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# FORACS

## SENSOR ACCURACY CHECK

FORACS IV REPORT NO. 129 (U)

USS WALDRON (DD-699)

3 October 1972

"DTIC USERS ONLY"

### Fleet Operational Readiness Accuracy

Check Site No. 4

Cape Cod, Massachusetts

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USS WALDRON (DD-699)

3 October 1972

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1. This report gives the results of analysis performed on the ship-board sensor alignment accuracy data taken by the Fleet Operational Readiness Accuracy Check Site No. IV, Cape Cod, Massachusetts. The dockside phase was conducted on 2 October 1972 at the Boston Naval Shipyard, Boston, Massachusetts. The on-range tests were conducted on 3 October 1972 at Provincetown, Massachusetts.

*G. R. Kirwin*  
G. R. KIRWIN  
By direction

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USS WALDRON (DD-699)

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Accuracy standards relating to shipboard sensors are given in NAVORD OD 41774 dated 1 October 1971. Available standards are shown in parentheses. Those parameters marked with an "→" do not meet standards. Refer to Appendix A for definitions of terms and abbreviations.

(C) 1.0 GYROCOMPASS MARK 11 MOD 6 (S/N 116378)

Dockside: → SE: +1.27° (±0.5°)

On-Range: PVV 0.73° (1.5°)  
MESE: +0.73° (±1.0°)(C) 2.0 SONAR AN/SQS-44V (S/N 292)

(Standards quoted are for Sonar AN/SQS-44V with Field Change 4 installed.)

ConsoleBearing: PVV: 1.84° (2.5°)  
→ MP: +2.40° (±1.0°)  
ASD: 0.56° (0.8°)Range Error vs Bearing: PVV: 540 yds (NA - See Text)  
MP: -198 yds (NA - See Text)  
ASD: 94 yds (NA - See Text)

## Range:

2,500 Yard Scale: → MME: -205 yds (±50 yds)  
→ ASD: 20 yds (16 yds)5,000 Yard Scale: → MME: -155 yds (±100 yds)  
→ ASD: 33 yds (26 yds)10,000 Yard Scale: MME: -179 yds (±200 yds)  
ASD: 40 yds (46 yds)Data ConverterBearing: PVV: 2.00° (2.5°)  
→ MP: 2.53° (±1.0°)  
ASD: 0.68° (0.8°)(C) 3.0 GUN FIRE CONTROL SYSTEM MARK3.1 Director Mark 37 Mod 49Bearing: PVV: 5 min (NA - See Text)  
MP: -7 min (NA - See Text)  
ASD: 4 min (NA - See Text)UNCLASSIFIED  
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Range:

0 - 20,000 yds: MME: -15 yds ( $\pm 24$  yds)  
 ASD: 6 yds ( 6 yds)

3.2 Computer Mark 1A Mod 13 (S/N 1264)

Bearing: PVV: 6 min (NA - See Text)  
 MP: -9 min (NA - See Text)  
 ASD: 5 min (NA - See Text)

Range:

0 - 20,000 yds: MME: +38 yds ( $\pm 24$  yds)  
 ASD: 6 yds ( 6 yds)

(C) 4.0 SURFACE SEARCH RADAR AN/SPS-10 (S/N 460)4.1 Range-Azimuth Indicator AN/SPA-25 (S/N 153) - Master CIC

Bearing: PVV:  $0.6^\circ$  (  $1.4^\circ$  )  
 MP:  $+0.5^\circ$  ( $\pm 0.8^\circ$ )  
 ASD:  $0.2^\circ$  (  $0.5^\circ$  )

Full Scale Range:

10,000 yds: MME: +73 yds ( $\pm 100$  yds)  
 ASD: 21 yds ( 40 yds)

20,000 yds: MME: +92 yds ( $\pm 200$  yds)  
 ASD: 30 yds ( 80 yds)

4.2 Range-Azimuth Indicator AN/SPA-4B (S/N 346) - Pilot House

Bearing: PVV:  $1.3^\circ$  (  $2.0^\circ$  )  
 MP:  $+0.7^\circ$  ( $\pm 0.8^\circ$ )  
 ASD:  $0.5^\circ$  (  $0.6^\circ$  )

Full Scale Range:

10,000 yds: MME: +93 yds ( $\pm 100$  yds)  
 → ASD: 43 yds ( 40 yds)

20,000 yds: MME: +1750 yds ( $\pm 200$  yds)  
 → ASD: 60 yds ( 65 yds)

(C) 5.0 PELORUSES - ALIDADE MARK 2 MOD 1 (S/N 5241)Port Pelorus

Normalized True Bearing: PVV:  $0.16^\circ$  (  $0.40^\circ$  )  
 MP:  $-0.01^\circ$  ( $+0.30^\circ$ )  
 ASD:  $0.13^\circ$  (  $0.25^\circ$  )

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Starboard Pelorus

Normalized True Bearing:

PVV:  $0.17^\circ$  (  $0.40^\circ$  )  
MP:  $0.04^\circ$  ( $\pm 0.30^\circ$ )  
ASD:  $0.17^\circ$  (  $0.25^\circ$  )

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INTRODUCTION

- (U) This report gives the results of analyses performed on the shipboard sensor accuracy data recorded at Fleet Operational Readiness Accuracy Check Site No. IV, Cape Cod, Massachusetts. The dockside survey was conducted on 2 October 1972 at the Boston Naval Shipyard, Boston, Massachusetts. The gyrocompass settled error test was conducted on 2 October 1972 and the on-range test on 3 October 1972.
- (U) A summary is included in this report which presents equipment error characteristics and available accuracy standards. Sections 1.0 through 5.0 present detailed information on the equipments tested. The text of these sections includes the type of data recorded (range, relative bearing, etc.), targets used, and other data pertinent to the testing. The results of analyses performed on the recorded data are displayed by error plots. Each plot also includes calculated error characteristics and available accuracy standards.
- (U) The following sign convention is used in this report:

Positive (+) Error

Indicates equipment reading is greater than the actual value.

Negative (-) Error

Indicates equipment reading is less than the actual value.

As an example, consider an actual bearing and range of 011 degrees at 5200 yards. If the operator obtained a reading of 012 degrees, the bearing error would be +1 degree. Similarly, an operator reading of 5000 yards would indicate a range error of -200 yards.

- (U) Definitions of terms and abbreviations used in this report are included in Appendix A. A description of the overall FORACS testing procedures is included in the ship's copy of this report as Appendix B.

Dockside Test

- (U) During the dockside portion of the FORACS testing, engineering transits were set up on the bow and DASH deck of the USS WALDRON and cross leveled athwartships with respect to the roller path of the MK 37 Gun Fire Control Director. The forward transit was aligned to the ship's centerline as established by the center of rotation of the Director, measurements athwartships, and angular measurements to symmetrical superstructure. By a reciprocal bearing technique, using a shore-based theodolite, the after transit was aligned to this centerline and subsequently utilized to perform the gyrocompass settled error check. Punch marks were placed on the DASH deck, bulkhead, and deck gutter in order that the location, cross level, and alignment of the after transit could be accurately reclaimed for the on-range test.

On-Range Test

- (U) Operating conditions during the test were satisfactory. Speed over the

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test path varied from 2 to 3 knots and speeds up to 10 knots were incurred while repositioning the ship for the next run.

- (U) The GFCS system had a casualty; therefore, limited data were obtained. The ESM was inoperative; therefore, no data were obtained.

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1.0 GYROCOMPASS MARK 11 MOD 6 (S/N 116378)

- (U) Ship's heading error was determined from data recorded during the dockside and on-range phases of the FORACS testing. The binnacle settings used during the tests are as follows:

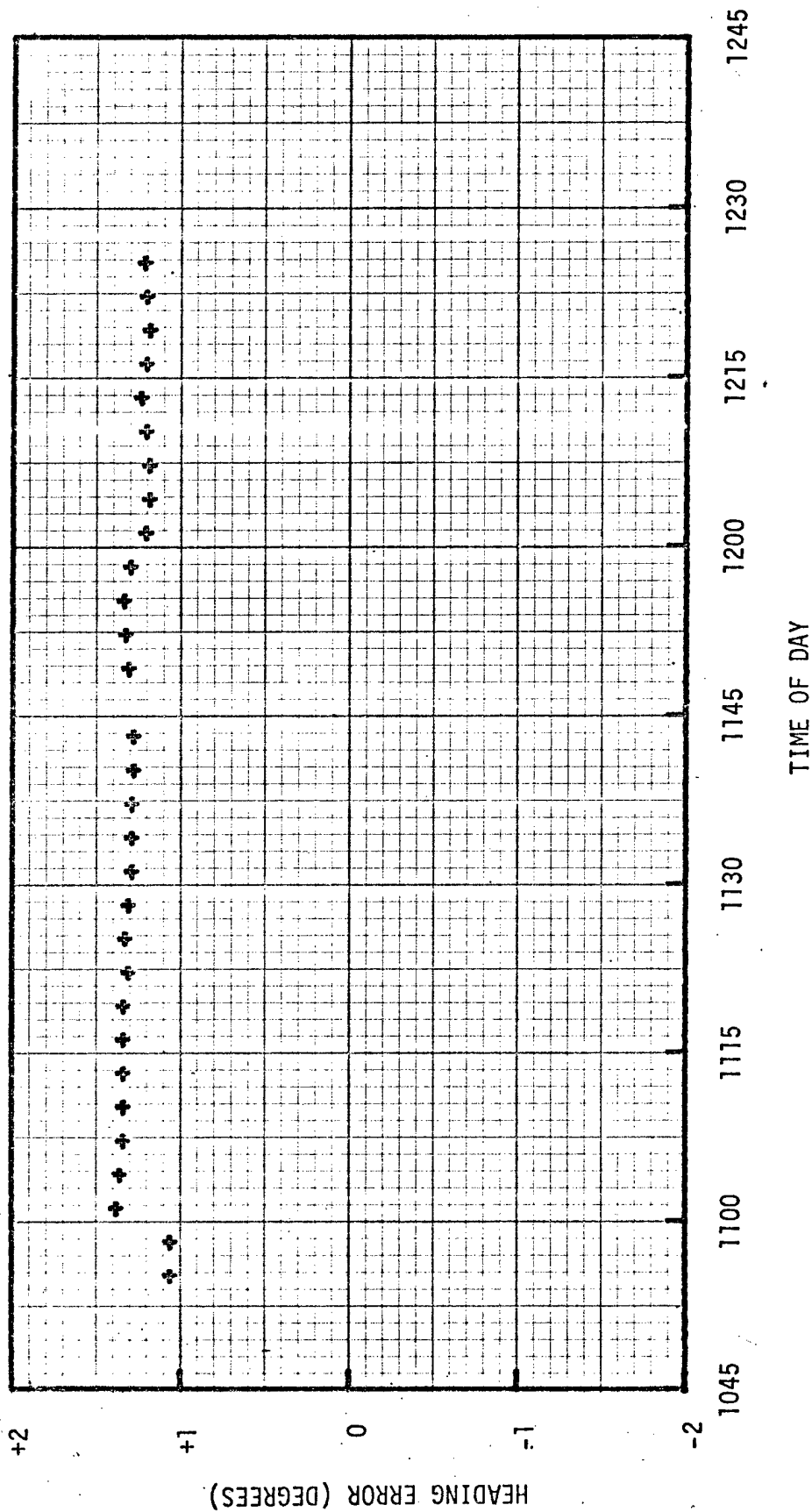
<u>Control</u>	<u>Dockside</u>	<u>On-Range</u>
Speed and Latitude Corrector	0 KNOTS	3 KNOTS AT 42°N.LAT
Auxiliary Latitude Corrector	42°N.LAT	42°N.LAT
Mercury Ballistics	31°N.LAT	31°N.LAT

- (U) Figures 1.0-a and 1.0-b are plots of the ship's heading error versus time of day. The gyrocompass had been running continuously on ship's power for approximately 8 hours prior to the dockside gyrocompass settled error check.
- (U) The 31° N. LAT adjustment on the Mercury Ballistics was discovered just prior to the FORACS test. To make the correction to 42°N.LAT would have delayed the whole FORACS operation by four hours and cause ship departure delays. For these reasons the election was made to forego any further adjustments to the Ballistics

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SETTLED ERROR TEST  
GYROCOMPASS MARK 11 MOD 6

USS WALDRON (DD-699)  
2 October 1972



SE: +1.27° (Std ±0.5°)

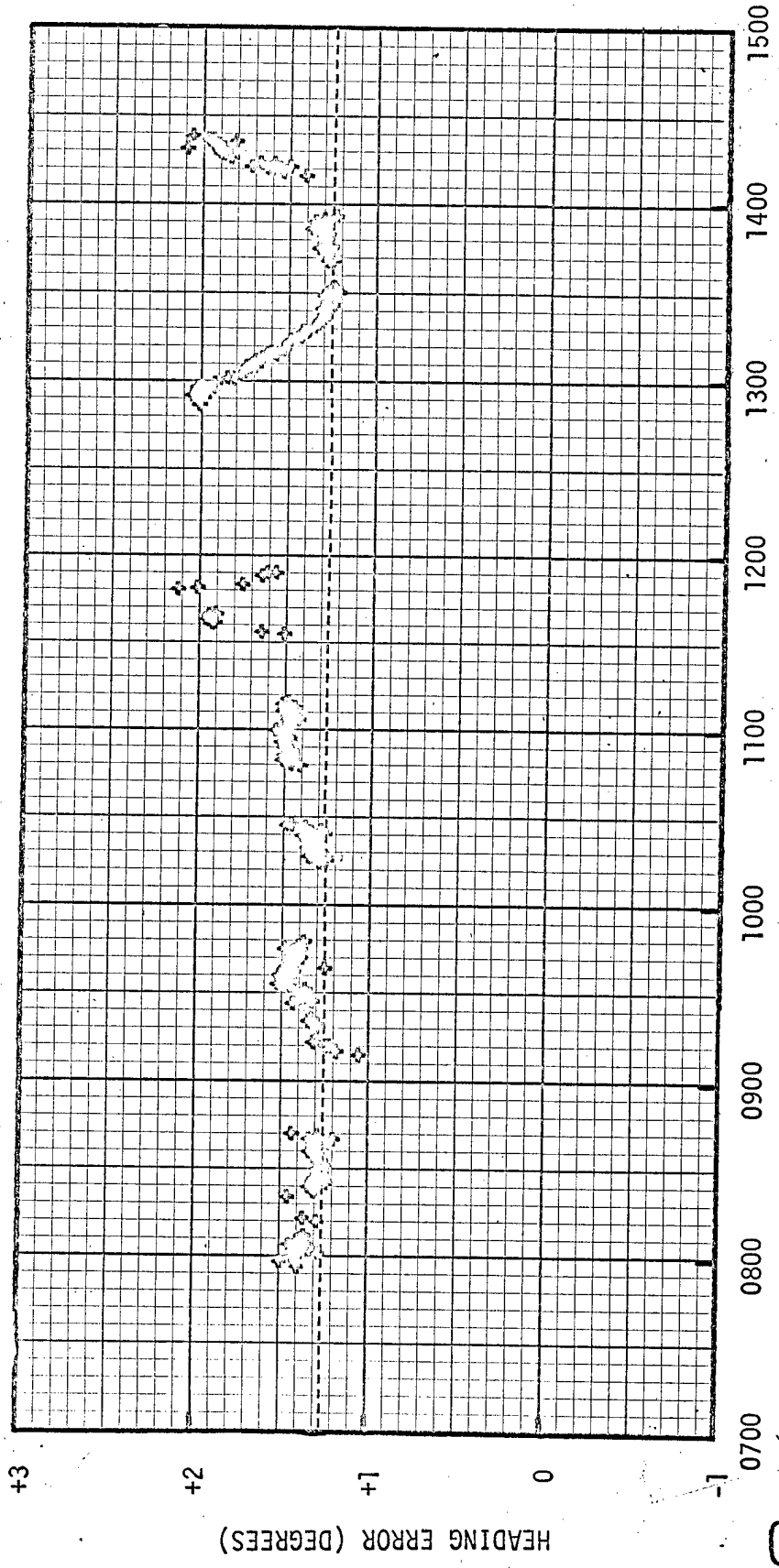
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Figure 1.0-a

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ON-RANGE TEST  
GYROCOMPASS MARK 11 MOD 6

USS WALDRON (DD-699)  
3 October 1972



HEADING ERROR (DEGREES)

TIME OF DAY

PEAK: +2.00° (1248 to 1300)  
VALLEY: +1.27° (1324 to 1336)  
PVW: 0.73° (Std 1.5°)  
MESE: +0.73° (Std ±1.0°)

+1.27° Settled Error Value of 2 October 1972

Figure 1.0-b

Enclosure (1) of NELC 1tr R112 FORACS:GRK:tmb Ser 6900-0284 of 27 October 1972

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2.0 SONAR AN/SQS-44V (S/N 292)

- (C) Range and relative bearing data were recorded at the Control-Indicator utilizing the FORACS shallow water sonar transducer. The following sonar settings were maintained during the testing:

Stabilization:	OFF
Ship'd Speed:	3 KNOTS
Video (SUM/DIFF):	DIFF
Pulse Length:	SDT 3 MS
Transducer Selector:	SEARCH, MCC XMIT
Sound Velocity:	4880 FT/SEC
Gyro:	OFF
Video (SCD/TCD):	SCD
Mode Selector:	SDT 10°

- (C) Bearing data were recorded while holding the indicated target range between 4,700 and 9,500 yards on the 10,000 yards scale. Range data were recorded on the 2,500, 5,000 and 10,000 yard scales while holding the indicated target bearing between 355 and 005 degrees.
- (U) Figures 2.0-a through 2.0-f present the bearing and range test data for the sonar equipment.
- (U) Figure 2.0-g is a plot of sound velocity versus depth of water. The data were derived from velocimeter measurements obtained in the vicinity of the FORACS transducers prior to the on-range testing.
- (U) Figure 2.0-b includes data which is not consistent with the majority of data. False triggering of the sonar transmitter sometimes can cause this inconsistency. The data analysis does not include this data.

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SONAR AN/SQS-44V (S/N 292)  
(READ AT CONSOLE)

USS WALDRON (DD-699)  
3 October 1972

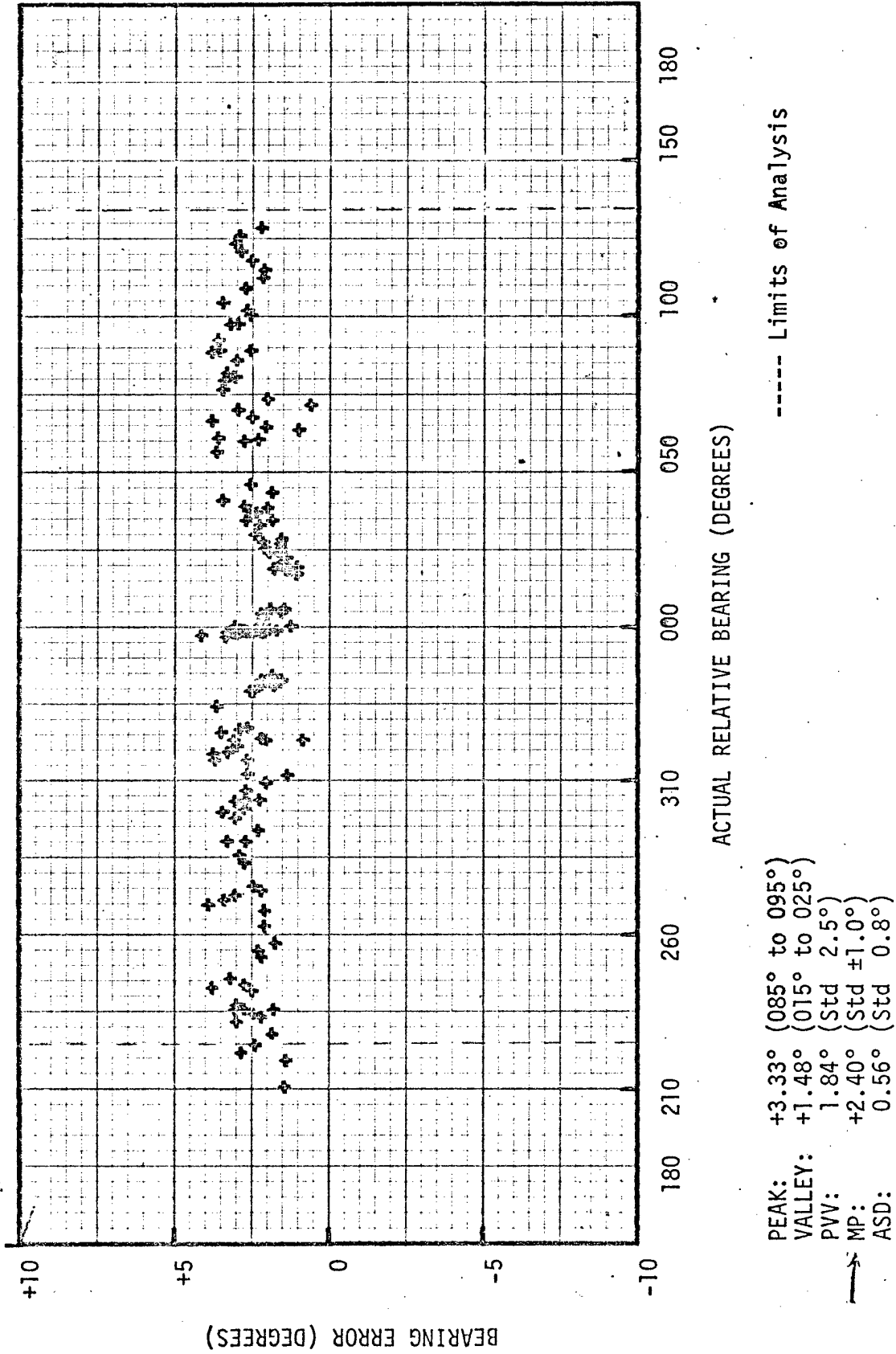


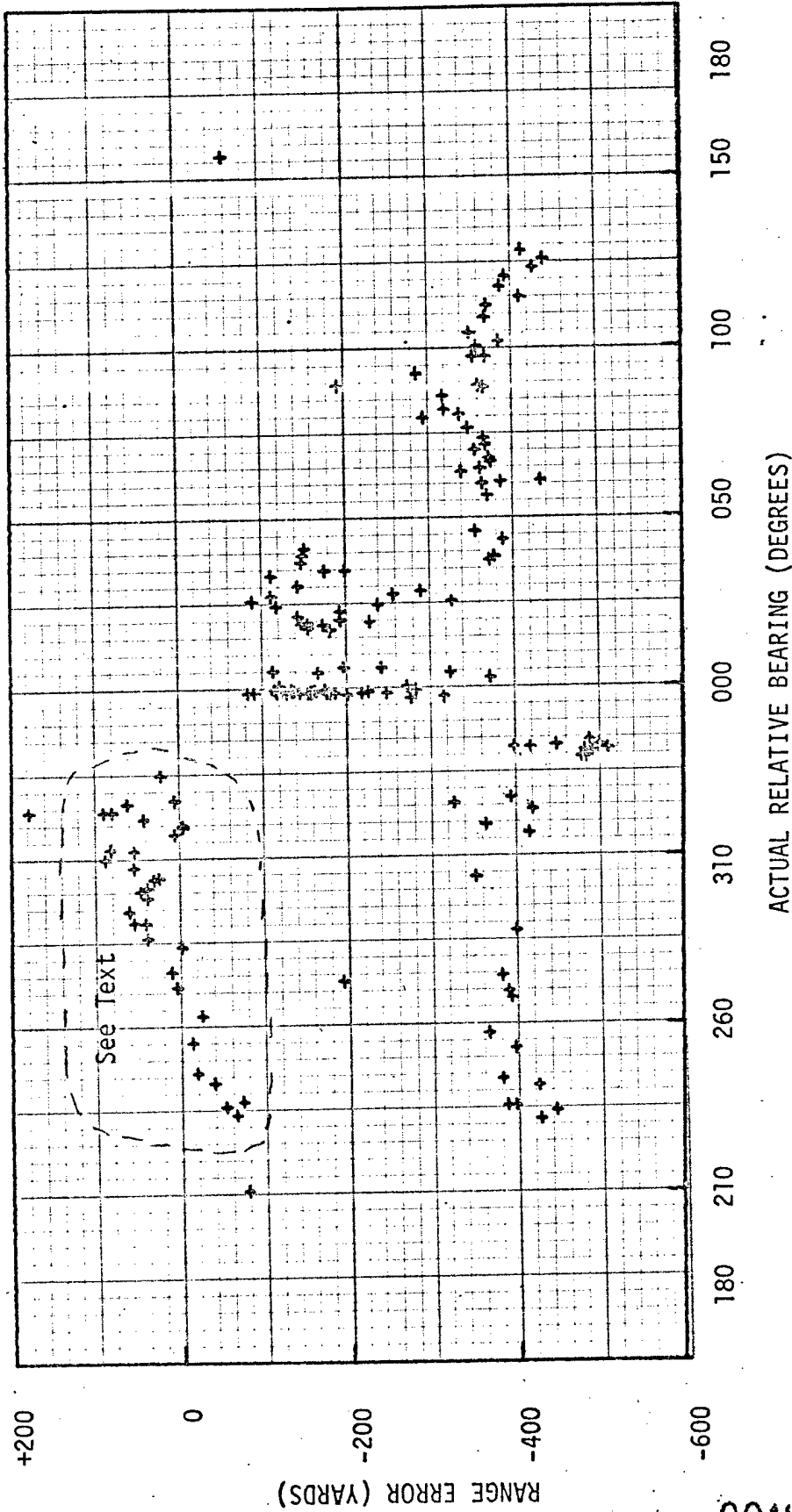
Figure 2.0-a

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SONAR AN/SQS-44V (S/N 292)  
(READ AT CONSOLE)

USS WALDRON (DD-699)  
3 October 1972



10,000 Yard Scale:  
PEAK: -171 yds (015° to 025°)  
VALLEY: -467 yds (335° to 345°)  
PVV: 296 yds (Std NA)  
MP: -319 yds (Std NA)  
ASD: 60 yds (Std NA)

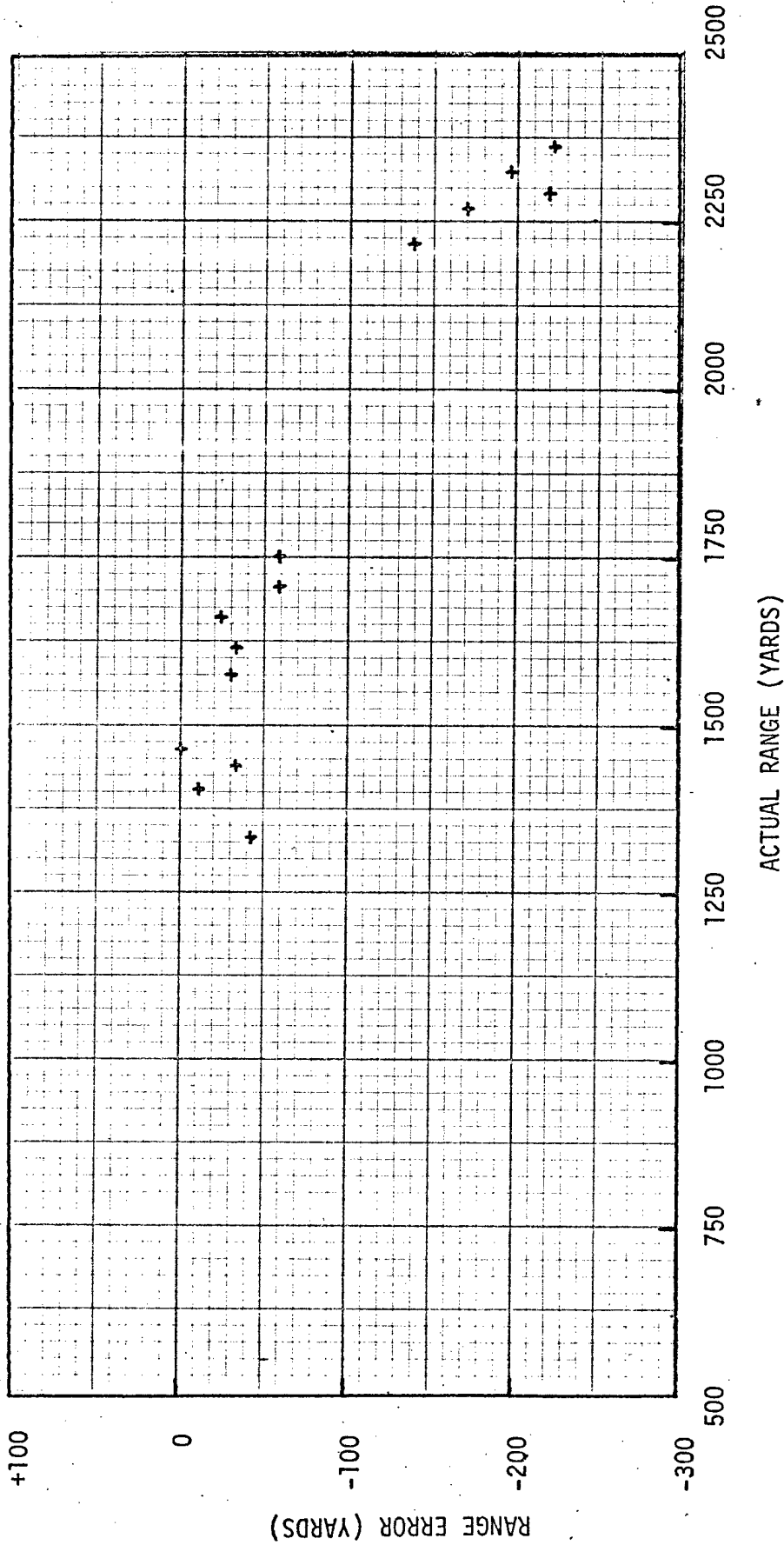
Figure 2.0-b

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SONAR AN/SQS-44V (S/N 292)  
(READ AT CONSOLE)

USS WALDRON (DD-699)  
3 October 1972

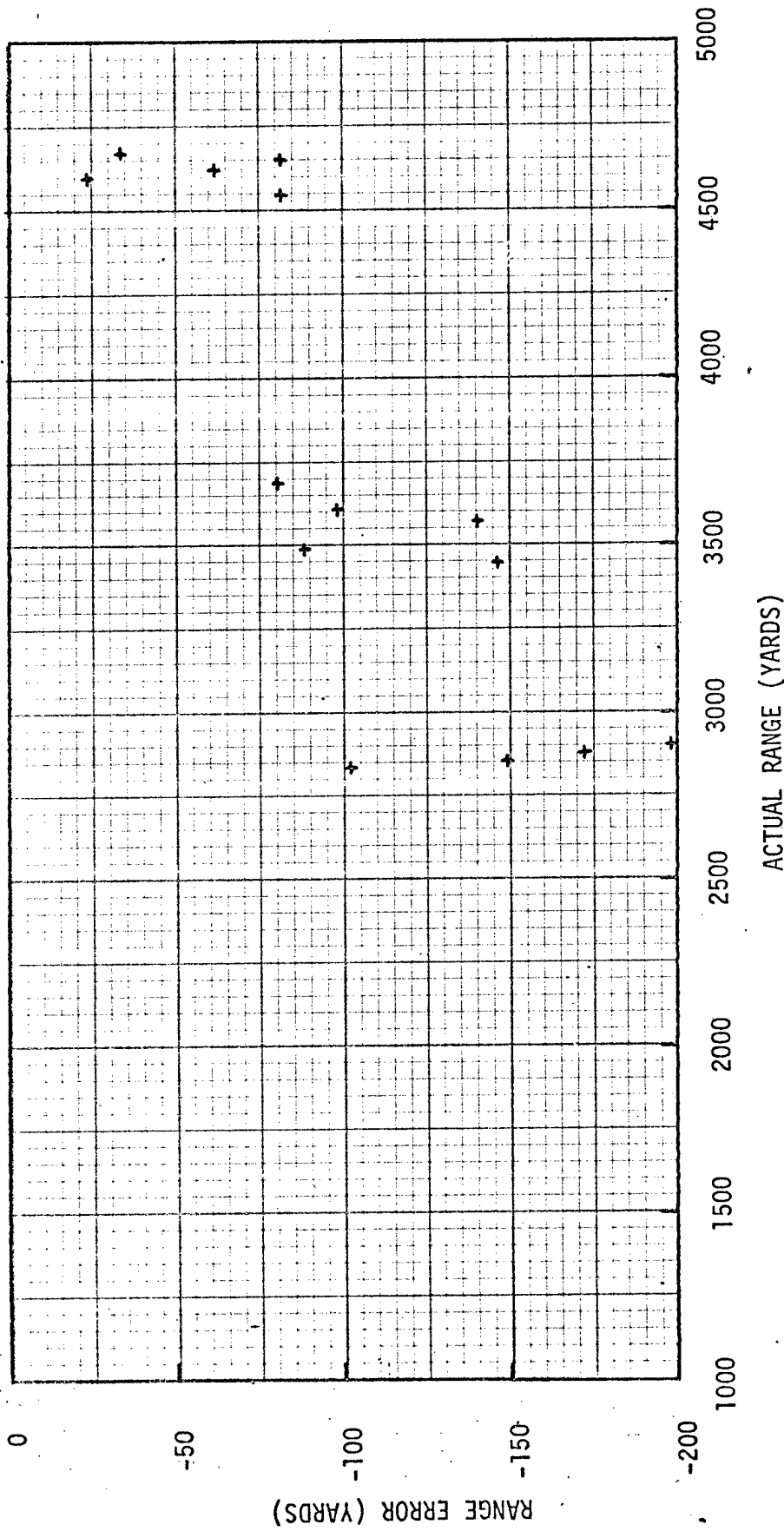


2,500 Yard Scale:  
MME: -205 yds (Std ±50 yds) (2,250 to 2,500 yds)  
ASD: 20 yds (Std 16 yds)

Figure 2.0-c

SONAR AN/SQS-44V (S/N 292)  
(READ AT CONSOLE)

USS WALDRON (DD-699)  
3 October 1972

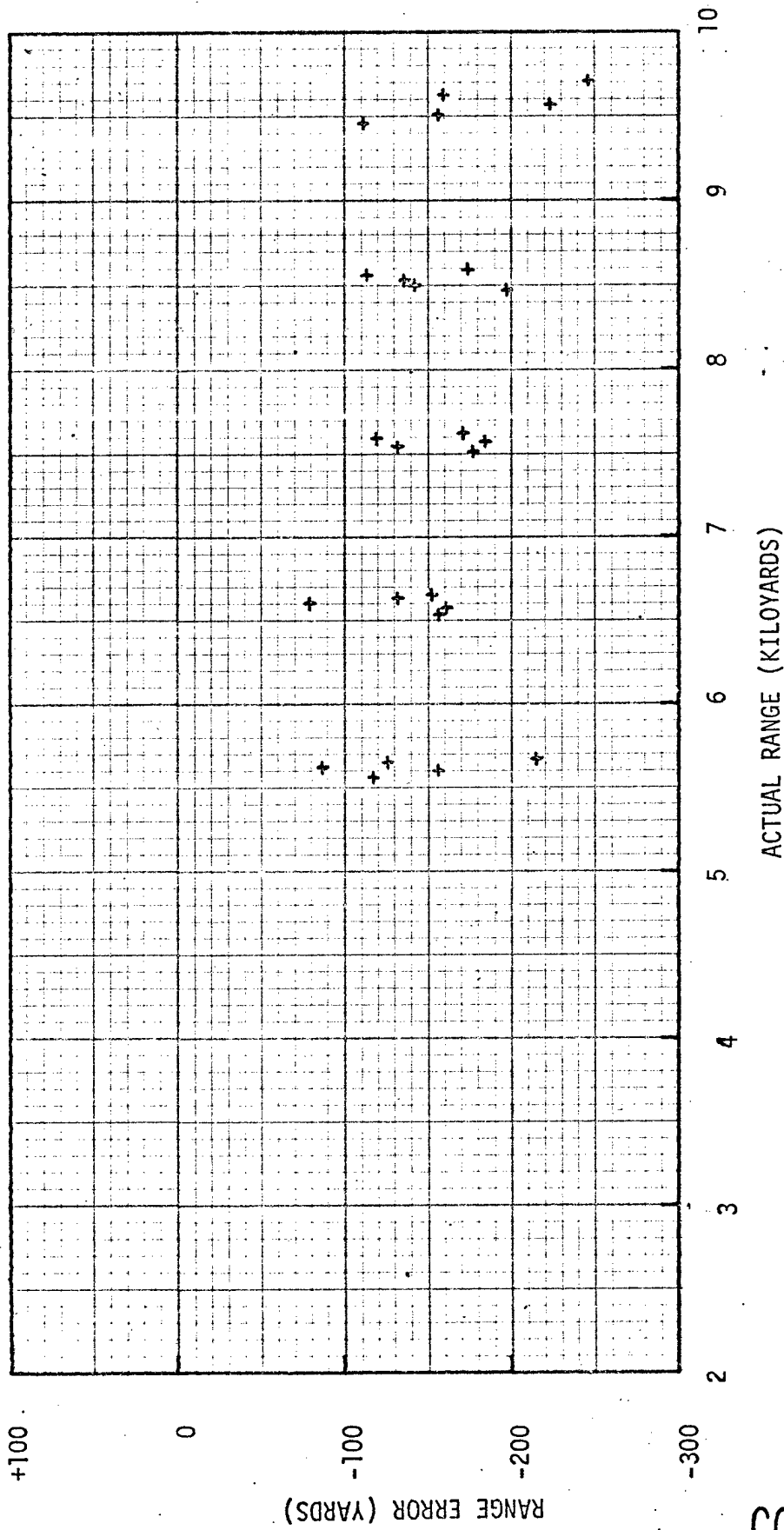


5,000 Yard Scale:  
↑ MME: -155 yds (Std ±100 yds) (2,750 to 3,250 yds)  
↑ ASD: 33 yds (Std 26 yds)

Figure 2.0-d

SONAR AN/SQS-44V (S/N 292)  
(READ AT CONSOLE)

USS WALDRON (DD-699)  
3 October 1972



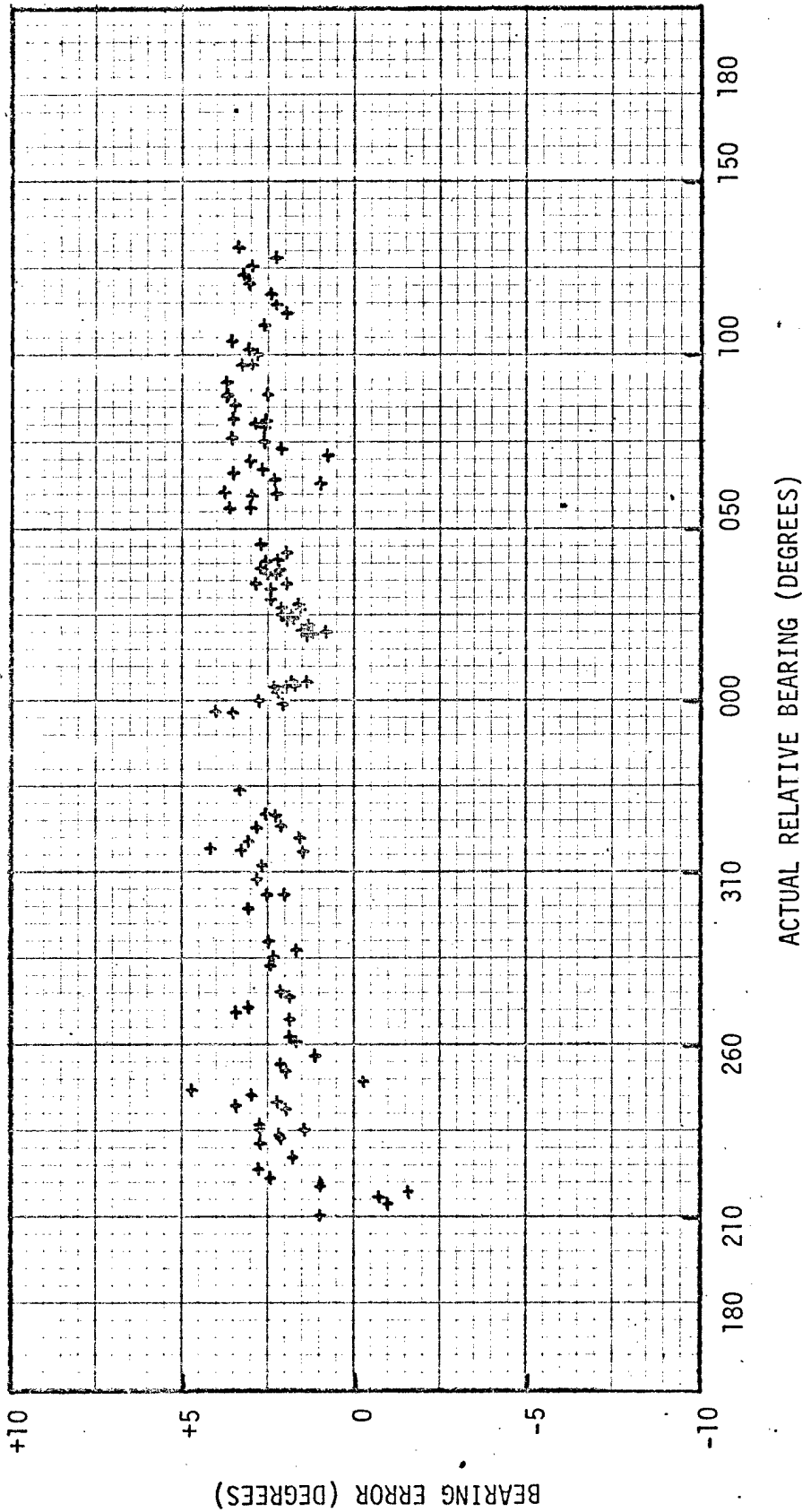
10,000 Yard Scale:  
MME: -179 yds (Std ±200 yds) (9,000 to 10,000 yds)  
ASD: 40 yds (Std 46 yds)

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Figure 2.0-e

SONAR AN/SQS-44V (S/N 292)  
(READ AT DATA CONVERTER)

USS WALDRON (DD-699)  
3 October 1972



PEAK: +3.52° (085° to 095°)  
VALLEY: +1.53° (015° to 025°)  
PVV: 2.00° (Std 2.5°)  
MP: +2.53° (Std ±1.0°)  
ASD: 0.68° (Std 0.8°)

----- Limits of Analysis

Figure 2.0-f

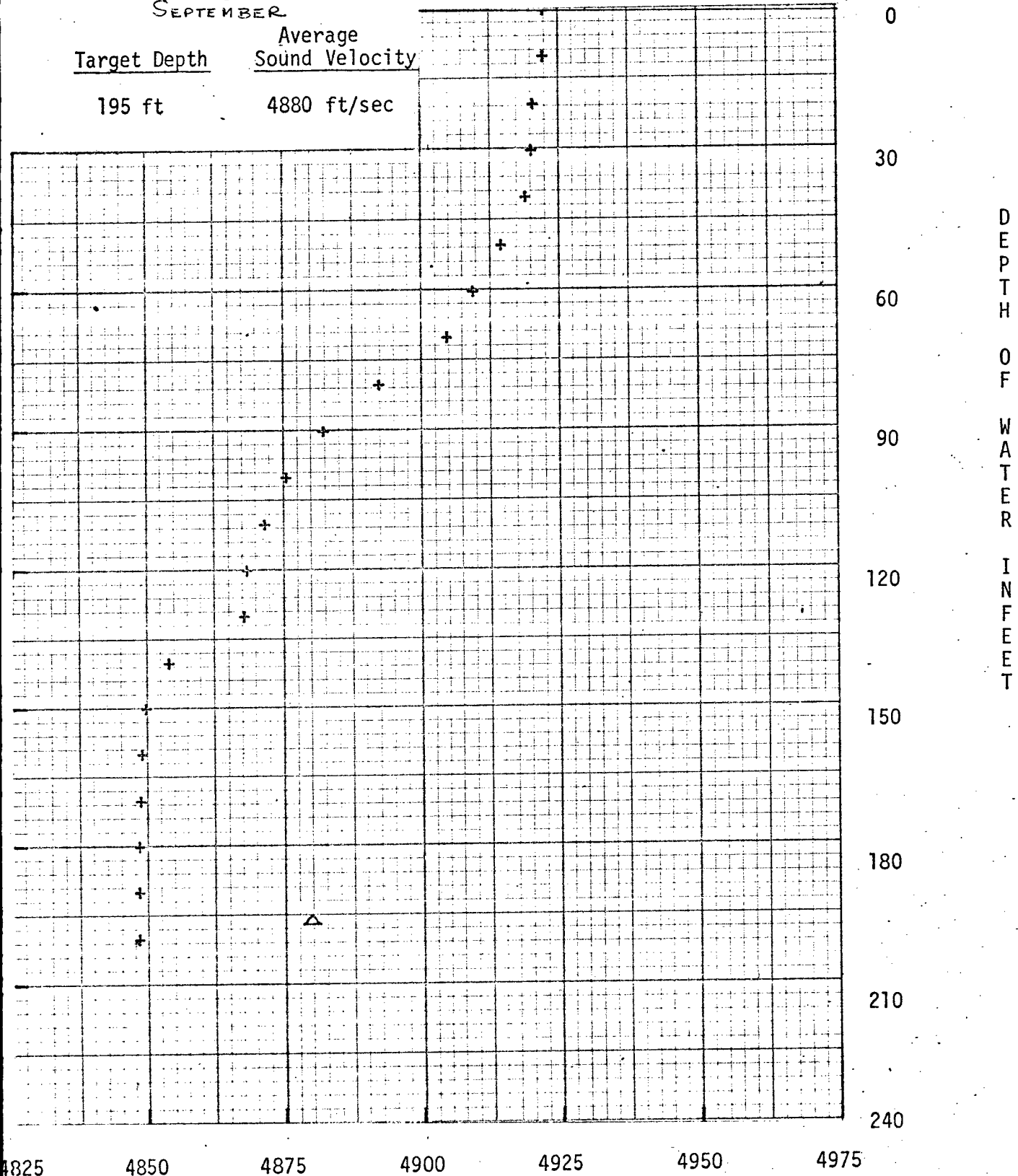
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SOUND VELOCITY  
VERSUS  
DEPTH OF WATER

USS WALDRON (DD-699)  
29 ~~October~~ 1972  
SEPTEMBER

Target Depth      Average  
                            Sound Velocity

195 ft              4880 ft/sec



SOUND VELOCITY (FEET/SECOND)

Figure 2.0-g

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3.0 GUN FIRE CONTROL SYSTEM MARK 37

- (C) Prior to the on-range testing FORACS personnel conducted benchmark and lost motion checks. An average of five train readings to the benchmark in each direction, read at the Director Train Indicator, produced the following data:

<u>Port to Stbd.</u>	<u>Stbd. to Port</u>	<u>Lost Motion</u>
1°43'	1°41'	2'

- (C) The train reading to the benchmark, per smooth log data, is 1 degree 40 minutes. FORACS personnel calculated the train to be 1 degree 52 minutes.
- (U) During the on-range testing relative bearing and range data were recorded at the director and computer while operating in the automatic mode. The target used was an active radar transponder located at the main control station on shore.

3.1 Director Mark 37 Mod 49

- (U) Relative bearing data were recorded at the trainer's dial in the director. Range data were recorded at the Radar Console.
- (U) Figures 3.1-a and 3.1-b present the bearing and range errors for data obtained at the Fire Control Computer.

3.2 Computer Mark 1A Mod 13 (S/N 1264)

- (U) Figures 3.2-a and 3.2-b present the bearing and range errors for data obtained at the Fire Control Computer.
- (U) The Fire Control system experienced a casualty late in the morning of the on-range. The bearing data presented are for information only.

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GUN FIRE CONTROL SYSTEM MARK 37  
DIRECTOR MARK 37 MOD 49

USS WALDRON (DD-699)  
3 October 1972

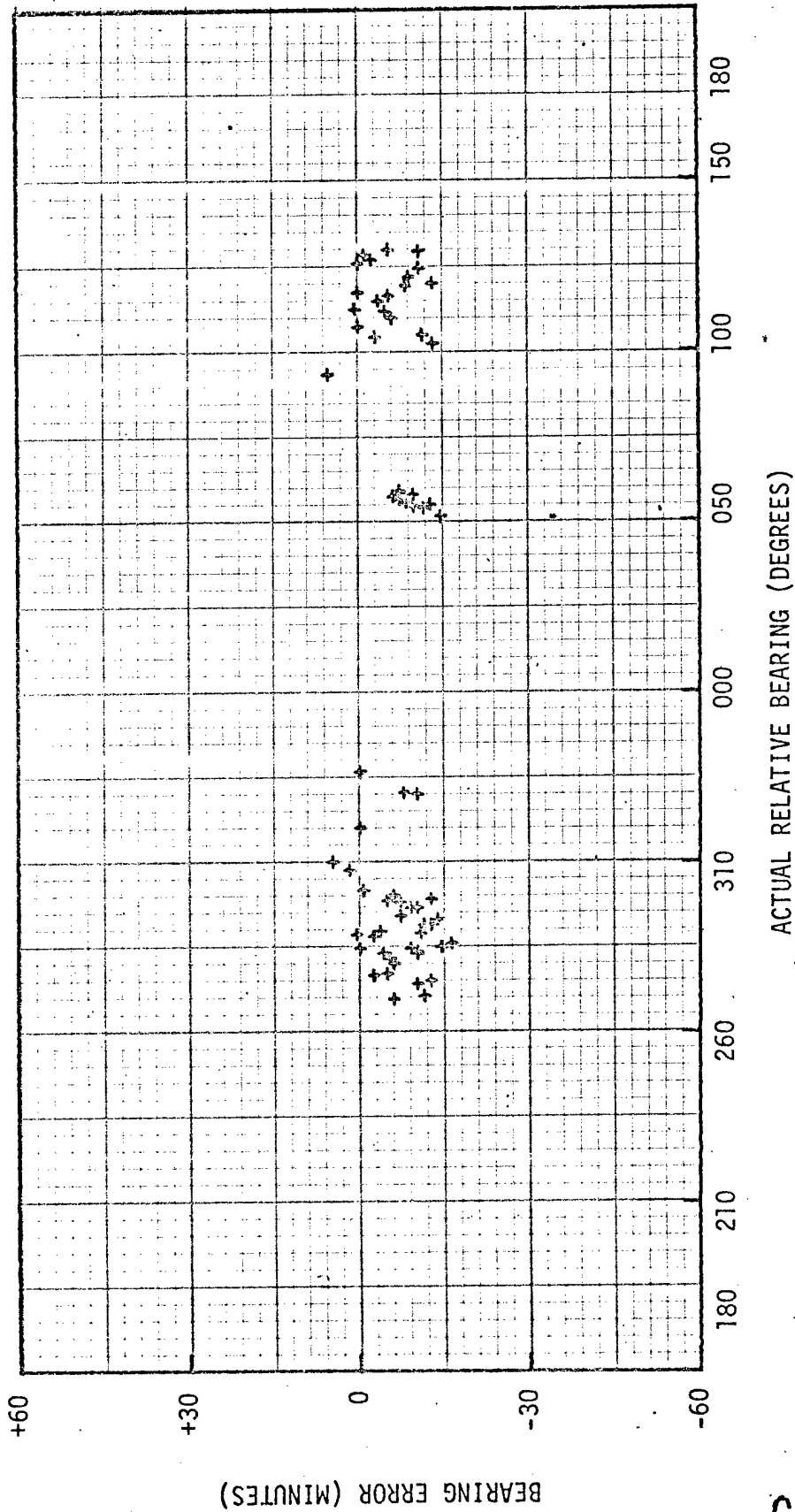
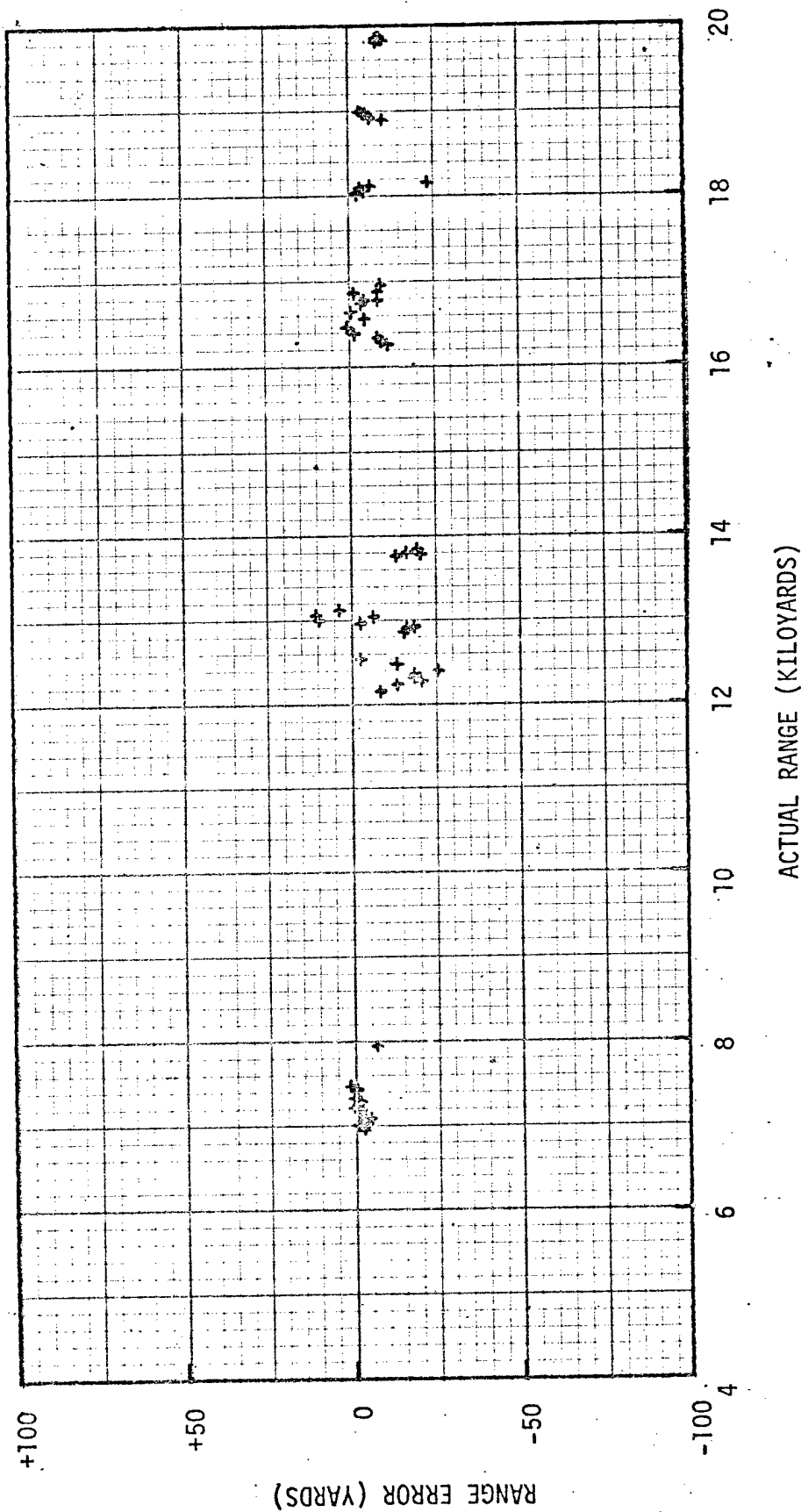


Figure 3.1-a

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GUN FIRE CONTROL SYSTEM MARK 37  
DIRECTOR MARK 37 MOD 49

USS WALDRON (DD-699)  
3 October 1972



0 - 20,000 Yards:  
MME: -15 yds (Std ±24 yds) (12,000 to 13,000 yds)  
ASD: 6 yds (Std ±6 yds)

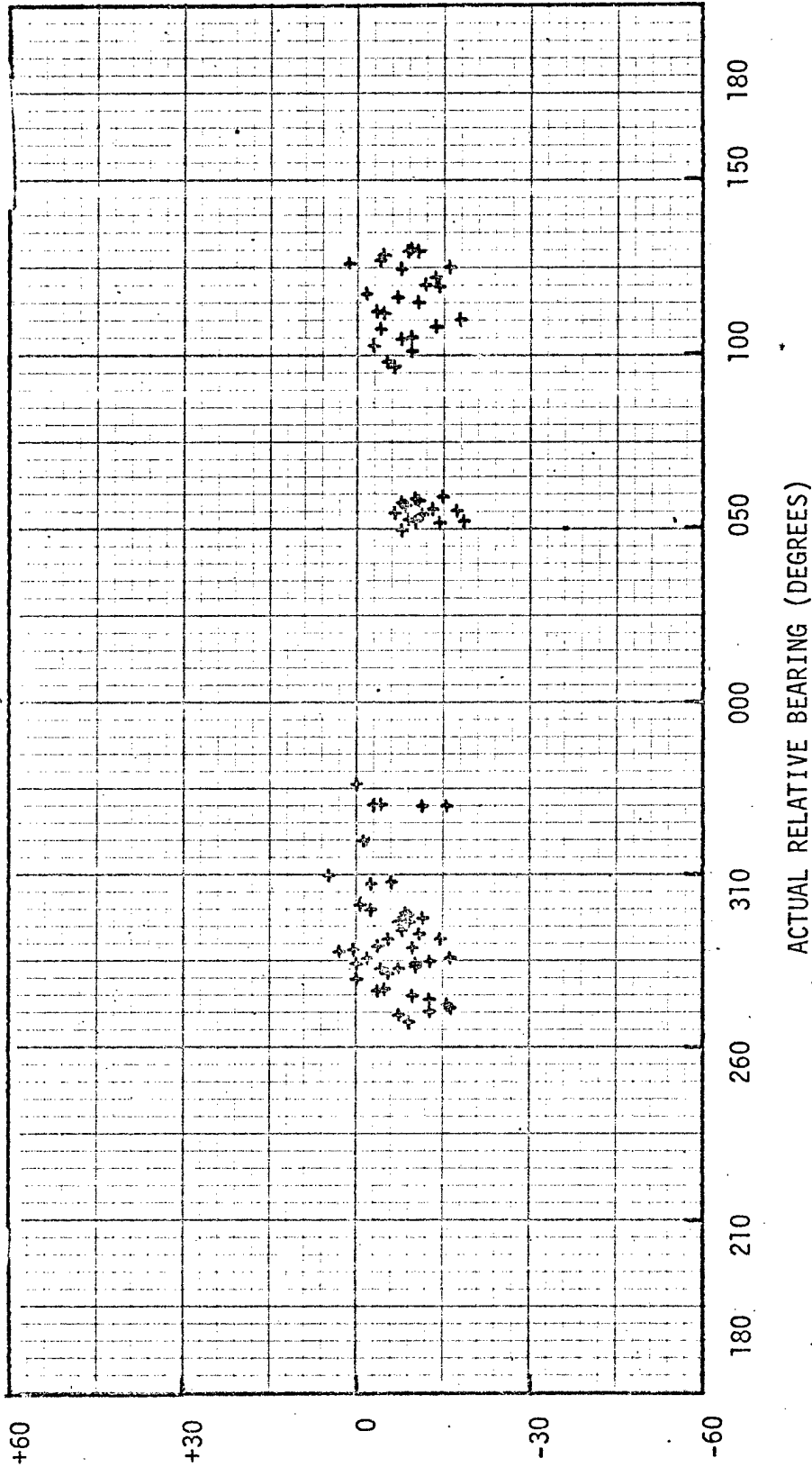
Figure 3.1-b

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GUN FIRE CONTROL SYSTEM MARK 37  
 COMPUTER MARK 1A MOD 13

USS WALDRON (DD-699)  
 3 October 1972



PEAK: -6 min (275° to 285°)  
 VALLEY: -12 min (265° to 275°)  
 PVW: 6 min (Std NA)  
 MP: -9 min (Std NA)  
 ASD: 5 min (Std NA)

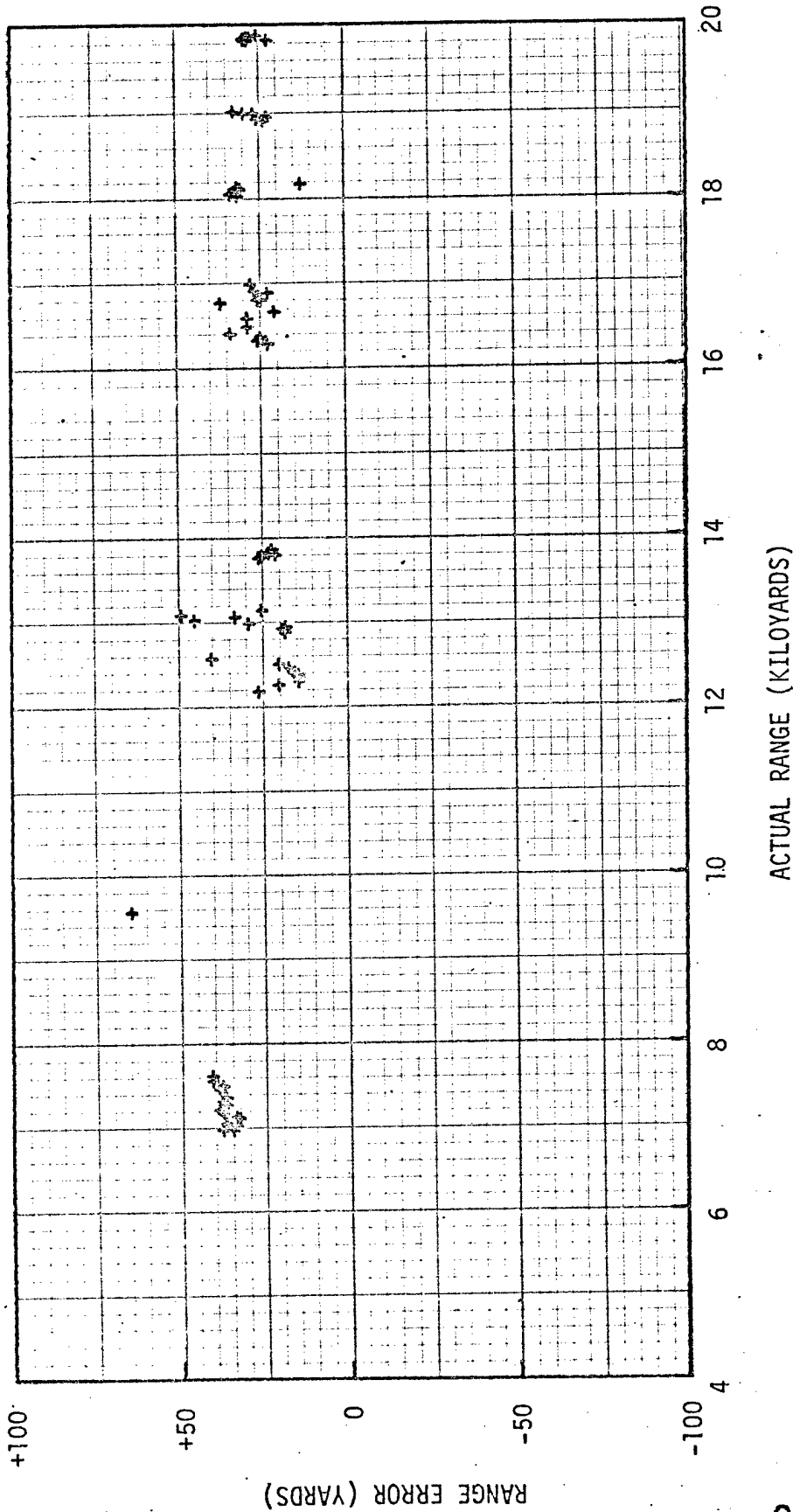


BEARING ERROR (MINUTES)

Figure 3.2-a

GUN FIRE CONTROL SYSTEM MARK 37  
COMPUTER MARK 1A MOD 13

USS WALDRON (DD-699)  
3 October 1972



0 - 20,000 Yards:  
MME: +38 yds (Std ±24 yds) (7,000 to 8,000 yds)  
ASD: 6 yds (Std ±6 yds)



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Figure 3.2-b

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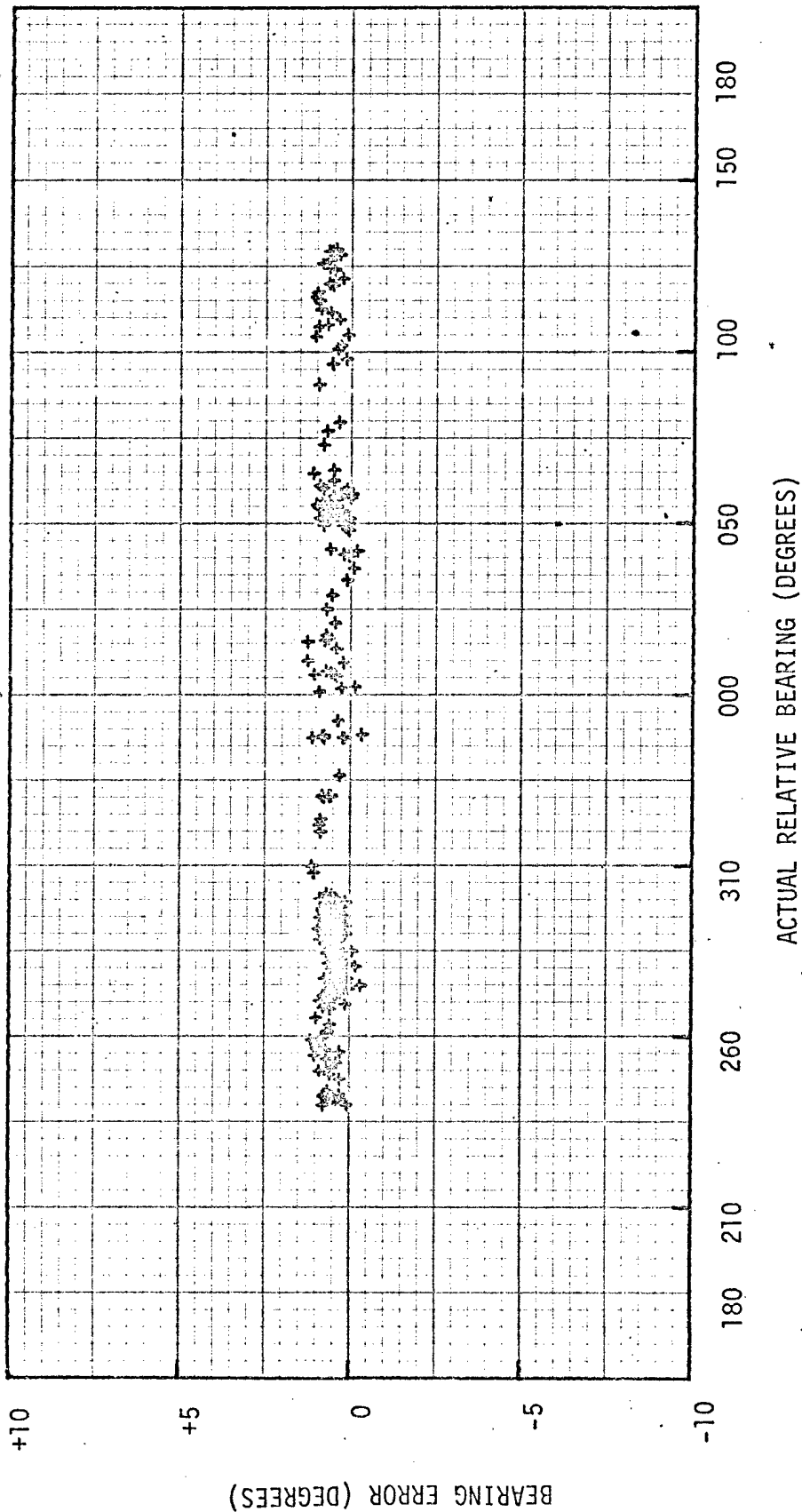
4.0 SURFACE SEARCH RADAR AN/SPS-10 (S/N 460)

- (U) Bearing and range data to radar targets as described in Section 3.0 were recorded at two indicators. The radar was operated in "RELATIVE BEARING" and "WIDE-SHORT" pulse; equipments were operated on full scale ranges of 10,000 and 20,000 yards.
- (U) Figures 4.1-a through 4.2-c show bearing and range accuracies for the following equipments:
  - 4.1 Range-Azimuth Indicator AN/SPA-25 (S/N 153) - Master CIC
  - 4.2 Range-Azimuth Indicator AN/SPA-4 (S/N 346) - Pilot House

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SURFACE SEARCH RADAR AN/SPS-10  
 RANGE-AZIMUTH INDICATOR AN/SPA-25 (S/N 153) - MASTER CIC

USS WALDRON (DD-699)  
 3 October 1972



PEAK: 0.84° (015° to 025°)  
 VALLEY: 0.18° (035° to 045°)  
 PVV: 0.6° (Std 1.4°)  
 MP: +0.5° (Std ±0.8°)  
 ASD: 0.2° (Std 0.5°)

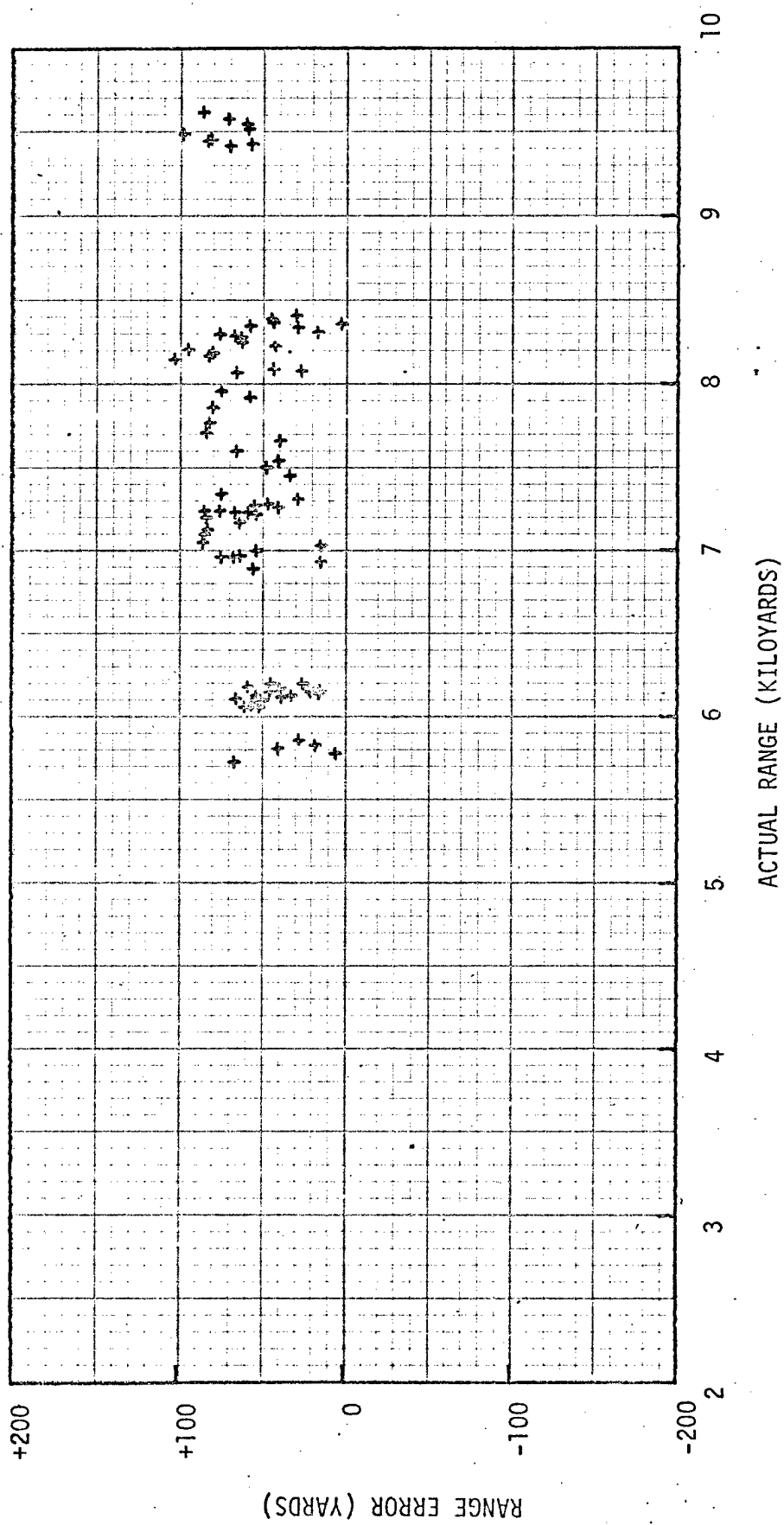
Figure 4.1-a

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SURFACE SEARCH RADAR AN/SPS-10  
RANGE-AZIMUTH INDICATOR AN/SPA-25 (S/N 153) - MASTER CIC

USS WALDRON (DD-699)  
3 October 1972



Full Scale Range: 10,000 yds  
MME: +73 yds (Std ±100 yds) (9,000 to 10,000 yds)  
ASD: 21 yds (Std 40 yds)

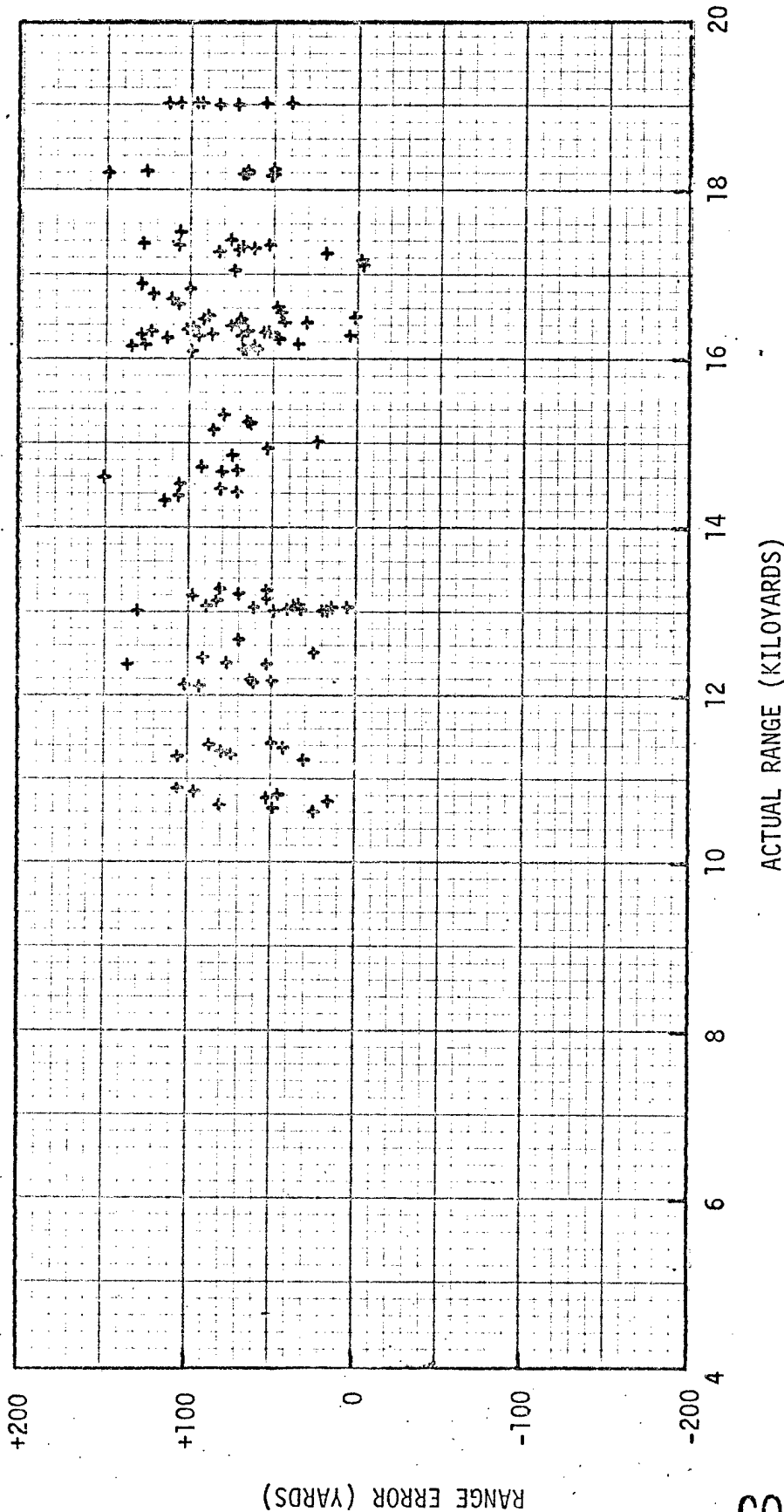
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Figure 4.1-b

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SURFACE SEARCH RADAR AN/SPS-10  
RANGE-AZIMUTH INDICATOR AN/SPA-25 (S/N 153) - MASTER CIC

USS WALDRON (DD-699)  
3 October 1972



Full Scale Range: 20,000 yds  
MME: +92 yds (Std ±200 yds) (14,000 to 15,000 yds)  
ASD: 30 yds (Std 80 yds)

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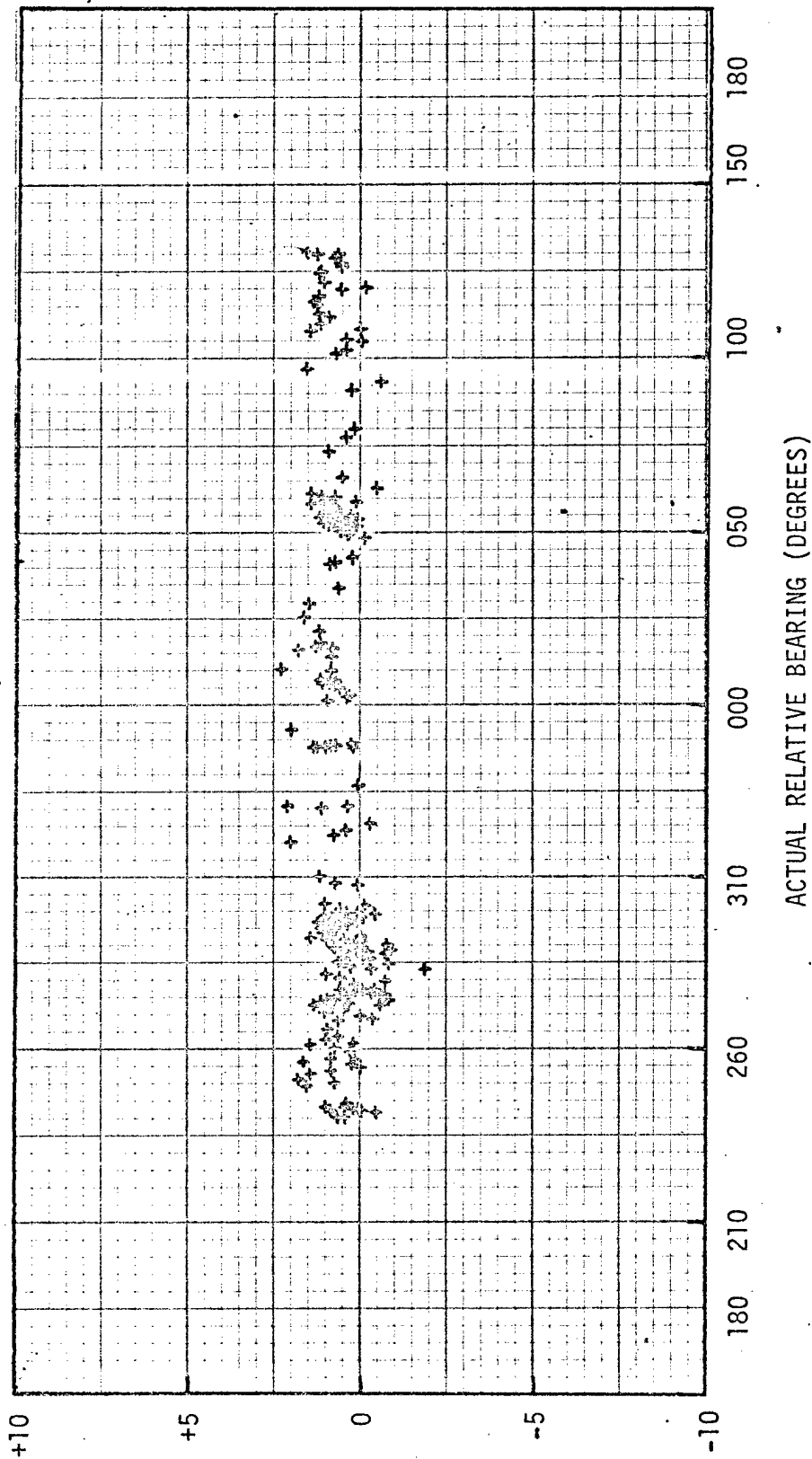
Figure 4.1-c

RANGE ERROR (YARDS)

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SURFACE SEARCH RADAR AN/SPS-10  
 RANGE-AZIMUTH INDICATOR AN/SPA-4B (S/N 346) - PILOT HOUSE

USS WALDRON (DD-699)  
 3 October 1972



PEAK: +1.38° (15° to 25°)  
 VALLEY: +0.07° (275° to 285°)  
 PVV: 1.3° (Std 2.0°)  
 MP: +0.7° (Std ±0.8°)  
 ASD: 0.5° (Std 0.6°)

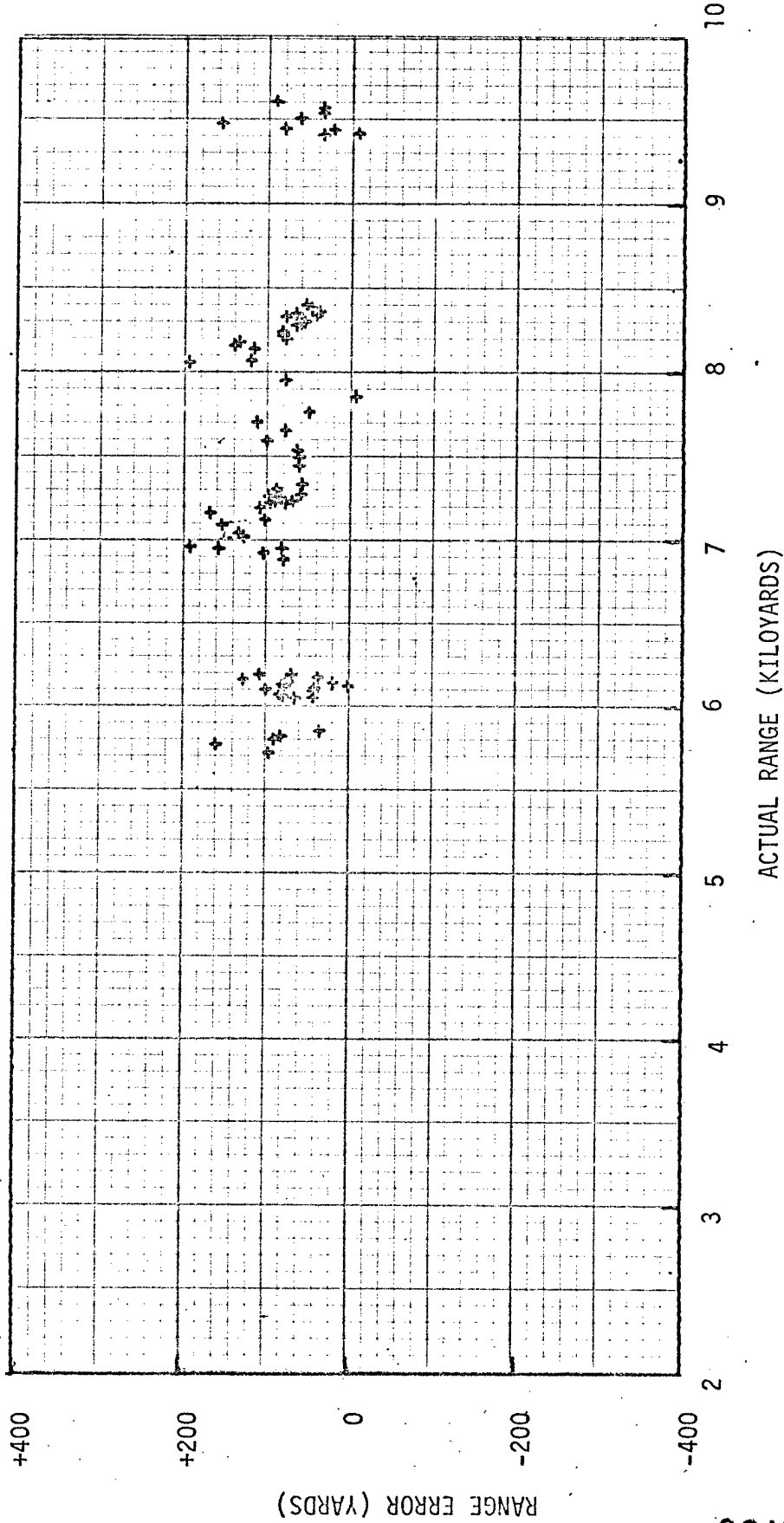
Figure 4.2-a

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SURFACE SEARCH RADAR AN/SPS-10  
RANGE-AZIMUTH INDICATOR AN/SPA-4B (S/N 346) - PILOT HOUSE

USS WALDRON (DD-699)  
3 October 1972



Full Scale Range: 10,000 yds  
MME: +93 yds (Std ±100 yds) (5,000 to 6,000 yds)  
ASD: 43 yds (Std 40 yds)

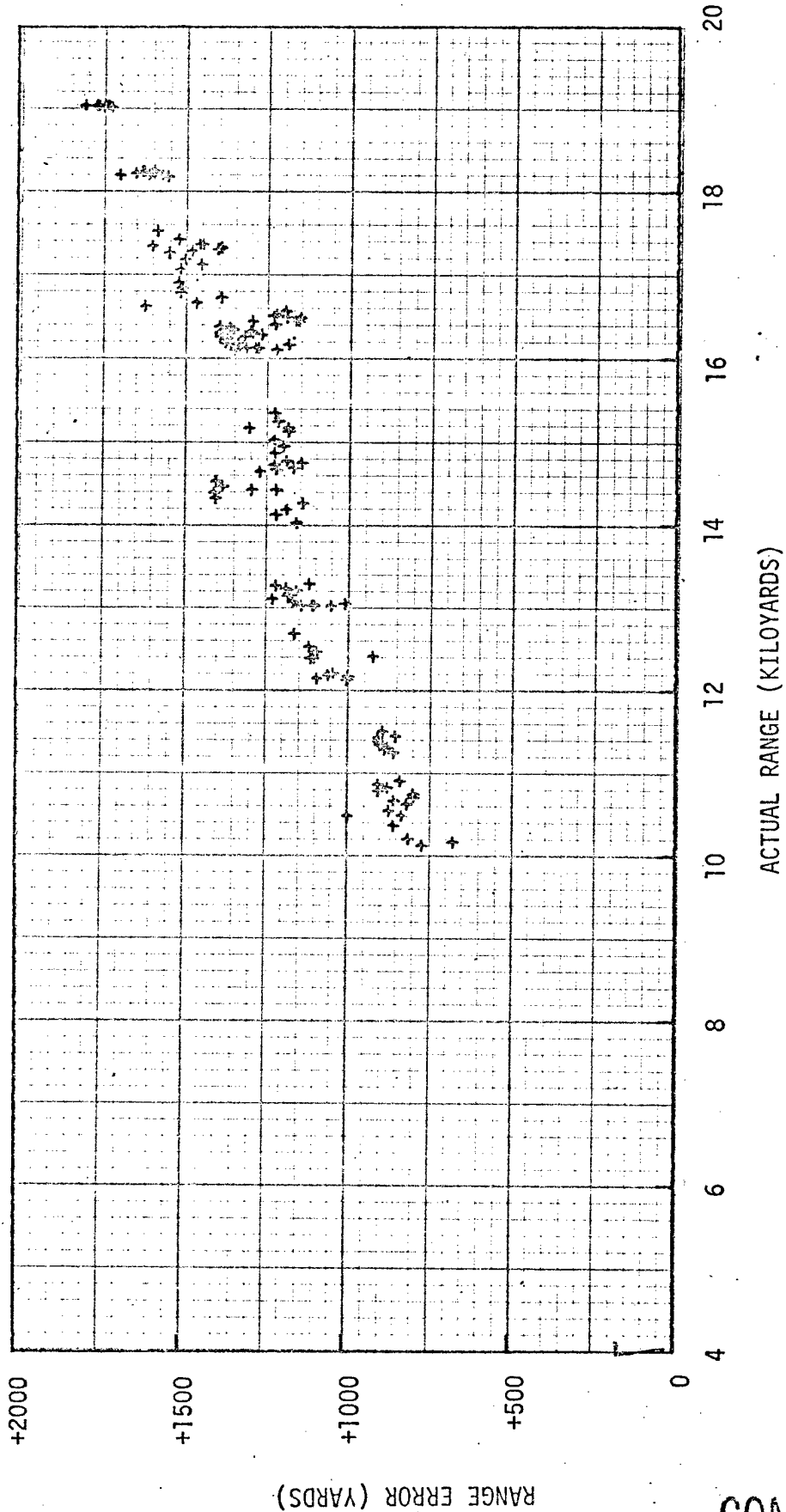
Figure 4.2-b

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SURFACE SEARCH RADAR AN/SPS-10  
RANGE-AZIMUTH INDICATOR AN/SPA-4B (S/N 346) - PILOT HOUSE

USS WALDRON (DD-699)  
3 October 1972



Full Scale Range: 20,000 yds  
MME: +1750 yds (Std ±200 yds) (19,000 to 20,000 yds)  
ASD: 60 yds (Std 65 yds)

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Figure 4.2-c

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5.0 ELECTRONIC SUPPORT MEASURES (ESM)

(U) The ESM equipment was inoperative and no data were taken.

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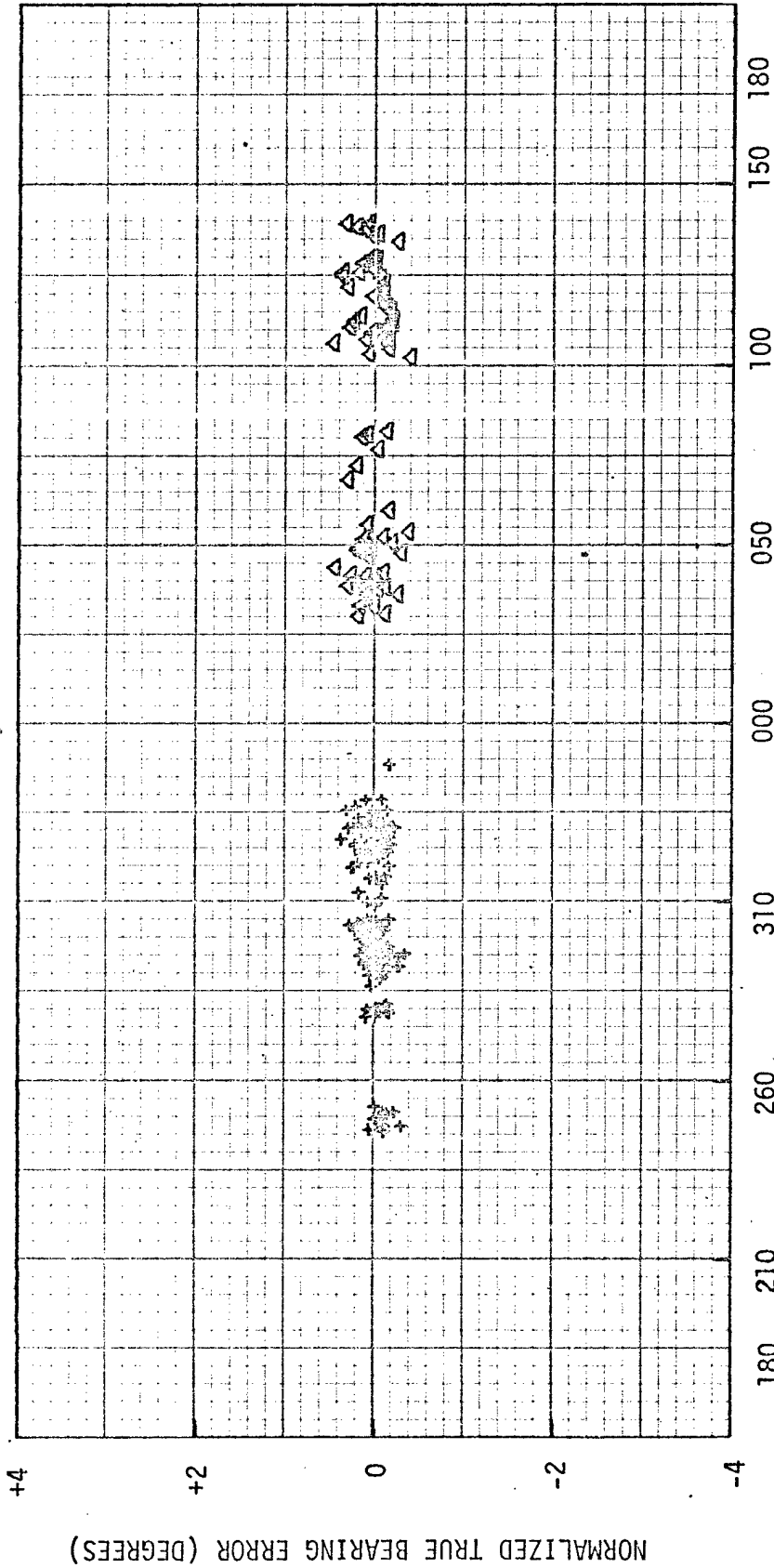
6.0 PELORUSES - ALIDADE MARK 2 MOD 1 (S/N 5241)

- (U) True bearings to one of the FORACS shore targets were obtained using either the port or starboard pelorus, depending on the ship's aspect to the target. The same alidade was used at both peloruses.
- (U) Figure 6.0-a is a plot of normalized true bearing error versus relative bearing.

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PORT AND STARBOARD PELORUSES  
ALIDADE MARK 2 MOD 1 (S/N 5241)

USS WALDRON (DD-699)  
3 October 1972



+ PORT DATA  
PEAK: 0.07° (335° to 345°)  
VALLEY: -0.09° (245° to 255°)  
PVV: 0.16° (Std 0.40°)  
MP: -0.01° (Std ±0.30°)  
ASD: 0.13° (Std 0.25°)

Δ STARBOARD DATA  
PEAK: 0.12° (135° to 145°)  
VALLEY: -0.05° (115° to 125°)  
PVV: 0.17° (Std 0.40°)  
MP: 0.04° (Std ±0.30°)  
ASD: 0.17° (Std 0.25°)

ACTUAL RELATIVE BEARING (DEGREES)

NORMALIZED TRUE BEARING ERROR

Figure 6.0-a

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APPENDIX A

Definition of Terms

- Gyrocompass Settled Error (SE): The difference between the settled indication of ship's heading and the actual ship's heading when the gyrocompass is allowed to settle to a point of minimum oscillation while the ship is moored alongside a dock.
- Maximum Excursion from Settled Error (MESE): The magnitude of the difference between the peak or valley of the gyro on-range error curve and the settled error, whichever is greater.
- Outlier: A data point which has an abnormally large deviation from the main body of data. All the apparent outliers are rejected from a set of error observations prior to computing the values of each error characteristic.
- Bearing Run: The ship is maneuvered so that the relative bearing to the sonar target is changed while the target range is held between 75% and 85% of the range scale by changing the transponder time delay.
- Range Run: The ship is maneuvered so that the relative bearing to the sonar target is held near 000 degrees while the range to the target is varied.
- Bearing-Dependent Errors: Errors which vary as a function of bearing.
- Range-Dependent Errors: Errors which vary as a function of range.
- Mean Error: (ME): The sum of all error values divided by the number of terms.
- Interval Mean Error: The mean of the range or bearing errors taken in specified intervals of range, bearing, or time.
- Best-Fit Curve: This curve is approximated by the curve passing through the set of interval mean errors.
- Maximum Mean Error (MME): The interval mean error furthest from zero.

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Peak-to-Valley  
Variation (PVV):

The magnitude of the difference between the maximum (peak) and the minimum (valley) of the "best-fit" curve, where "maximum" is the most positive value on the curve and "minimum" is the most negative value.

Midpoint PVV (MP):

A point halfway between maximum (peak) and minimum (valley) of the "best-fit" curve, equal to the mean of the peak and valley.

Standard Deviation:

A measure of dispersion of errors about the mean. For a normal distribution, the standard deviation is the value above and below the mean which would enclose about 2/3 of the points plotted. It is computed in intervals like those for the computation of the mean.

Average Standard  
Deviation (ASD):

The arithmetic mean of the interval standard deviations. The "average standard deviation" serves as an estimate of the standard deviation of observed values about a "best-fit" curve.

Valid Interval:

An interval must have at least four points to be considered valid for computation of various characteristics.

Normalized True  
Bearing Error:

Any true bearing reading which is referenced to the gyrocompass will fluctuate as the gyrocompass fluctuates. Gyrocompass errors are subtracted from the true bearing errors mark-by-mark. The results are referred to as normalized true bearing errors.

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