333
309	341
310	339
311	325/334
312	102/334
313	343
314	343/345/346
315	348
316	347
317	201
318	201
319	328
320	331
321	102



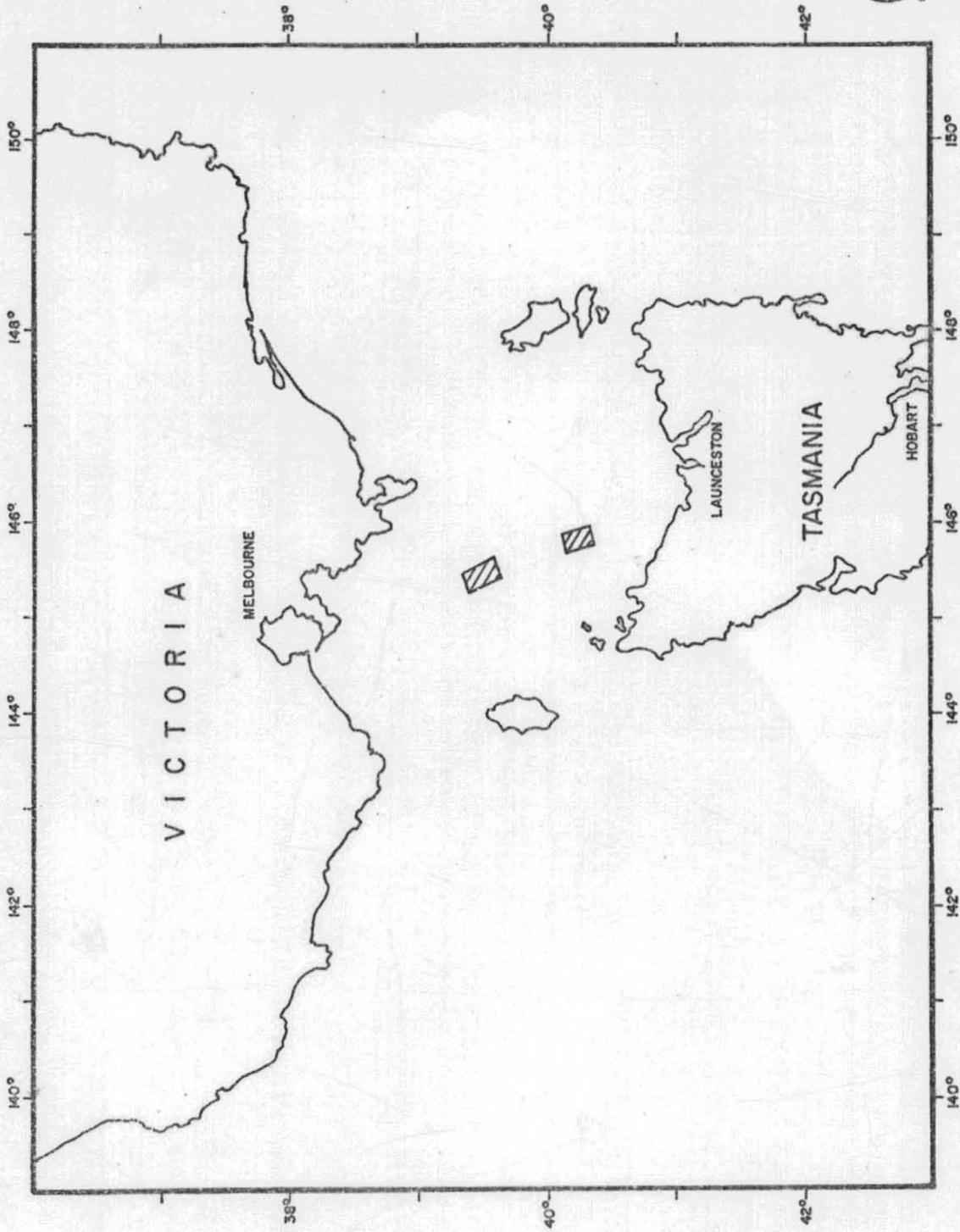
## 2. Stack Tapes - Cormorant.

<u>LINE</u>	<u>TAPE NUMBERS</u>
HB77A-300	447
301	447
302	447
303	447
304	447
305	447
306	447
307	447
308	447
309	447
310	447
311	447
312	447
313	302
314	302
315	302
316	302
317	302
318	302
319	302
320	303
321	302



## 3. Stack Tapes - Pelican.

<u>LINE</u>	<u>TAPE NUMBERS</u>
HB77A-330	455
331	455
332	289
333	455
334	455
335	455
336	455
337	455
338	289
339	289
340	289
341	455
342	289
343	289
344	289
345	289
346	289
347	289
348	289
349	289
350	289
351	289
352	289
354	455
356	289
358	455
360	455
361	455



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GEOPHYSICAL SERVICE INTERNATIONAL PARTY 931



## PRODUCTION PROCESSING FLOW

