Surveying of Outrigger Tanks

Matthew Green and Cy Hoffman

The locations of the outrigger tanks tanks have been resurveyed using a laser-based theodolite borrowed from LANSCE Division. This system, which is basically the same as the system used by Ken Butterfield in previous surveys, uses light reflected from a corner reflector to determine the theodolite orientation and the distance to the reflector. The input to the survey is the location of a bolt on each corner of the pond used to hold the cover down. Ken had marked these bolts (painted black) and used them as fiducials in his surveys. The elevation of the fiducial includes 13.5 cm for the height of an aluminum spacer block and the corner reflector - in other words, the fiducial height is the height of the corner reflector, not the top of the bolt.

The surveying was performed in the first three weeks of January, 2001. Matthew Green operated the theodolite (and its onboard computer). He was assisted by Damian Blazy, Scott Delay, and Cy Hoffman. The intrinsic accuracy of the instrument is mm, although in practice it is limited by how well we know the location of the corner reflector relative to the point we want to measure. Nevertheless, it blows away the hand surveying Scott and I did in December, and should be viewed as superceding those measurements. One important benefit of this system is that it is free of mistakes (as opposed to errors) - the hand survey always has the strong possibility of getting the inches right but the feet wrong.

Table I gives the locations of the 23 newly-installed outriggers in the "standard" coordinate system. Recently, Allen Mincer suggested using a translated coordinate system so the measurements are also given in that system (labeled "NYU"). For these measurements, the corner reflector is placed on the top of the "mushroom" at the top center of each tank. The coordinates given have the 7-cm height of the corner reflector subtracted out (no spacer block is used here). Remember that the coordinates given for the bolts **do not** subtract out the 13.5 cm from the top of the bolt to the height of the corner reflector.

We have checked these coordinates with the locations obtained earlier in the hand survey and they are consistent (after correcting a few systematic errors in the hand survey). The differences are usually a couple of centimeters in N-S and E-W, and ~1 cm for the elevations.

In the course of these measurements, one new fiducial was scribed on the concrete pad outside the door to the pond. The location of this fiducial is:

3919.2 (N), -1914.4 (E), 810.8 (Elev.)

or

3829.2 (N-NYU), -1895.4 (E-NYU), 766.8 (Elev-NYU).

The elevation given here is for the top of the concrete - no height for a corner reflector is included. The height was determined by calculating the height of the scope (with its computer) and measuring the height of the center of the scope with a tape measure.

Tank or Bolt	North	East	Elev.	North-NYU	East-NYU	Elev-NYU
NE corner	**5132.4**	**1052.3**	814.1	5042.4	1071.3	770.1
NW corner	**2643.4**	**-4520.9**	813.3	2553.4	-4501.9	769.3
SE corner	**-2384.7**	**4435.4**	811.5	-2474.7	4454.4	767.5
SW Corner	**-4883.6**	**-1157.9**	815.8	-4973.6	-1138.9	771.8
1	3754.8	-2466.7	922.6	3664.8	-2447.7	878.6
2	4274.6	-1275.8	918.3	4184.6	-1256.82	874.3
3	4619.8	-534.1	925.1	4529.8	-515.12	881.1
4	4843.7	-82.3	926.7	4753.7	-63.34	882.7
5	5151.9	573.9	930.1	5061.9	592.89	886.1
6	4511.2	1506.4	920.4	4421.2	1525.39	876.4
7	3806.5	1814.5	922.3	3716.5	1833.48	878.3
8	3144.7	2119.9	924.8	3054.7	2138.94	880.8
9	2490.6	2426.0	921.1	2400.6	2445.04	877.1
10	1809.0	2733.3	922.6	1719.0	2752.31	878.6
11	1090.3	3064.8	922.1	1000.3	3083.82	878.1
12	438.3	3358.5	919.7	348.3	3377.5	875.7
13	-254.5	3655.8	921.7	-344.5	3674.82	877.7
14	-846.7	3935.8	920.5	-936.7	3954.83	876.5
15	-1556.0	4252.5	918.9	-1646.0	4271.48	874.9
16	-2691.1	4132.8	912.6	-2781.1	4151.83	868.6
17	-2966.4	3523.3	910.5	-3056.4	3542.33	866.5
18	-3234.2	2932.3	914.6	-3324.2	2951.3	870.6
19	-3571.8	2156.8	916.4	-3661.8	2175.79	872.4
20	-3978.5	1269.9	919.7	-4068.5	1288.92	875.7
21	-4323.7	510.9	917.2	-4413.7	529.88	873.2
22	-4602.6	-61.5	917.8	-4692.6	-42.47	873.8
23	-4856.0	-615.6	919.6	-4946.0	-596.59	875.6

Table 1: Coordinates (in cm) of the outrigger tanks #1-23 in the coordinate system previously used and the newly proposed "NYU" coordinate system. The locations of the four corner bolts are also given.

The outrigger tanks that were installed last year were also surveyed. The coordinates of these are given in Table 2. Note that two tank numbers are given for the tanks inside the old fence; the old tank number, and the number to be used in the future (in parentheses). The tanks outside the old fence (old tank # 2,3,5,6,7,10) do not yet have new numbers.

Tank #	North	East	Elev.	North-NYU	East-NYU	Elev-NYU
1 (44)	-4123.4	-3015.9	701.6	-4213.4	-2996.9	657.6
2	4061.2	-6112.0	767.0	3971.2	-6093.0	723.0
3	5888.6	-5772.7	854.2	5798.6	-5753.7	810.2
4 (46)	-2833.0	-4187.8	511.5	-2923.0	-4168.8	467.5
5	6754.4	-3473.2	926.6	6664.4	-3454.2	882.6
6	4908.1	-5586.4	831.1	4818.1	-5567.4	787.1
7	5814.5	-3094.0	892.6	5724.5	-3075	848.6
9 (50)	-748.2	-5434.9	395.9	-838.2	-5415.9	351.9
10	5529.5	-4031.2	875.1	5439.5	-4012.2	831.1
11 (48)	-1658.9	-5038.4	395.6	-1748.9	-5019.4	351.6
12 (54)	3547.3	-5479.9	803.6	3457.3	-5460.9	759.6

Table 2: Coordinates (in cm) of the old outrigger tanks in the coordinate system previously used and the newly proposed "NYU" coordinate system. The old tank number and the new tank number in parentheses are given in the first column.

Note that while all of the coordinates outside the pond are measured in a consistent coordinate system, nothing new has been done (or can be done) to relate these measurements with measurements made inside the pond. Also, the elevations of the tanks given are all consistently measured, but they are just an arbitrary physical point on the tank. While this point could be used to determine the relative elevations of any point in a tank and a shower-layer PMT, it is some other effective tank elevation that is determined by light paths and travel times, that is needed to combine outriggers and shower-layer PMTs in a fit. This can only be obtained by looking at events and finding the best effective tank height. Thus there appears to be no reason to worry about relatively small (10s of cm) uncertainties in the relative elevations of coordinates inside and outside the pond.

Finally, the locations of the 6 WACT pads were surveyed. The locations are scribed on the concrete pads. Four of the six pads have two marks, and these two locations are given in Table 3. For simplicity, the pads are labeled with their location relative to the pond. So, for example, the "NE Near" pad was the first one laid and is inside the old fence near the sea-container holding the rafts. Note that these elevations do not agree well with the hand measurements made in December of pad SE Far and SW Far (the others do agree). These two pads were very difficult to measure in December so the discrepancy is not surprising. In all cases, take these new measurements as correct.

WACT Pad	North	East	Elev.	North-NYU	East-NYU	Elev-NYU
NE Near A	6385.5	943.5	834.1	6295.5	962.5	790.1
NE Near B	6383.5	941.2	829.2	6293.5	960.2	785.2
SE Near	-1309.8	6128.2	623.2	-1399.8	6147.2	579.2
SE Far A	-6924.3	10583.7	39.3	-7014.3	10602.7	-4.7
SE Far B	-7012.4	10842.3	41.0	-7102.4	10861.3	-3.0
SW Far	-13174.1	857.0	376.7	-13264.1	876.0	332.7
NW Near A	3533.9	-6006.3	659.8	3443.9	-5987.3	615.8
NW Near B	3476.8	-5870.7	659.8	3386.8	-5851.7	615.8
NW Far A	5374.5	-11758.4	652.5	5284.5	-11739.4	608.5
NW Far B	5314.8	-11647.8	653.3	5224.8	-11628.8	609.3

Table 3: The locations (in cm) of the marks on the six WACT pads.