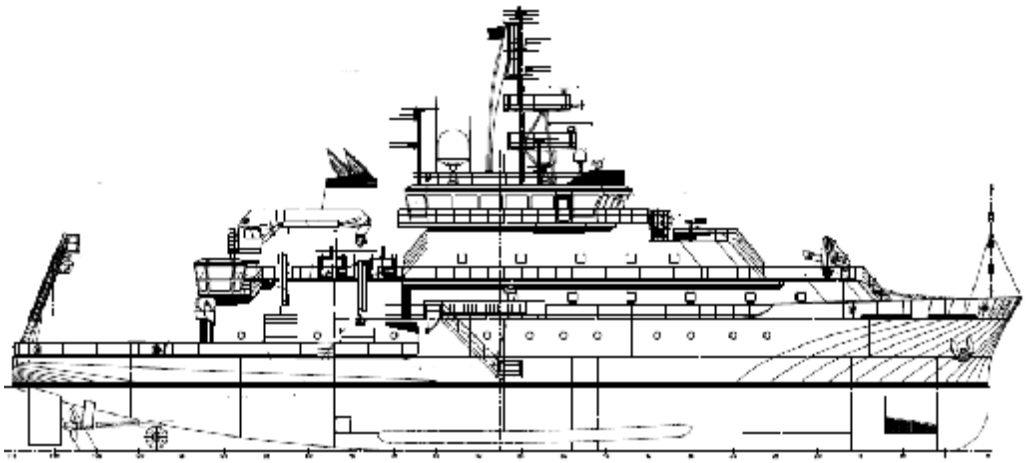
R/V SALLY RIDE (AGOR 28)
SENSOR ALIGNMENT & ORTHOGONAL COORDINATE SURVEY
APRIL/MAY 2016

FINAL REPORT

MAY 13, 2016 Rev - 0



Prepared By:

The **IMTEC** Group, Ltd.

19004 E Ringo Circle
Independence, MO 64057-1400 USA
Phone 816-795-1782
Facsimile 816-795-8760
ImtecGroup @ AOL . com
On the Web at www • ImtecGroup •.com
On the Web at www • Accuracy-Control •.com

Industrial **M**easurement **T**echnology **E**ngineering **C**onsultants

CONTENTS

PROJECT OVERVIEW

PROJECT DATA

PROJECT OVERVIEW

General Comments – Tasks Performed

This report summarizes coordinate measurement data taken on the R/V SALLY RIDE during several trips from April 5, 2016 thru May 6, 2016. The survey work was performed at Dakota Creek Industries Shipyard in Anacortes, WA after the vessel had been lifted out of the water and pulled onto an adjacent pierside work area via a rolling keel block/rail system.

Trip 1 (April 5 – 8, 2016): Coordinate measurements were taken to characterize the vessel and create a temporary reference coordinate system for reporting azimuth, pitch, and roll.

IMTEC personnel then assisted shipyard personnel with locating the new Kongsberg transducer frames to within specified azimuth tolerance so that drilling and tapping could be accomplished in the structure of the transducer mounting pockets.

An existing seachest on the Stbd side for a new 70Khz transducer required modification so IMTEC was requested to establish an offset centerline parallel to the ship's azimuth such that a new mounting ring could be oriented correctly.

Trip 2 (April 21 – 29, 2016): Transducer frames were installed and shimmed to Kongsberg specified flatness tolerances and surveyed to establish pitch, roll and XY position. Final elevation values were obtained at the transducer faces after installation.

Additional features requested by Scripps representative were surveyed during this trip:

- All transducer seachests (including 2 spares that are not being used at this time). Azimuth values for the seachests (since none of the actual transducers were installed) were obtained by creating circle centers for each and measuring to a bolt oriented in Fwd direction for reference. SBP was not yet installed so XYZ location / Azimuth, Pitch & Roll was established by surveying the corners of frame on inside of hull plate.

- Moon Pool, Aft Crane mounting base bolts, Stbd side cranes (center of each overhead door), several antennas atop pilot house and main mast, 2 MRU's, center of foundations for (2) Big Eye Binoculars, and (6) existing benchmarks from original ship construction.

- Granite Block was aligned to ship's Azimuth, Pitch and Roll and then Chockfast Epoxy was poured to hold it in place. Ship's Azimuth line was then scribed down the center.

- The new Reference Block was also shimmed as close as possible to match the Granite block Pitch and Roll and also adjusted to 0 degrees Azimuth. Azimuth was set to zero but due to use of shims and configuration of adjustment, the Pitch and Roll were set as close as possible to the Granite Block, deviations noted in Element Table.

- Several reference marks in the form of Sokkia adhesive targets were placed atop the pilot house main mast as requested for future use by ship personnel.

- Fwd/Aft reference marks were surveyed and marked on the Port/Stbd main deck (weatherdeck below handrails) to aid in calibration of the 18Khz, 70Khz, 120/200Khz & 38Khz transducers.

Continued on page 3.

Trip 3 (May 6, 2016): Due to a problem with being able to shim the 710TX frame to specified flatness, a replacement 710TX frame was installed, shimmed for flatness and final survey performed after transducers were installed. The new HiPap transducer (not available for survey during trip 2) was also surveyed at this time in a partially extended position such that the Azimuth was obtained by surveying a mark on the transducer itself and the pitch and roll values were obtained by measuring the transducer pole to create a cylinder, the vector of which was was used to determine pitch and roll.

3-D Coordinate Measurement Equipment

Temporary "benchmarks" or reference points were placed throughout the vessel as required to allow for re-locating the instrument to a new position or "Station" and tie all of the data to the common coordinate system for comparison.

The measuring system used for this final inspection report is one of several owned by The IMTEC Group, Ltd. The NET 1200 total station, S/N 110554 was calibrated, traceable to N.I.S.T. and in accordance with A.N.S.I. Z-540-1, at the Sokkia USA Factory Service Center November 17, 2015

Reference Coordinate System

The following parameters were used to define the reference coordinate system for reporting the survey data:

> Keel survey was performed by surveying pairs of points near Frames 6, 16, 29, 39, 55, 58, 67, 77, 88, 95 and a single point at the aft end of skeg. A best-fit line faired through each bisected pair of points was used as the ships zero heading (Azimuth).
>
> Due to hull shape fwd and aft, the pairs of points from frame 16 through frame 58 were determined to be the most suitable to create the best-fit plane that was used as the ships pitch and roll axis as docked.
>
> Coordinate system is defined with the Origin at the Aft Stbd corner of the new Reference Block. The X-axis is positive Forward, the Y-axis is positive Starboard and the Z-axis is positive towards the keel.

Measurement Procedure

Adhesive targets with retro reflective target face were used throughout the survey as temporary benchmarks for relocating the instrument to new stations. Kinematic (a target with a known offset) retro reflective targets such as the RT-50M swivel targets used to measure some of the features defining the specified elements to be reported. Where possible, a retro reflective surface target was used to eliminate any offsets.

3-D X, Y, Z coordinates, Post Processing

In some cases, the features or targets defining the elements required by the survey were made to a kinematic target with a known offset orthogonal to the vessel's final reference coordinate system. After the each survey was complete, these offsets were applied to report the final X, Y, Z value of the element.

Data files

One measurement file was used to perform the survey.

All measurement files were backed up at the completion of a set of observations from a particular station and on a daily basis.

This vessel coordinate system was created from the initial characterization file.

Station transformations are used to bring a new instrument location into the current vessel coordinate system. The result produces some residuals.

Measurement Precision and Uncertainty

Point to Point, any element or target within the vessel survey to another element or feature in the survey

X, Y, & Z $\leq$ 2.3 mm

Region to Region, i.e., keel features to DGPS antenna

X $\leq$ 3 mm
Y $\leq$ 3 mm
Z $\leq$ 4 mm

Angular precision is based on analysis of features measured and calculation of the mathematical relationship of these features.

The angular measurement precision of the NET1200 is < 1 arc second in azimuth and zenith. There can be some error introduced by targeting. Random and systematic errors can be introduced by the working environment.

The expected angular precision is analyzed to be:

Azimuth:	≤ 00° 00' 30"
Pitch:	≤ 00° 01' 00"
Roll:	≤ 00° 01' 00"

PROJECT DATA

Orthogonal coordinate system defined with the Origin at the Aft Stbd corner of the new Steel Reference Bock. All coordinates are in meters.

The Draft Mark table is reported in feet.

R/V SALLY RIDE

ELEMENT TABLE - ORIGIN AT STBD AFT CORNER OF REFERENCE BLOCK - April/May 2016

ELEMENT	COORDINATE (METERS)			INCLINATION		HEADING
	X	Y	Z	Pitch	Roll	Azimuth
GRANITE BLOCK	3.4896	-0.2291	-0.0572	0.00000	0.00000	0.00000
REF BLOCK STBD AFT	0.0000	0.0000	0.0000	0.00444 Bow Up	0.01306 Stbd Up	0.00000
REF BLOCK PORT AFT	0.0003	-0.4577	0.0001			
REF BLOCK PORT FWD	0.6105	-0.4576	0.0000			
REF BLOCK STBD FWD	0.6101	0.0000	-0.0001			
REF BLOCK CENTER	0.3052	-0.2288	0.0000			
IMU				Not yet installed		
122TX @ Array	2.0491	-0.7779	0.8269	0.02251 Bow Up	0.07417 Stbd Up	0.06726 Stbd
122RX @ Array	-2.3572	-0.2182	0.9009	0.06337 Bow Dn	0.01197 Stbd Dn	0.00993 Stbd
710TX @ Array	0.3226	0.0598	0.9052	0.14840 Bow Dn	0.07092 Stbd Dn	.09424 Stbd
710RX @ Array	-1.1006	0.4049	0.9009	0.02252 Bow Dn	0.03929 Stbd Dn	0.00935 Stbd
HIPAP @ Split	-3.8169	0.3891	1.4602	0.18454 Bow Dn	0.01367 Stbd Dn	0.08749 Stbd
Port O/B Seachest (12 Khz)	-3.8164	-2.6565	0.9937	0.11350 Bow Up	0.04078 Stbd Dn	0.28520 Stbd
PORT I/B SEACHEST	-3.8184	-1.4385	1.0213	0.06583 Bow Up	0.16401 Stbd Dn	0.25070 Stbd
STBD O/B SEACHEST	-3.8195	2.2184	1.0238	0.00255 Bow Up	0.49755 Stbd Up	0.52903 Stbd
18 KHZ	-1.3797	2.2159	0.9786	0.02341 Bow Up	0.23364 Stbd Dn	1.90642 Port
70 KHZ	0.1430	2.2956	1.0257	0.19934 Bow Dn	0.05649 Stbd Up	0.00615 Port
200 KHZ	0.7509	1.9894	1.0264	0.33335 Bow Dn	0.33499 Stbd Up	0.66501 Port
120 KHZ	0.7512	2.6758	1.0262	0.33201 Bow Up	0.21911 Stbd Up	0.04808 Port
38 KHZ	1.6620	2.2196	1.0024	0.27346 Bow Up	0.16747 Stbd Up	0.10148 Port
SBP	3.1650	0.8408	0.9938	0.01930 Bow Dn	0.04837 Stbd Dn	0.21496 Port
300 KHZ ADCP	6.2359	0.3931	0.9110	0.17929 Bow Up	0.78950 Stbd Dn	16.30151 Port
38 KHZ ADCP	6.9070	-1.4441	0.8763	0.29194 Bow Dn	0.28044 Stbd Dn	7.20581 Stbd
150 KHZ ADCP	6.5397	-2.6649	0.8713	0.12501 Bow Dn	0.56261 Stbd Up	9.34433 Stbd
MRU - SEAPATH	-16.6389	-0.5744	-7.6689	1.08668 Bow Up	0.70767 Stbd Up	1.25438 Port
MRU MARKEY WINCH	-22.4685	3.4645	-9.1217	0.28016 Bow Dn	0.43436 Stbd Up	0.58281 Stbd
MOONPOOL	-28.7829	-2.0572	-0.0694			
STBD FWD A FRAME BOLT	-41.7944	3.8107	-5.8498	PUNCH MARK ON BOLT HEAD		
PORT FWD A FRAME BOLT	-41.7926	-4.2800	-5.8468	PUNCH MARK ON BOLT HEAD		
PORT AFT A FRAME BOLT	-44.3771	-3.4062	-5.8523	PUNCH MARK ON BOLT HEAD		
STBD AFT A FRAME BOLT	-44.3781	2.9316	-5.8590	PUNCH MARK ON BOLT HEAD		
FWD CRANE DOOR CTR	-19.9494	3.5055	-5.7541	FWD/AFT CENTER OF DOOR OPENING		
AFT CRANE DOOR CTR	-25.4201	3.4266	-5.7441	FWD/AFT CENTER OF DOOR OPENING		
PORT BIGEYE CTR	4.7152	-5.0917	-13.9464	CENTER OF FOUNDATION		
STBD BIGEYE CTR	4.7204	4.6509	-13.9461	CENTER OF FOUNDATION		
IBS DGPS #1	-3.7274	-7.0907	-19.2070	CENTER AT BOTTOM OF ANTENNA		
IBS DGPS #2	-14.4560	5.6199	-19.2246	CENTER AT BOTTOM OF ANTENNA		
DP SPOTBEAM	-8.1449	0.1077	-29.9811	CENTER AT BOTTOM OF ANTENNA		
DP IALA	-7.6271	5.6438	-19.3742	CENTER AT BOTTOM OF ANTENNA		
DP DGPS	-8.0449	-0.5251	-30.0492	CENTER AT BOTTOM OF ANTENNA		
PORT DGPS	-15.9162	2.1870	-19.1347	MOUNTING HOLE CENTER ON BRACKET		
STBD DGPS	-15.9248	4.6867	-19.1229	MOUNTING HOLE CENTER ON BRACKET		

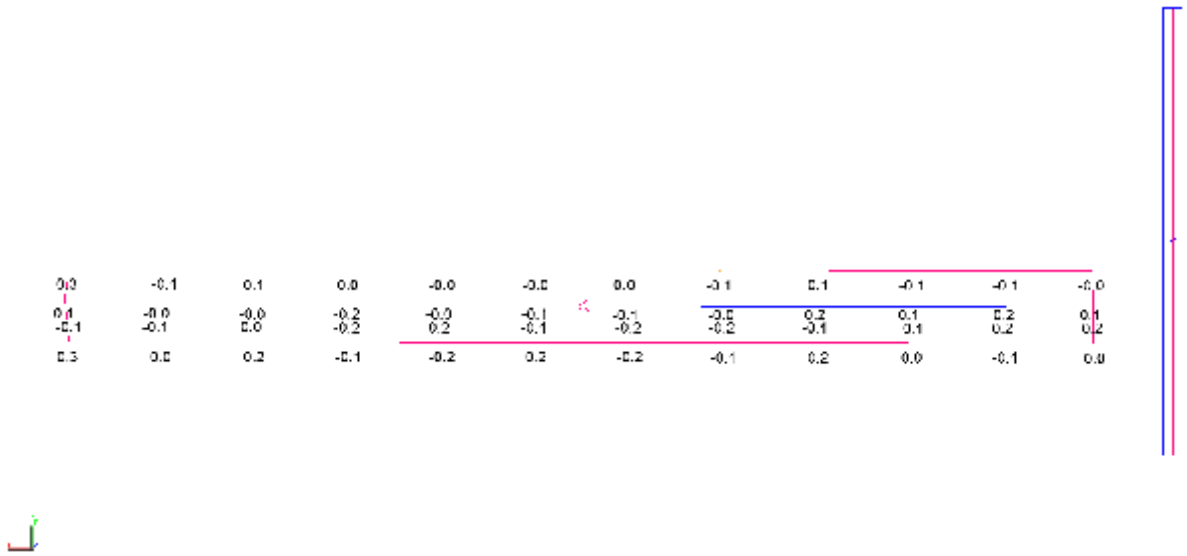
BM AFT PORT	-41.2544	-6.6339	-5.7742			
BM AFT CTR	-41.2558	-0.2361	-5.7758			
BM AFT STBD	-41.2546	6.1635	-5.7718			
BM MID STBD	-27.8802	6.1681	-5.7490			
F'CSLE DECK BM	15.0724	-0.2292	-11.1962			
FWD DECK BM	25.0904	-0.2207	-8.4771			
MAIN MAST BASE	-7.9014	-0.2179	-18.0592			
FWD MAST TOP	25.9168	-0.2303	-17.7000			
PORT LIGHT BASE	-5.4955	-6.8329	-18.0460			
PORT LIGHT TOP	-5.4588	-6.8798	-21.1636			
STBD LIGHT BASE	-5.4768	6.3988	-18.0447			
STBD LIGHT TOP	-5.4254	6.4410	-21.1460			
AFT MAST BASE	-15.1493	2.0273	-18.0276			

PORT 18 KHZ	-1.3790	Calibration Reference Marks for Fwd/Aft Reference Only
PORT 70 KHZ	0.1441	
PORT 120/200	0.7517	
PORT 38 KHZ	1.6619	
STBD 18 KHZ	-1.3802	
STBD 70 KHZ	0.1439	
STBD 120/200 KHZ	0.7506	
STBD 38 KHZ	1.6628	

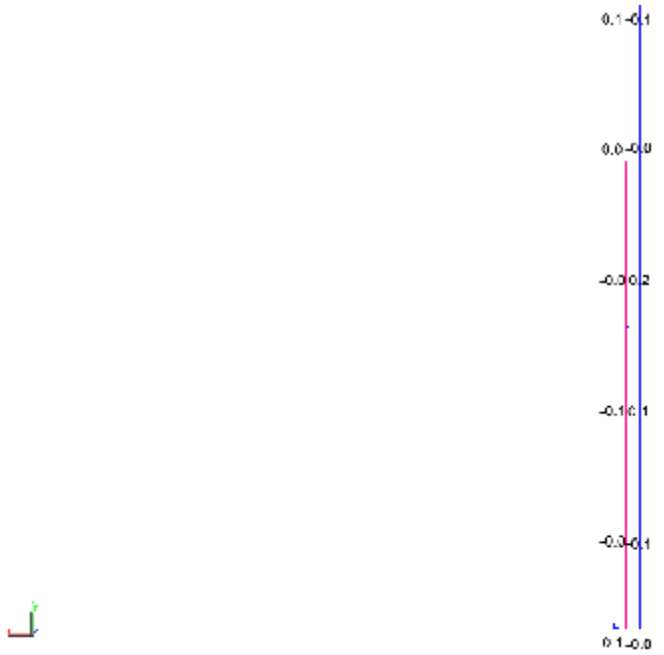
FWD DRAFT MARKS (FT)			AFT DRAFT MARKS (FT)		
MARK	**STBD**	**PORT**	**MARK**	**STBD**	**PORT**
10	9.9	9.9	10	10.1	10.1
11	10.9	10.9	11	11.1	11.1
12	11.9	11.9	12	12.1	12.1
13	12.9	12.9	13	13.1	13.1
14	13.9	13.9	14	14.1	14.1
15	14.9	14.9	15	15.1	15.1
16	15.9	15.9	16	16.1	16.1
17	16.9	16.9	17	17.1	17.1

PLIMSOLL DRAFT MARKS		
MARK	**STBD**	**PORT**
AB	16.3	16.3
TF	16.9	16.9
F	16.6	16.5
S	16.3	16.2
W	15.9	15.9
WNA	15.8	15.7

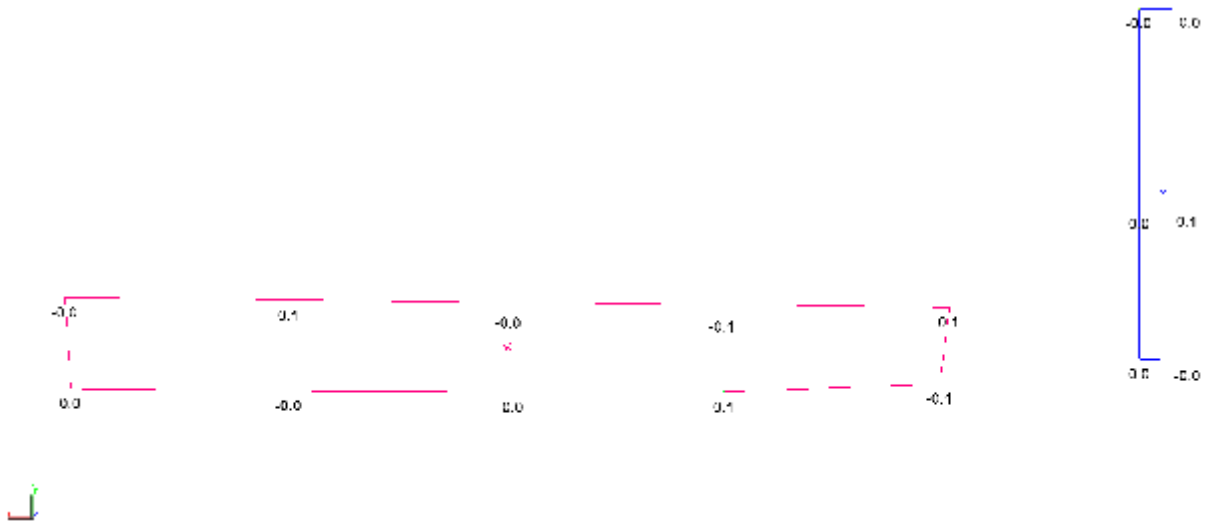
FLATNESS EM122 TX AS INSTALLED (MM)



FLATNESS EM122 RX AS INSTALLED



FLATNESS- EM 710 TX/RX AS INSTALLED (MM)



Certificate of Calibration

Item No. / Model: NET 1200

Manufacturer: SOKKIA

Serial No.: 110554 Certificate Number: 60997

This certifies that the above instrument has been inspected and calibrated by the Sokkia Corporation Service Department. This inspection was performed using the procedures set forth in the NET SERIES INSTRUMENT CALIBRATION AND CERTIFICATION MANUAL (August 18, 2005 Rev. 8). At the time of completion of this service, Sokkia Corporation certifies that the above stated instrument meets or exceeds all factory specifications and tolerances for instrument parameters and performance of this instrument model. The certification is effective for a 12 month period from the calibration date shown below.

All distance measurement parameters were tested and adjusted using factory calibration jigs and with the 10 Meter Calibration Rail whose accuracy is traceable to the National Institute of Standards and Technology (N.I.S.T) via Mutual Recognition Agreement. All angle measurement parameters were tested with a NIST traceable optical collimation system, using accepted collimation and adjustment procedures.

The quality system addresses and conforms to ANSI/NCSL Z540-1-1994 and ISO/IEC 17025-1999 (and, as a result ISO 9001-1994 or ISO 9002-1994)

This certificate shall not be reproduced except in full, without the written approval of Sokkia Corporation

Customer Name: IMTEC GROUP, Ltd

Customer Address: 19004 E. RINGO CIR.

Customer City/State/Zip: INDEPENDENCE, MO 64057

See individual sets of data for temperature and pressure

Date Calibrated: 11/17/2015 Date Recalibration Due: 11/17/2016

Signed: [signature] Date: 11/17/2015

Yes	No	
___	X	Is this a new instrument?

Answer the following questions only if the above answer is "No".

___	X	Is this the first NIST calibration we have performed on this instrument?
X	___	Were the calibration seals intact when the instrument was received?
___	X	Were the initial collimation inspection results within tolerance?
___	X	Were the initial EDM inspection results within tolerance?
___	X	Was the instrument damaged/defective and unable to have an initial inspection?
___	X	Corrective action recommended?

* See page 2 for a list of primary standards

Page 1 of 2