

R/V ATLANTIS  
ORTHOGONAL COORDINATE SURVEY & SENSOR ALIGNMENT  
JANUARY – March 2011

# FINAL REPORT

April 4, 2013 – Rev “4”



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

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#### Electronic Data-Atlantis

- Final Data – mm.xls (Excel File of Tables)
- All Observations DXF.dxf
- All Observations Text .txt

3-25-2011 Rev 1- Shifted Origin Back to Aft Port Corner Hippy Plate- Table 1, 2 & 3, Hippy Plate Graphic, Old PHIN Graphic

5-20-2011 Rev 2 -Shifted origin to locate PBM10 24.456 Meters aft of Frame zero and at faired baseline at bottom of keel thus placing the origin at Frame Zero on the Faired Ship Base line.

6-21-2011 Rev 3 –added PLN1,2,3 & 4 on object to Table 1. Revised X and Y values for draft marks to be in relation to FP and SCP, added RX,TX pitch & roll data page 12

4-4-2013 Rev 4- Described Origin, pp4, Rev & added Notes pp5, Revised Table formats (no data change) Table 1, 2 & 3 pp6-7, Rev Hippy, TX & RX Information, pp12 (no Data Change)

## **PROJECT OVERVIEW**

### **Purpose**

The purpose of this commentary is to summarize the procedures and analytical methods employed to perform the 3-D coordinate total station inspection that produced the data in this report for those unfamiliar with the equipment and process.

Dimensional data resulting from the inspection is included with the report.

### **General Comments**

This report summarizes coordinate measurement data taken on the vessel R/V Atlantis during the period of January 26, 2011 through March 7, 2011. The vessel was in a floating drydock at BAE Systems in Jacksonville, FL.

#### **Tasks performed January 26-28:**

Coordinate measurements were taken to characterize the vessel and create the required reference coordinate system for reporting azimuth, pitch, and roll and coordinate data.

Measurements were taken to obtain the center coordinates of antennae located on the main mast.

Verification of Pitch of the existing fairing structure that was being reworked to allow the installation of a Kongsberg EM122 Multibeam Sonar Array TX frame.

Transfer ship's reference system into the GSM Stores room via a hole cut in the hull side shell. Reference plate is being machined to accept 3 IXSEA PHINS units that will be aligned to the ships AZ line.

A reference plane was left on keel blocks and drydock walls to allow personnel from BAE Systems to tack wing normal to the ship's reference plane.

#### **Tasks performed February 16 through February 19, 2011:**

Verify Wing installation/ monitor welding.

Layout 2 degree reference lines to facilitate strut installation.

Set Reference Plate (old Hippy plate) to ship's azimuth.

Survey the final position and inclination of new IXSEA PHINS units.

Value all existing permanent benchmarks (4 fantail, 4 bow, 4 in GSM Stores room / Passageway)

#### **Tasks performed March 4 through March 7, 2011**

Support installation of Kongsberg EM122 TX and RX frames to achieve required flatness.

Survey the remaining transducers/ sensors on hull bottom.

### **3-D Coordinate Measurement Equipment**

A Sokkia NET 1200 enhanced electronic total station operated through a notebook computer running New River Kinematics Spatial Analyzer™ measurement and analysis software was utilized. This system measures 3-D spherical coordinates by recording an azimuth and zenith angle simultaneously with the near infrared distance coaxial with the telescope line of sight for each observation. Spatial Analyzer measurement and analysis software converts the spherical coordinate data to a Cartesian coordinate system that can be defined by the user. Measurements are made to either adhesive or kinematic targets that have a retro-reflective target face. Where practical, certain features were measured with the instrument in the “Reflectorless” targeting mode.

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 110350 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 January 19, 2011.

### **Reference Coordinate System**

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

A total of 9 pairs of points were taken along the keel to represent the vessel's Azimuth and Pitch. 6 points were acquired on the Fantail to represent the vessel's Roll plane.

The X-axis is positive forward, the Y-axis is positive starboard and the Z-axis is positive towards the keel.

ORIGIN is located at the intersection of the Forward Perpendicular (FP) and the ship's Base Line (Centerline at keel). (Rev-4)

### **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. The RT-50M was also frequently used as a temporary benchmark. Where possible, a retro reflective surface target was used to eliminate any offsets.

A Sokkia NET 1200 total station operated through a notebook computer running Spatial Analyzer™ industrial measurement software was used to measure the benchmarks, targets and record observations.

### **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.

The azimuth, pitch and roll values for the MRP were processed mathematically in the Spatial Analyzer software. Backup data is provided with this report.

### **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 (see measurement procedure). The result produces some residuals.

### **Measurement Precision and Uncertainty**

Based on the best fit solution Uncertainties are reported to be:

(Note: Uncertainty values are based on fit to previous survey values and may be less than shown)

Region to Region, i.e., Reference Plate to antennae, EM122 TX/RX and other hull features:

$$\begin{aligned} X &\leq 3 \text{ mm} \\ Y &\leq 3 \text{ mm} \\ Z &\leq 3 \text{ mm} \end{aligned}$$

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:

$$\begin{aligned} \text{Azimuth:} &\quad \leq 00^{\circ} 00' 30'' \\ \text{Pitch:} &\quad \leq 00^{\circ} 01' 00'' \\ \text{Roll:} &\quad \leq 00^{\circ} 01' 00'' \end{aligned}$$

## PROJECT DATA

The required data is summarized in tabular form on the following page. The units of measure for reporting are indicated on the table.

Nearly all of the data included with this report, both by hard and electronic format has been reviewed by the **WHOI** engineer in the form of preliminary reports submitted electronically, e.g. e-mail, by the IMTEC engineer for review.

The measurement data is also included in electronic format, AutoCad\*.dxf”, ASCII \*.txt and SA \*.xit. The electronic data files include X, Y, and Z coordinates for all targets measured during the performance of this orthogonal survey. Included are temporary benchmarks or reference points used to re-locate the instrument or to tie the area surveys together. Some editing was done on various targets to correct for kinematic target offsets and some targets are calculated values such as circle centers, etc.

See the contents page of this report for the listing of electronic files included by attachment with this report.

Table 1 reports the X, Y and Z, values for specified components in units of meters <sup>(Rev-4)</sup> and in the final vessel coordinate system.

Table 2 Reports the X,Y and Z values for the permanent benchmarks. <sup>(Rev-4)</sup>

Table 3 Reports the measured coordinate of the specified draft mark with respect to the ship’s coordinate system origin and elevation of the measured point at the bottom of the draft mark weld in feet. <sup>(Rev-4)</sup>

<b>TABLE 1 ELEMENTS (Meters)</b>			
<b>DESCRIPTION</b>	<b>X</b>	<b>Y</b>	<b>Z</b>
ORIGIN <sup>(Rev 4)</sup> Intersection, FP @ BL	0.000	0.000	0.000
TR109_CENTER	-32.288	0.627	0.626
TX_CENTER	-30.181	-0.390	0.424
RX_CENTER	-25.716	-0.011	0.505
HIPPIE_CALC_CENTER POINT	-27.233	0.457	-2.768
OLD_PHIN_CENTER	-27.325	0.508	-4.418
UQC_A_Center	-32.500	-2.190	-0.159
UQC_B_Center	-31.682	-2.659	-0.227
UQC_C_Center	-32.509	2.172	-0.154
UQC_D_Center	-31.675	2.651	-0.227
RD500B_Center	-27.711	0.715	0.624
RD500A_Center	-28.318	0.711	0.611
TC12A_Center	-31.363	0.517	0.619
TC12B_Center	-31.364	0.973	0.622
DS530_Center	-29.554	0.827	0.603
CURRENT PROFILER	-33.188	0.557	0.628
TRACK_POINT_Center	-33.189	-1.851	-0.121
PHIN_PIN_LOC_1	-27.476	0.528	-2.767
PHIN_PIN_LOC_2	-27.477	0.388	-2.768
PHIN_PIN_LOC_3	-27.355	0.658	-2.766
PHIN_PIN_LOC_4	-27.229	0.658	-2.766
PHIN_PIN_LOC_5	-27.345	0.458	-2.768
PHIN_PIN_LOC_6	-27.220	0.458	-2.768
PHIN_PIN_LOC_7	-27.356	0.258	-2.769
PHIN_PIN_LOC_8	-27.231	0.258	-2.769
HP_AFT_AZ_FINAL	-27.565	0.743	-2.790
HP_FWD_AZ_FINAL	-26.900	0.743	-2.792
TX_AZ_FINAL_Mid	-30.172	-0.390	0.424
TX_AZ_FINAL_A	-26.374	-0.390	0.420
TX_AZ_FINAL_B	-33.970	-0.390	0.427
RX_AZ_FINAL_Mid	-25.716	-0.014	0.505
RX_AZ_FINAL_A	-25.708	3.405	0.500
RX_AZ_FINAL_B	-25.724	-3.434	0.510
GP90D-GPS	-37.838	2.933	-30.624
INMARSAT-C	-37.389	2.991	-30.580
STBD WINDBIRD	-36.883	3.043	-30.143
NORTHSTAR 941 GPS	-37.921	1.503	-29.925
FURUNO GPS 1	-37.974	-2.365	-29.852
AIS	-38.138	-2.969	-29.955
FURUNO GPS 2	-36.935	-1.577	-30.537
C-NAV	-37.462	-3.158	-30.235
PORT WINDBIRD	-36.905	-3.145	-30.120
RX_CL_POINT	-25.709	-0.010	0.602
OLD_PHIN_LOCATION_1	-27.246	0.586	-4.418
OLD_PHIN_LOCATION_2	-27.403	0.586	-4.418
OLD_PHIN_LOCATION_3	-27.403	0.430	-4.418
OLD_PHIN_LOCATION_4	-27.246	0.430	-4.418
PLN1 on object	-26.900	0.743	-2.767
PLN2 on Object	-27.565	0.742	-2.765
PLN3 on Object	-27.566	0.172	-2.769
PLN4 on Object	-26.901	0.173	-2.771

(Rev 4)

TABLE 2 BENCHMARKS (Meters)			
Description	X	Y	Z
PBM1	5.133	1.380	-12.576
PBM2	-30.720	0.445	-21.165
PBM3	-34.145	-7.901	-21.187
PBM4	-34.148	7.908	-21.177
PBM5	-43.527	1.672	-21.138
PBM6	-62.810	-3.346	-10.274
PBM7	-66.925	5.816	-9.666
PBM8	-76.297	2.597	-8.462
PBM9	-76.299	-3.487	-8.469
PBM10	-24.456	-0.850	-2.625
PBM11	-25.084	-5.505	-2.598
PBM12	-26.199	5.789	-2.603
PBM13	-33.390	-0.991	-4.761

(Rev 4)

TABLE 3 DRAFT MARKS				
LOCATION	X <sup>(1)</sup>	Y <sup>(1)</sup>	Z <sup>(1)</sup>	Z <sup>(2)</sup>
GONDOLA DMS10	-24.021	5.806	-2.427	10.0
GONDOLA DMS12	-24.015	6.155	-3.038	12.0
GONDOLA DMS14	-23.991	6.387	-3.648	14.0
GONDOLA DMS16	-24.010	6.606	-4.254	16.0
GONDOLA DMS18	-24.013	6.818	-4.861	17.9
GONDOLA DMS20	-24.012	7.025	-5.470	19.9
GONDOLA DMS24	-23.988	7.340	-6.692	24.0
GONDOLA DMP10	-24.140	-5.834	-2.418	9.9
GONDOLA DMP12	-24.117	-6.173	-3.028	11.9
GONDOLA DMP14	-24.131	-6.420	-3.639	13.9
GONDOLA DMP16	-24.104	-6.637	-4.250	15.9
GONDOLA DMP18	-24.103	-6.850	-4.856	17.9
GONDOLA DMP20	-24.106	-7.049	-5.463	19.9
GONDOLA DMP24	-24.135	-7.376	-6.683	23.9
AFT DMS16	-69.925	6.806	-4.856	15.9
AFT DMS18	-69.937	7.322	-5.467	17.9
AFT DMS20	-69.935	7.653	-6.078	19.9
AFT DMP 16	-70.096	-6.727	-4.868	16.0
AFT DMP 18	-70.079	-7.276	-5.489	18.0
AFT DMP 20	-70.093	-7.607	-6.110	20.0
FWD DMS9	-4.842	0.832	-2.737	9.0
FWD DMS10	-4.836	0.929	-3.040	10.0
FWD DMS12	-4.849	1.148	-3.653	12.0
FWD DMS14	-4.830	1.383	-4.262	14.0
FWD DMS16	-4.841	1.661	-4.871	16.0
FWD DMS18	-4.833	1.946	-5.480	18.0
FWD DMS20	-4.834	2.264	-6.090	20.0
FWD DMS22	-4.845	2.593	-6.693	22.0
FWD DMP10	-4.951	-1.014	-3.048	10.0
FWD DMP12	-4.951	-1.233	-3.656	12.0
FWD DMP14	-4.979	-1.490	-4.269	14.0
FWD DMP16	-4.960	-1.763	-4.879	16.0
FWD DMP18	-4.963	-2.068	-5.493	18.0
FWD DMP20	-4.969	-2.389	-6.103	20.0
FWD DMP22	-4.962	-2.716	-6.705	22.0

(1) : Coordinate value with respect to Origin, in Meters

(2) : Measured at bottom of Draft Mark weld, Elevation above projection in Feet

(Rev 4)



## Certificate of Calibration

Item No. / Model: NET1200

Manufacturer: SOKKIA CO., LTD.

Serial No.: 110350

Certificate Number: 69640

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/NCCL 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 THE

Customer Address: 19004 E. Ringo Circle

Customer City/State/Zip: Independence, MO 64057

See Individual sets of data for temperature and pressure

Date Calibrated: 01/19/2011 Date Recalibration Due: 01/19/2012

Signed: *Randy Tipton* Date: 01/19/2011

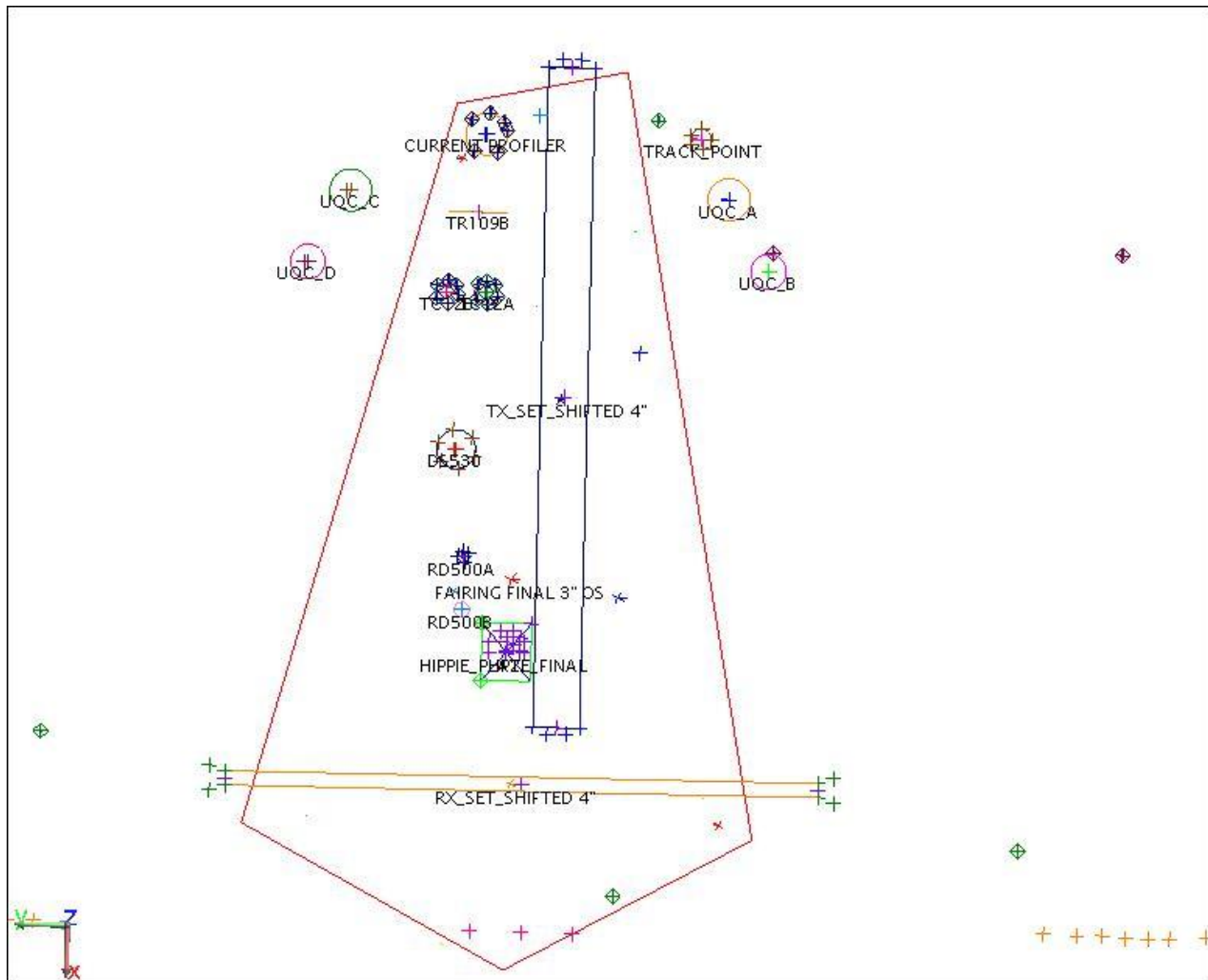
Yes No  
     X Is this a new instrument?

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

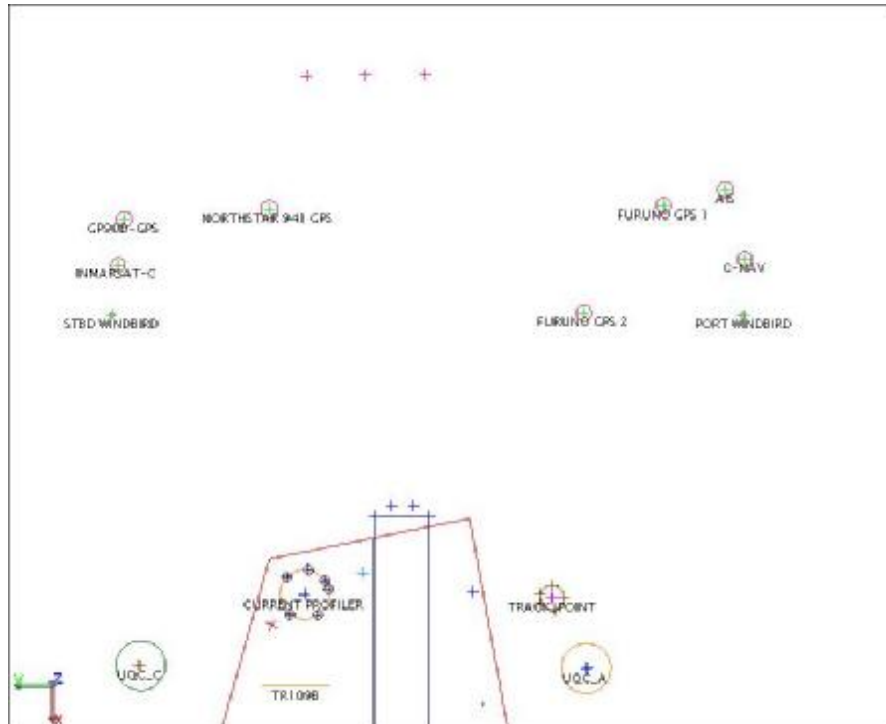
     X Is this the first NIST calibration we have performed on this instrument?  
X      Were the calibration seals intact when the instrument was received?  
     X Were the initial collimation inspection results within tolerance?  
     X Were the initial EDM inspection results within tolerance?  
     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

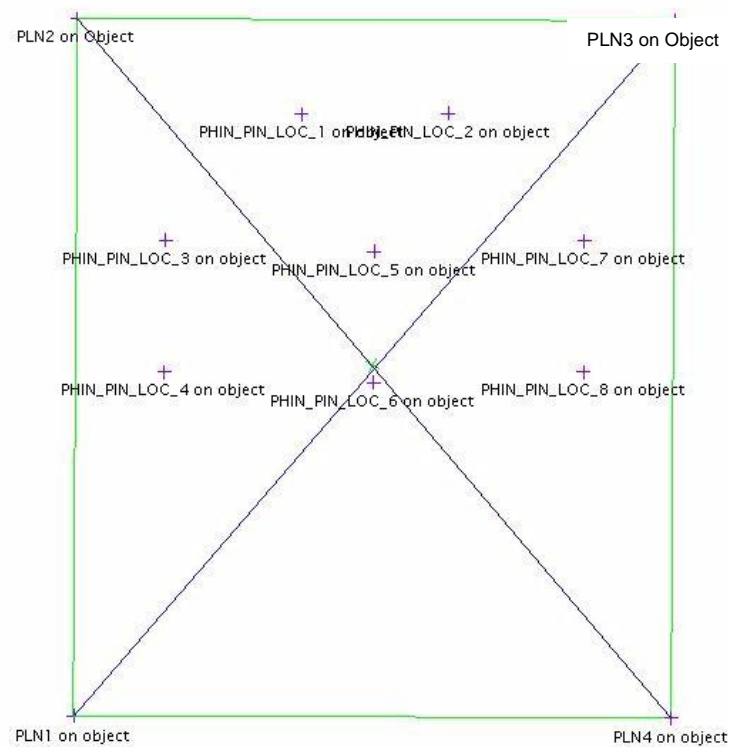
Page 1 of 2



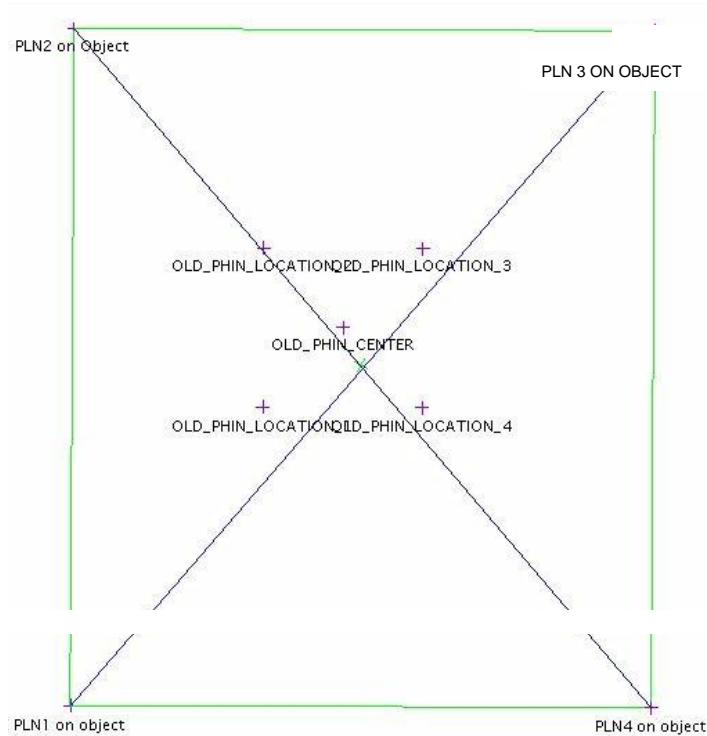
**Fairing Features**



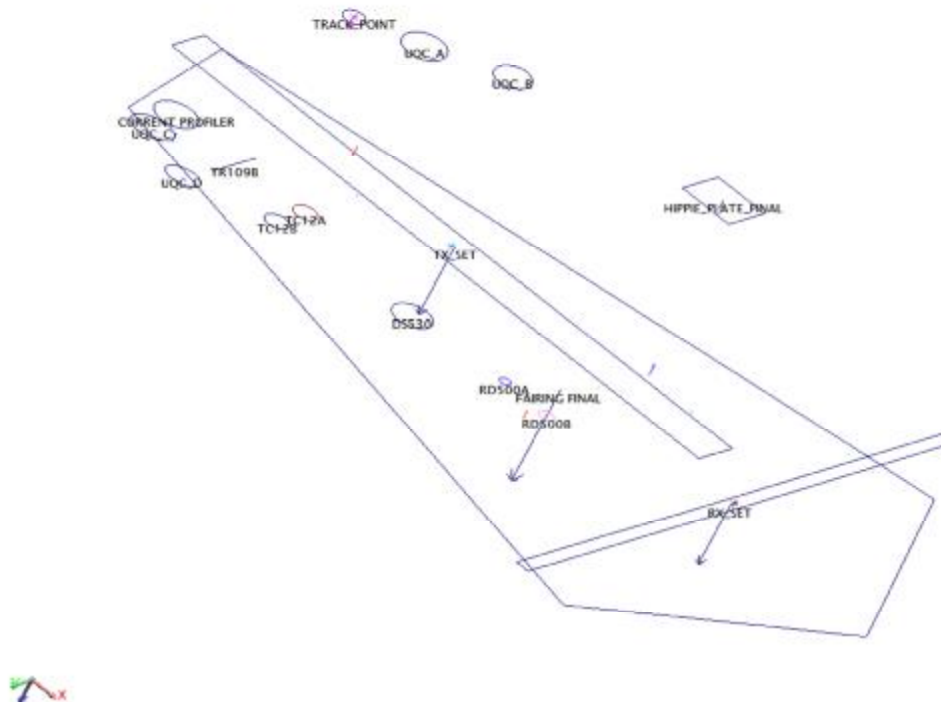
### Mast Features



### Hippy Plate



**Old PHIN Locations**



FINAL DATA-HIPPY PLATE		
Proj. Ang.	Rx from Y	Ry from Z
{deg.}	90.4122	0.1424
	STBD DOWN	BOW DOWN

FINAL DATA-TX SET		
Proj. Ang.	Rx from Y	Ry from Z
{deg.}	89.8531	0.0581
	STBD UP	BOW UP

FINAL DATA-RX SET		
Proj. Ang.	Rx from Y	Ry from Z
{deg.}	89.9120	-0.0277
	STBD UP	BOW DOWN

TX-AZIMUTH= 0.00568 Degrees to Stbd  
 RX AZIMUTH= 0.13801 Degrees to Port

(Rev-4)