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NSF-ISR

Registered
to AS9100



R/V Neil Armstrong , AGOR 27
IMU Heading, 3 Flying Bridge Antennas, and 01 Deck Benchmarks Survey Report
February 9, 2017

TOOL#:	CUSTOMER: Woods Hole Oceanographic Institution	DATE: 2/9/2017	UNIT: millimeters	EQUIPMENT: Leica AT401 SN 390600
TOOL S/N:	TOOL NAME: R/V Neil Armstrong	INSPECTOR: T. Yen		NEXT CAL DATE: 01/25/2017

Task: Survey IMU Heading

Instrument Alignment: Best-Fit transformation of (4) transducer room benchmarks to values reported in the original survey performed by IMTEC Group, reported in meters

Best-Fit Transformation (Summary)				
IMU::leica0_loc to A::Benchmarks WHOI				
2/9/2017 5:08:17 PM				
Results	X	Y	Z	Mag
Count	4	4	4	4
Max Error	0.0007	0.0005	0.0000	0.0007
RMS Error	0.0004	0.0003	0.0000	0.0005
StdDev Error	0.0005	0.0003	0.0000	0.0006
Max Error (all)	0.0007	0.0005	0.0000	0.0007
RMS Error (all)	0.0004	0.0003	0.0000	0.0005
	Unknowns	6	Equations	12
Transformation				
Translation	22.0195	1.2029	-1.9248	22.1362
Rotation (Fixed XYZ)	179.801	0.408	-171.944	
Rotation (Euler xyz)	-179.746	0.376	171.942	
Rotation (Angle axis)	-0.070251	0.997527	0.001983	179.607
Matrix	-0.990106	-0.140166	0.006561	22.019507
	-0.140139	0.990122	0.004438	1.202934
	-0.007118	0.003475	-0.999969	-1.924799
	0.000000	0.000000	0.000000	1.000000
Scale Factor				1.000000
Working frame	A::WHOI			

Best-Fit Transformation (Details)											
IMU::leica0_loc to A::Benchmarks WHOI											
2/9/2017 5:08:17 PM											
Name	On	Nom X	Nom Y	Nom Z	Wt X	Wt Y	Wt Z	dX	dY	dZ	dMag
DUCER_ROOM_1	X	19.0900	0.0670	-2.6746	1.000	1.000	1.000	-0.0007	-0.0002	0.0000	0.0007
DUCER_ROOM_2	X	24.2010	-3.6340	-2.6635	1.000	1.000	1.000	0.0003	0.0005	-0.0000	0.0006
DUCER_ROOM_3	X	29.8680	-1.0360	-3.0231	1.000	1.000	1.000	0.0001	-0.0001	-0.0000	0.0001
DUCER_ROOM_4	X	26.2180	3.6340	-2.6997	1.000	1.000	1.000	0.0003	-0.0002	0.0000	0.0004

IMU Measurements: The starboard edge of the IMU base was measured 4 times showing azimuth angles that averages out to .407° Port. I cannot provide a good explanation for the large variance in azimuth heading, as the RMS errors for each edge measurement is very small.

IMU AZ	
	Measured
Linearity	0.0223
RMS	0.0304
Measurements	5

IMU AZ - Point List		
Point Name		Error
IMU::IMU AZ::p5		0.0205
IMU::IMU AZ::p4		0.0206
IMU::IMU AZ::p3		0.0422
IMU::IMU AZ::p2		0.0401
IMU::IMU AZ::p1		0.0199

Line IMU::GR-IMU AZ			
	X	Y	Z
Begin	27813.0881	-164.1953	-1065.5906
End	28019.9028	-165.7719	-1065.4900
Direction	0.999971	-0.007623	0.000487
Proj. Ang. (deg.)	Rx from Y 176.348	Ry from Z 89.972	Rz from X -0.437
Length	206.8207		

IMU AZ1	
	Measured
Linearity	0.0634
RMS	0.0537
Measurements	5

IMU AZ1 - Point List		
Point Name		Error
IMU::IMU AZ1::p1		0.0293
IMU::IMU AZ1::p2		0.0781
IMU::IMU AZ1::p3		0.0794
IMU::IMU AZ1::p4		0.0160
IMU::IMU AZ1::p5		0.0300

Line IMU::GR-IMU AZ1			
	X	Y	Z
Begin	27813.0458	-164.3015	-1065.5378
End	28019.7996	-165.7272	-1065.5396
Direction	0.999976	-0.006895	-0.000009
Proj. Ang. (deg.)	Rx from Y -179.928	Ry from Z 90.000	Rz from X -0.395
Length	206.7587		

IMU AZ2	
	Measured
Linearity	0.0541
RMS	0.0396
Measurements	5

IMU AZ2 - Point List		
Point Name		Error
IMU::IMU AZ2::p1		0.0566
IMU::IMU AZ2::p2		0.0606
IMU::IMU AZ2::p3		0.0187
IMU::IMU AZ2::p4		0.0065
IMU::IMU AZ2::p5		0.0241

Line IMU::GR-IMU AZ2			
	X	Y	Z
Begin	27811.3155	-164.2884	-1065.5465
End	28021.9489	-165.7069	-1065.4994
Direction	0.999977	-0.006734	0.000223
Proj. Ang. (deg.)	Rx from Y 178.100	Ry from Z 89.987	Rz from X -0.386
Length	210.6382		

IMU AZ3	
	Measured
Linearity	0.0497
RMS	0.0317
Measurements	5

IMU AZ3 - Point List		
Point Name		Error
IMU::IMU AZ3::p1		0.0279
IMU::IMU AZ3::p2		0.0553
IMU::IMU AZ3::p3		0.0324
IMU::IMU AZ3::p4		0.0056
IMU::IMU AZ3::p5		0.0105

Line IMU::GR-IMU AZ3			
	X	Y	Z
Begin	27812.4736	-164.2268	-1065.6018
End	28022.5171	-165.7331	-1065.4886
Direction	0.999974	-0.007171	0.000539
Proj. Ang. (deg.)	Rx from Y 175.700	Ry from Z 89.969	Rz from X -0.411
Length	210.0490		

Azimuth

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IMU Measurement Data

Point Group IMU::IMU AZ			
Point Name	X	Y	Z
p1	28019.9027	-165.7902	-1065.4821
p2	27975.9713	-165.4046	-1065.4877
p3	27933.8995	-165.1206	-1065.5738
p4	27864.3014	-164.6048	-1065.5734
p5	27813.0882	-164.1861	-1065.5723

Point Group IMU::IMU AZ1			
Point Name	X	Y	Z
p1	27813.0460	-164.2824	-1065.5157
p2	27872.3315	-164.7881	-1065.5457
p3	27920.4443	-164.9725	-1065.5770
p4	27978.3347	-165.4269	-1065.5321
p5	28019.7994	-165.7524	-1065.5234

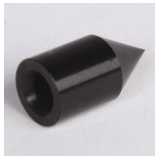
Point Group IMU::IMU AZ2			
Point Name	X	Y	Z
p1	27811.3151	-164.3450	-1065.5457
p2	27859.3157	-164.5511	-1065.5328
p3	27911.9185	-164.9474	-1065.5271
p4	27973.7559	-165.3813	-1065.5166
p5	28021.9488	-165.7303	-1065.4936

Point Group IMU::IMU AZ3			
Point Name	X	Y	Z
p1	27812.4738	-164.1996	-1065.5957
p2	27859.4621	-164.6191	-1065.5761
p3	27918.7027	-164.9581	-1065.5553
p4	27973.5299	-165.3793	-1065.5200
p5	28022.5171	-165.7382	-1065.4794

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Task: Measure Heading of Main Granite Block

Comment: Two points on the end of the scribed line were measured to form a line. Using a hard point adaptor as shown, a sphere is measured about each point. The center of the calculated sphere is the desired point itself.



Line IMU::GR-MAIN GRANITE X			
	X	Y	Z
Begin	21787.4275	-0.1943	-1103.2281
End	22067.4140	0.6198	-1103.5502
Direction	0.999995	0.002908	-0.001150
Proj. Ang. (deg.)	Rx from Y -21.586	Ry from Z 90.066	Rz from X 0.167
Length	279.9878		

MAIN GRANITE X1	
	Measured
Diameter	63.2944
X	21787.4275
Y	-0.1943
Z	-1103.2281
Sphereicity	0.0349
RMS	0.0126
Measurements	9

MAIN GRANITE X1 - Point List	
Point Name	Error
IMU::MAIN GRANITE X1::p1	0.0151
IMU::MAIN GRANITE X1::p2	-0.0056
IMU::MAIN GRANITE X1::p3	-0.0097
IMU::MAIN GRANITE X1::p4	-0.0132
IMU::MAIN GRANITE X1::p5	0.0175
IMU::MAIN GRANITE X1::p6	-0.0175
IMU::MAIN GRANITE X1::p7	-0.0065
IMU::MAIN GRANITE X1::p8	0.0152
IMU::MAIN GRANITE X1::p9	0.0046

MAIN GRANITE X2	
	Measured
Diameter	63.2171
X	22067.4140
Y	0.6198
Z	-1103.5502
Sphereicity	0.0510
RMS	0.0160
Measurements	9

MAIN GRANITE X2 - Point List	
Point Name	Error
IMU::MAIN GRANITE X2::p1	-0.0025
IMU::MAIN GRANITE X2::p2	-0.0156
IMU::MAIN GRANITE X2::p3	-0.0094
IMU::MAIN GRANITE X2::p4	0.0086
IMU::MAIN GRANITE X2::p5	-0.0036
IMU::MAIN GRANITE X2::p6	-0.0182
IMU::MAIN GRANITE X2::p7	0.0190
IMU::MAIN GRANITE X2::p8	-0.0109
IMU::MAIN GRANITE X2::p9	0.0327

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Task: Survey locations of 3 antennas on the flying bridge

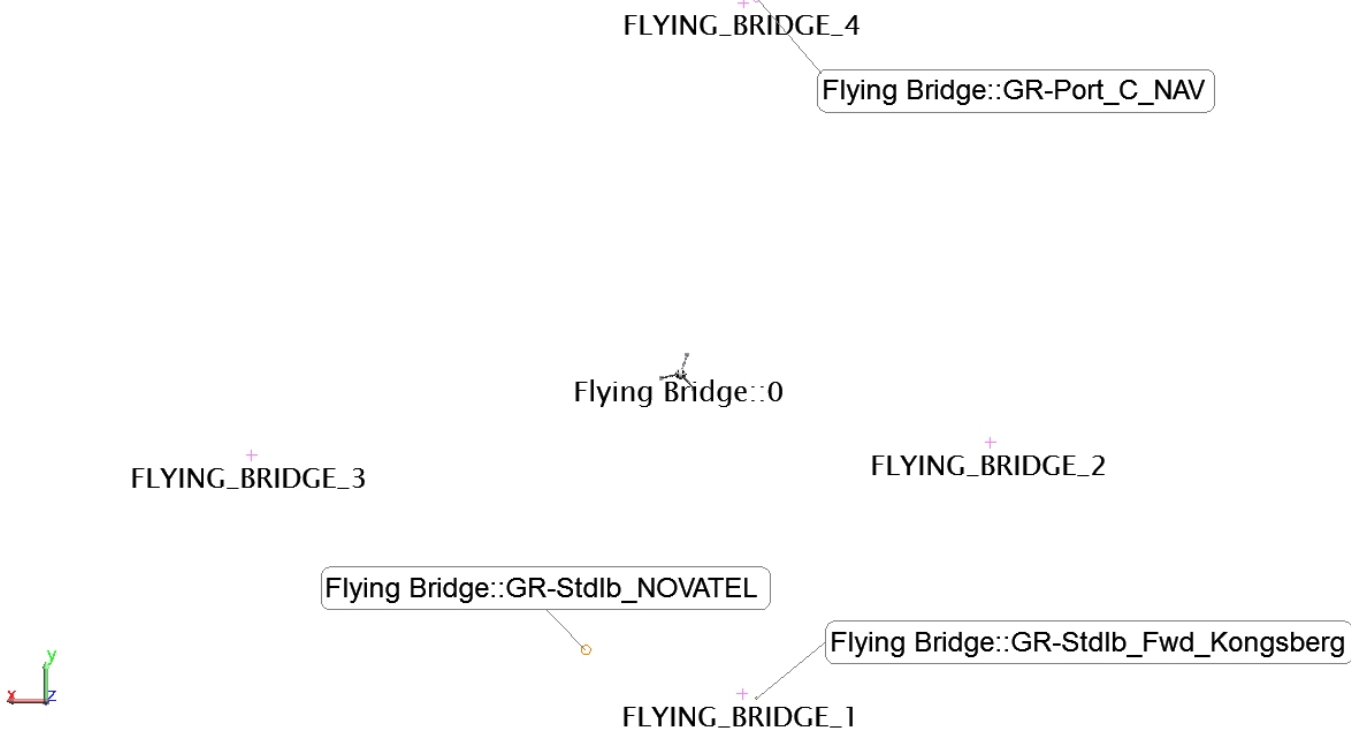
Instrument Alignment: Best-Fit transformation of (4) flying bridge benchmarks to values reported in the original survey performed by IMTEC Group, reported in millimeters

Best-Fit Transformation (Summary)				
Flying Deck::leica0_loc to A::Benchmarks WHOI				
2/9/2017 7:07:29 PM				
Results	X	Y	Z	Mag
Count	4	4	4	4
Max Error	2.4329	1.7611	1.1658	2.7653
RMS Error	1.5130	1.0171	0.8989	2.0327
StdDev Error	1.7471	1.1744	1.0380	2.3471
Max Error (all)	2.4329	1.7611	1.1658	2.7653
RMS Error (all)	1.5130	1.0171	0.8989	2.0327
Unknowns	7		Equations	12
Transformation				
Translation	27462.8889	20372.5120	-21282.1536	40276.2905
Rotation (Fixed XYZ)	-0.162	0.163	-80.061	
Rotation (Euler xyz)	0.133	0.188	-80.061	
Rotation (Angle axis)	-0.000264	0.003110	-0.999995	80.061
Matrix	0.172631	0.985185	0.003282	27462.888948
	-0.985187	0.172639	-0.002313	20372.511985
	-0.002845	-0.002833	1.000193	-21282.153564
	0.000000	0.000000	0.000000	1.000000
Scale Factor				1.000201
Working frame	A::WHOI			

Best-Fit Transformation (Details)											
Flying Deck::leica0_loc to A::Benchmarks WHOI											
2/9/2017 7:07:29 PM											
Name	On	Nom X	Nom Y	Nom Z	Wt X	Wt Y	Wt Z	dX	dY	dZ	dMag
FLYING_BRIDGE_1	X	31046.0000	-6689.0000	-19093.2000	1.000	1.000	1.000	1.6824	1.7611	1.0925	2.6693
FLYING_BRIDGE_2	X	26238.0000	-1822.0000	-19251.9000	1.000	1.000	1.000	-2.4329	-0.6073	-1.1658	2.7653
FLYING_BRIDGE_3	X	40581.0000	-2057.0000	-19084.3000	1.000	1.000	1.000	0.1241	-0.6092	-0.5450	0.8267
FLYING_BRIDGE_4	X	31024.0000	6705.0000	-19080.1000	1.000	1.000	1.000	0.6264	-0.5446	0.6184	1.0350

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Antenna Coordinates



Antenna Locations in WHOI Reference Frame				
ELEMENT	COORDINATE (METERS)			
	X	Y	Z	
Stbd NOVATEL	34.081	-5.841	-20.636	Phase Center
Stbd Fwd Kongsberg	30.774	-6.787	-22.644	Center of Mounting Hole
Port C NAV	30.776	6.772	-22.917	Phase Center

Antenna Locations in Kornsborg Reference Frame				
ELEMENT	COORDINATE (METERS)			
	X	Y	Z	
Stbd NOVATEL	-12.133	5.841	-19.533	Phase Center
Stbd Fwd Kongsberg	-8.826	6.787	-21.542	Center of Mounting Hole
Port C NAV	-8.827	-6.771	-21.815	Phase Center

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Starboard Novatel Data

Circle measurements taken around the circumference

Circle Flying Bridge::GR-StdIb_NOVATEL			
	X	Y	Z
Origin	34081.3520	-5840.7915	-20635.5578
Normal	0.012431	-0.030085	-0.999470
Proj. Ang. (deg.)	Rx from Y -91.724	Ry from Z 179.287	Rz from X -67.551
Radius	90.6726	Diameter	181.3453

StdIb_NOVATEL	
	Measured
Diameter	181.3453
X	34081.3520
Y	-5840.7915
Z	-20635.5578
Circularity	0.1657
RMS	0.1233
Measurements	6

StdIb_NOVATEL - Point List			
Point Name	Error	Radial Error	Planar Error
Flying Bridge::StdIb_NOVATEL::p1	0.1141	-0.0768	0.0844
Flying Bridge::StdIb_NOVATEL::p2	0.1054	0.0889	-0.0566
Flying Bridge::StdIb_NOVATEL::p3	0.0884	-0.0205	-0.0860
Flying Bridge::StdIb_NOVATEL::p4	0.1975	-0.0573	0.1890
Flying Bridge::StdIb_NOVATEL::p5	0.1419	0.0564	-0.1303
Flying Bridge::StdIb_NOVATEL::p6	0.0093	0.0092	-0.0006

Point Group Flying Bridge::StdIb_NOVATEL			
Point Name	X	Y	Z
p1	34171.3537	-5829.9815	-20641.2016
p2	34123.4527	-5760.5559	-20643.7461
p3	34040.0317	-5760.3861	-20644.7593
p4	33991.5112	-5829.8957	-20643.5456
p5	34017.8593	-5905.7032	-20640.6166
p6	34162.8640	-5880.8192	-20639.6919

Port C Nav Data

Circle measurements taken around the circumference

Circle Flying Bridge::GR-Port_C_NAV			
	X	Y	Z
Origin	30775.7616	6771.6485	-22917.1286
Normal	0.005315	-0.032836	-0.999447
Proj. Ang. (deg.)	Rx from Y -91.882	Ry from Z 179.695	Rz from X -80.806
Radius	70.4237	Diameter	140.8474

Port_C_NAV	
	Measured
Diameter	140.8474
X	30775.7616
Y	6771.6485
Z	-22917.1286
Circularity	0.3024
RMS	0.1222
Measurements	7

Port_C_NAV - Point List			
Point Name	Error	Radial Error	Planar Error
Flying Bridge::Port_C_NAV::p1	0.0224	0.0041	0.0220
Flying Bridge::Port_C_NAV::p2	0.0106	0.0059	0.0089
Flying Bridge::Port_C_NAV::p3	0.1107	0.0510	-0.0983
Flying Bridge::Port_C_NAV::p4	0.1686	-0.0559	0.1591
Flying Bridge::Port_C_NAV::p5	0.1168	-0.0877	-0.0772
Flying Bridge::Port_C_NAV::p6	0.1926	0.1925	0.0071
Flying Bridge::Port_C_NAV::p7	0.1120	-0.1099	-0.0216

Point Group Flying Bridge::Port_C_NAV			
Point Name	X	Y	Z
p1	30705.4807	6767.4581	-22923.7402
p2	30717.1744	6732.4145	-22922.5135
p3	30748.1374	6706.6527	-22921.3952
p4	30792.0464	6703.0088	-22921.2996
p5	30824.3477	6720.5891	-22921.4689
p6	30805.1693	6707.2627	-22921.2174
p7	30761.4986	6702.6304	-22921.2688

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Starboard Forward Kongsberg Data

Antenna was missing, mounting hole measured instead

Circle Flying Bridge::GR-StdIb_Fwd_Kongsberg			
	X	Y	Z
Origin	30773.9851	-6787.2769	-22644.2597
Normal	0.023830	-0.002650	-0.999713
Proj. Ang. (deg.)	Rx from Y -90.152	Ry from Z 178.634	Rz from X -6.346
Radius	19.0576	Diameter	38.1152

StdIb_Fwd_Kongsberg - Point List			
Point Name	Error	Radial Error	Planar Error
Flying	0.0688	-0.0581	0.0369
Bridge::StdIb_Fwd_Kongsberg::p1			
Flying	0.0792	0.0158	0.0776
Bridge::StdIb_Fwd_Kongsberg::p2			
Flying	0.0577	0.0564	-0.0122
Bridge::StdIb_Fwd_Kongsberg::p3			
Flying	0.0999	-0.0663	-0.0747
Bridge::StdIb_Fwd_Kongsberg::p4			
Flying	0.1085	0.0347	0.1028
Bridge::StdIb_Fwd_Kongsberg::p5			
Flying	0.1315	0.0174	-0.1304
Bridge::StdIb_Fwd_Kongsberg::p6			

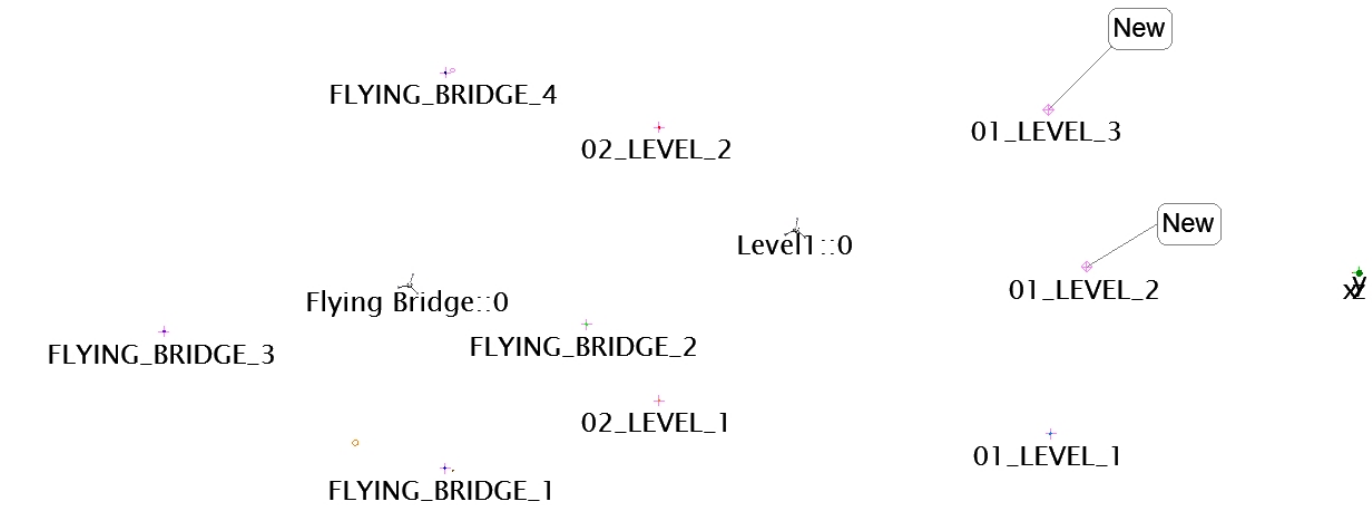
StdIb_Fwd_Kongsberg	
	Measured
Diameter	38.1152
X	30773.9851
Y	-6787.2769
Z	-22644.2597
Circularity	0.1226
RMS	0.0943
Measurements	6

Point Group Flying Bridge::StdIb_Fwd_Kongsberg			
Point Name	X	Y	Z
p1	30788.1226	-6779.1450	-22669.3885
p2	30777.9094	-6771.7960	-22669.6921
p3	30764.1585	-6775.2963	-22669.9208
p4	30758.8872	-6789.2105	-22669.9470
p5	30774.6220	-6803.2617	-22669.7122
p6	30790.4518	-6788.3360	-22669.1412

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New 01 Level Benchmarks [0.500" offset]

Instrument Alignment: Temporary benchmarks were glued down to the 01 level and valued while the tracker was still set up on the flying bridge. Tracker was then relocated to 02 level to measure the new (2) 01 level benchmarks.



NB: 0.500" offset

New 01 Level Benchmarks in WHOI Reference Frame			
Location	COORDINATE (METERS)		
	X	Y	Z
01 Level 2	9.2617	1.6220	-12.2516
01 Level 3	10.5572	5.4851	-12.2559

New 01 Level Benchmarks in Kornsborg Reference Frame			
Location	COORDINATE (METERS)		
	X	Y	Z
01 Level 2	12.6867	-1.6205	-11.1494
01 Level 3	11.3911	-5.4850	-11.1537