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What Accuracy Should I Expect from My MobileMapper 6 GPS?

Date: 24 July 2010
By: Mark Silver, ms@igage.com, Igage Mapping Corporation, +1 801-412-0011

Note: all of the raw data and spreadsheets used for this note are available in a single ZIP file which you can download from:

http://www.ashgps.com/ms/mm6/mm6_oly/MM6_OLY_DATA.zip

SYNOPSIS

What accuracy and repeatability can we expect with careful collection techniques using the $900 Ashtech Mobile Mapper 6 GPS receiver under moderate conditions?

CONCLUSIONS

Real Time:

50% CEP = 1.9 Meters meets the 2-5 meter accuracy stated on the datasheet.

Post Processed:

2DRMS 1-Sigma = 0.108 Meters, this accuracy is substantially better than the ½ meter stated accuracy of the MM6.

INTRODUCTION

The accuracy of a given GPS receiver is a function of canopy, satellite constellation, ionospheric conditions, sunspot emissions, distance to reference correction data (if post-processed), antenna type and the user's collection technique.

Because the satellite constellation does not repeat and we have no control over the ionosphere, it is difficult to estimate exact accuracy and more difficult to compare receivers unless we test them at the same location, with the same satellite constellation and the same ionospheric conditions.

However I think it is reasonable to run a test in average conditions and look at the results to get a general idea of performance, which is what I have done for this note.

I collected two points with a MobileMapper 6 receiver using the Ashtech MobileMapper Field software and a L1 antenna (the Ashtech R802001) capable of being mounted on a quick-release fitting so I can accurately move the GPS antenna between the two points.

For the first point I selected the OLYMPIC mark, near the University of Utah. I have included a data sheet for this mark at the end of this paper. The second point was a random point 5 meters distant from the OLYMPIC mark.

OLYMPIC is a class 0 horizontal mark, set by David Doyle of the NGS in commemoration of the 2002 Winter Olympics. The University has since planted some large trees surrounding the mark and the mark now suffers from some canopy issues, however I think that this makes this location a reasonable approximation of real-world moderate canopy conditions.

On the first point OLYMPIC, I set a 2 meter fixed height tripod with the required quick connect fitting on the head (HI = 2.10 Meters). I verified the ARP position using a PM500 Dual Frequency RTK receiver logged into the TURN reference system (http://turngps.utah.gov):



DF4639 OLYMPIC, Pnt 1

NGS Datasheet: 40 45 32.75708 N 111 50 41.20721 W NAD83
4,512,358.561 N 428,694.293 E
ELLIP HEIGHT- 1419.232
GEOID HEIGHT- -16.52

Ortho Height- **1435.8**

PM500 Measured:
4,512,358.556 N 428,694.320 E; Ortho: 1435.852

On the second "random" point, I set a 2 meter pole with a prism pole tripod.

RANDOM POINT, Pnt 2

PM500 Measured:
4,512,360.158 N 428,699.473 E; Ortho 1435.362

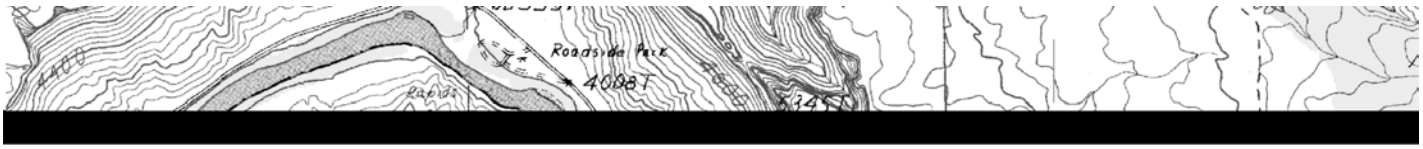
With the antenna mounted on Pnt 2, I created a new job on the SD card named "oly.map". This job contains a single shapefile "olypt.shp" with a couple of attributes. The job was opened at 2:27 PM July 23, 2010 and closed at 4:07 PM. The matching raw data file for this file is "063110072301.grw".

I set the GPS Height to 2.10 meters under "Options: Antenna" and then moved the antenna to Pnt 1, waited 5-seconds and stored a 60 second average. Then I moved the antenna to Pnt 2, waited 5-seconds and stored a 60 second average. I repeated these two points 20 times each.

At the end of each occupation, I set the 'P' attribute to the point name (OLY or PR) and entered the occupation number in the description. (I miscoded the fourth occupation of Pnt 2, which you will see if you look at the data.)

I received a couple of phone calls during the process so there are some interruptions where I immediately move the receiver after taking a point.

At the end of the job, I exited MobileMapper Field.



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REAL-TIME RESULTS

Here are the Real-Time results of the collected data (the worksheet is contained in 20PT_RealTimeResults.xls):

TRUE COOR	428694.293	4512358.561	1435.800

	OLYMPIC			
	Easting	**Northing**	**Height**	**Delta-XY**
	428697.069	4512358.641	1434.120	2.777
	428697.044	4512359.754	1432.934	2.998
	428696.577	4512359.927	1433.836	2.661
	428697.099	4512359.695	1434.845	3.027
	428697.177	4512359.369	1434.909	2.995
	428696.679	4512359.976	1435.032	2.774
	428696.677	4512360.125	1434.638	2.852
	428696.845	4512360.164	1434.939	3.014
	428696.072	4512360.356	1435.076	2.527
	428696.402	4512359.287	1434.121	2.231
	428695.314	4512359.414	1436.355	1.331
	428695.974	4512360.165	1437.622	2.323
	428695.350	4512359.454	1438.131	1.383
	428695.193	4512359.608	1438.433	1.380
	428695.278	4512359.753	1436.764	1.546
	428695.083	4512359.175	1437.080	1.001
	428695.570	4512359.625	1437.548	1.663
	428695.272	4512359.607	1437.269	1.433
	428694.983	4512359.762	1436.164	1.385
	428695.066	4512359.631	1435.223	1.320
Avg	428696.036	4512359.674	1435.752	2.131
Max	428697.177	4512360.356	1438.433	3.027
Min	428694.983	4512358.641	1432.934	1.001
Rng	2.194	1.715	5.499	2.026
StdDev	0.810	0.393	1.570	0.733
AvgErr	1.743	1.113	-0.048	
1-Sigma 2DRMS (RMS(AvgErr+StdDev))				**2.254** 1-Sigma 2DRMS
50% CEP (1-Sigma CEP / 1.2)				**1.878** 50% CEP

The TRUE COOR is the UTM coordinate of Olympic from the NGS datasheet.

Each of the rows represents the real-time average for a 60-second occupation.

The '**Delta XY'** column is the 2-D Horizontal error of the measurement with respect to the TRUE COOR for each occupation.

The '**AvgErr**' row shows the difference between the average Easting, Northing and Elevation with respect to the TRUE COOR.

The '**1-Sigma 2DRMS = 2.254 Meters**' is the RMS average of the average horizontal error (2.131 M) and the standard deviation of these errors (0.733 M). [This is the 1-sigma (68% confidence) expected error of a measurement.]

Typically real-time results are reported with a 50% confidence interval. This can be approximated by the 68% interval divided by 1.2 and is shown as '**50% CEP = 1.878 Meters**'.

The average vertical error was only -0.048 meters (5 cm), however the standard deviation was 1.5 meters.

Of note, the maximum horizontal error over 20 occupations was 3.0 meters and the maximum vertical error was 2.8 meters.

REAL-TIME CONCLUSIONS

50% CEP = 1.878 Meters meets the 2-5 meter accuracy stated on the datasheet.

POST PROCESSING THE JOB

The data was brought into MobileMapper Office 1.0.1.3, combined with the raw gps data, and the automatic download procedure was used to download CORS data from the SLCU station 6-miles distant.

The default coordinates for SLCU in MobileMapper Office are:

419410.069 4513904.620 1294.372

These are the ITRF2000 coordinates transformed to the project datum NAD83-CORS96 by this 7-parameter translation:

The NGS datasheet for SLCU L1-Phase Center shows:

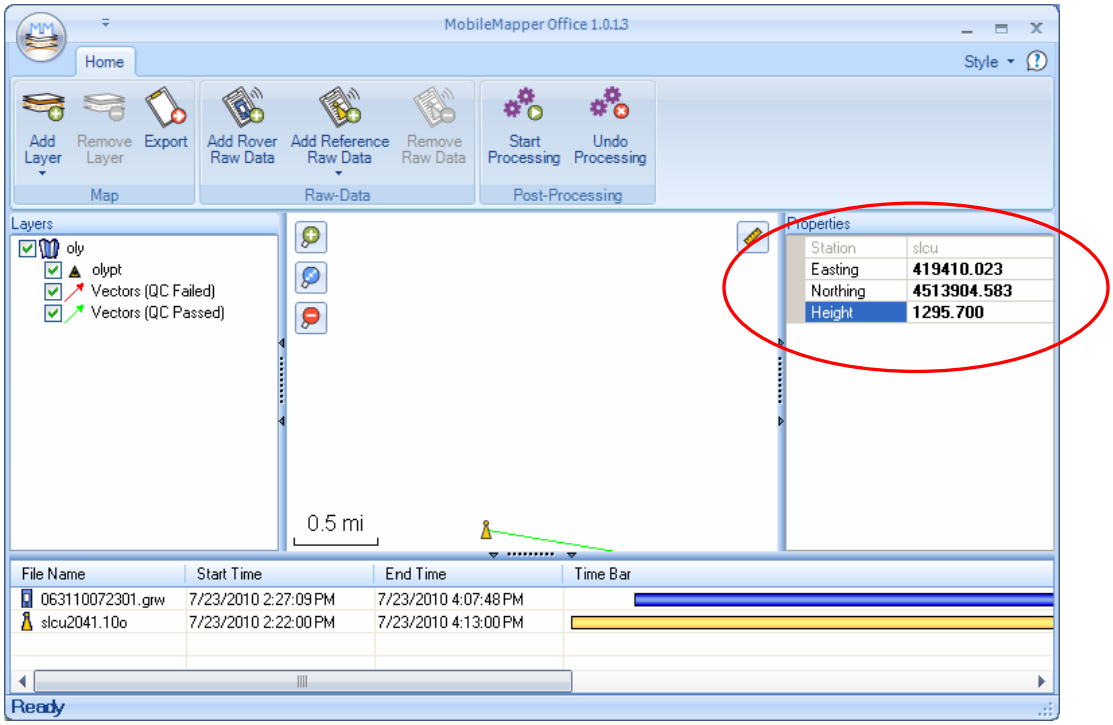
```
| NAD_83 (CORS96) POSITION (EPOCH 2002.0)
| Transformed from ITRF00 (epoch 1997.0) position in Aug. 2007.
|      X =  -1808864.887 m      latitude     =  40 46 19.80217 N
|      Y =  -4487250.546 m      longitude    = 111 57 17.85199 W
|      Z =   4144130.233 m      ellipsoid height = 1278.691   m
```

Geoid 2009 returns -17.009 meters for SLCU, which transforms to UTM as:

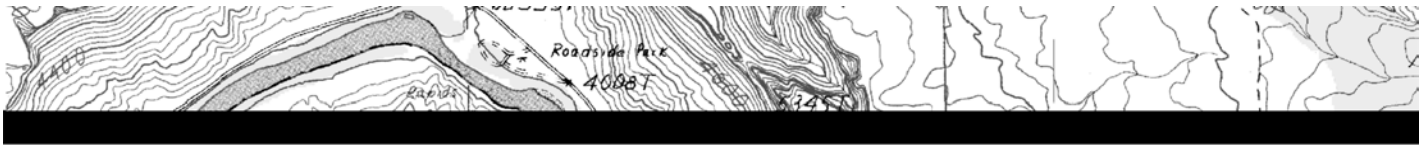
419410.023 4513904.583 1295.700

where 1295.700 is the NAVD88 orthometric height of the L1-Phase Center of the SLCU antenna

I manually entered these adjusted values into MMOffice:



And pressed 'Start Processing'. Finally I exported the results a CSV file (oly_PP_SLCU.olypt.csv) and used the spreadsheet (20PT_OLY_PP_SLCU.xls) to tabulate results for the post-processed results.



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POST-PROCESSED RESULTS

TRUE COOR	428694.293	4512358.561	1435.800

	OLYMPIC				
	Easting	**Northing**	**Height**	**Delta-XY**	Delta-Z
	428694.313	4512358.708	1436.116	0.148	0.316
	428694.337	4512358.697	1436.200	0.143	0.400
	428694.338	4512358.700	1436.192	0.146	0.392
	428694.336	4512358.695	1436.254	0.140	0.454
	428694.324	4512358.671	1436.234	0.115	0.434
	428694.333	4512358.689	1436.274	0.134	0.474
	428694.350	4512358.693	1436.291	0.144	0.491
	428694.372	4512358.659	1436.231	0.126	0.431
	428694.369	4512358.635	1436.299	0.106	0.499
	428694.374	4512358.607	1436.269	0.094	0.469
	428694.359	4512358.615	1436.277	0.085	0.477
	428694.347	4512358.575	1436.250	0.055	0.450
	428694.306	4512358.554	1436.240	0.015	0.440
	428694.299	4512358.588	1436.316	0.028	0.516
	428694.311	4512358.599	1436.326	0.042	0.526
	428694.342	4512358.607	1436.280	0.067	0.480
	428694.325	4512358.607	1436.266	0.056	0.466
	428694.325	4512358.623	1436.234	0.070	0.434
	428694.322	4512358.630	1436.226	0.074	0.426
	428694.189	4512358.423	1436.359	0.173	0.559
Avg	428694.328	4512358.629	1436.257	0.098	0.457
Max	428694.374	4512358.708	1436.359	0.173	0.559
Min	428694.189	4512358.423	1436.116	0.015	0.316
Rng	0.186	0.285	0.243	0.158	0.243
StdDev	0.039	0.000	0.053	0.046	0.053
AvgErr	0.035	0.068	0.457		
1-Sigma 2DRMS (RMS(AvgErr+StdDev))				**0.108**	1-Sigma 2DRMS

The TRUE COOR is the UTM coordinate of Olympic from the NGS datasheet.

Each of the lines represents a single post-processed point.

The '**Delta XY'** column is the 2-D Horizontal error of the measurement with respect to the TRUE COOR for each occupation.

The '**AvgErr**' row shows the difference between the average Easting, Northing and Elevation with respect to the TRUE COOR.

The '**1-Sigma 2DRMS = 0.108 Meters**' is the RMS average of the average horizontal error (0.098 M) and the standard deviation of these errors (0.046 M). [This is the 1-sigma (68% confidence) expected horizontal error of a measurement.]

The average vertical error was 0.457 meters, however the range of vertical measurements was only 0.24 meters.

Of note, the maximum horizontal error over 20 occupations was only 0.173 meters, in other words the maximum error from the true value was less than 20 cm.

POST-PROCESSED CONCLUSIONS

0.108 Meters 2DRMS 1-Sigma accuracy is much better than the ½ meter stated accuracy of the MM6.

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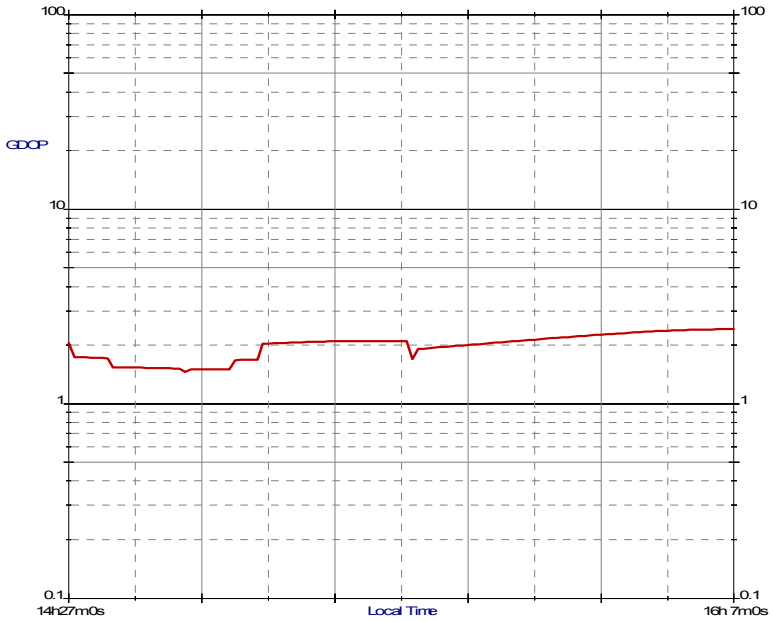
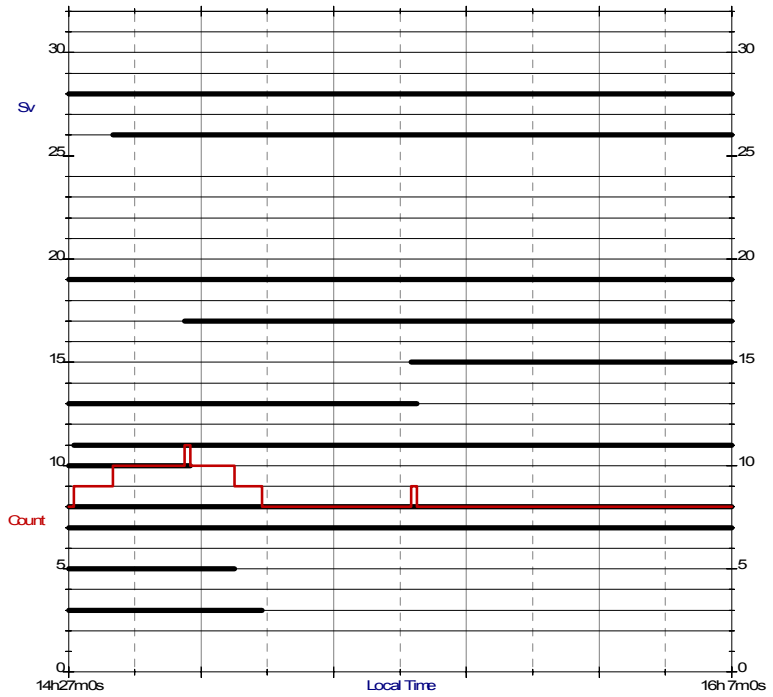
MISSION PLANNING FOR JOB:

Geometric Dilution of Precision (3D+T)
At Site CLYMPIC: 40°45'32.7570"N, 111°50'41.2070"W, 1419.800 m
From 07/23/2010, 14h27m0s To 07/23/2010, 16h7m0s (UTC-06:00:00)
With almanac 07/15/2010; Ev Min: 10.0 deg; Curtain ignored



Predicted SVs - Schedule
At Site CLYMPIC: 40°45'32.7570"N, 111°50'41.2070"W, 1419.800 m
From 07/23/2010, 14h27m0s To 07/23/2010, 16h7m0s (UTC-06:00:00)
With almanac 07/15/2010; Ev Min: 10.0 deg; Curtain ignored



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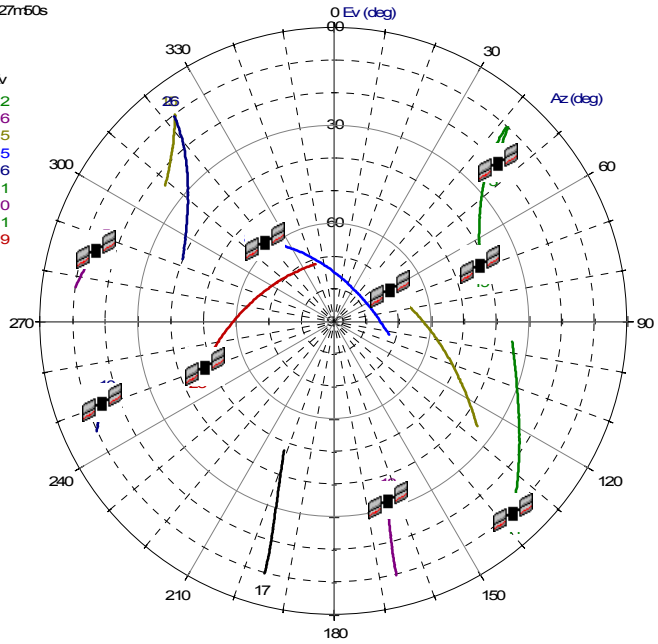
Predicted SVs - Azimuth/Elevation

At Site OLYMPIC: 40°45'32.7570"N, 111°50'41.2070"W, 1419.800 m
From 07/23/2010, 14h27m0s To 07/23/2010, 16h 7m0s (UTC - 06:00:00)
With almanac 07/15/2010; Ev Min: 10.0 deg; Curtain ignored

On 07/23/2010, 14h27m50s

GDOP (3D+T) : 1.7

Sv	Az	Ev
3	45.7	20.2
5	287.0	13.6
7	59.3	70.5
8	319.2	57.5
10	250.9	14.6
11	136.9	10.1
13	163.5	33.0
19	68.6	42.1
28	251.1	47.9



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The NGS Data Sheet for OLYMPIC mark:

Data Sheet Retrieval

The NGS Data SheetSee file dsdata.txt for more information about the datasheet.
DATABASE = ,PROGRAM = datasheet, VERSION = 7.85
1 National Geodetic Survey, Retrieval Date = JULY 24, 2010
DF4639 ***
DF4639 DESIGNATION - OLYMPIC
DF4639 PID - DF4639
DF4639 STATE/COUNTY- UT/SALT LAKE
DF4639 USGS QUAD - FORT DOUGLAS (1975)
DF4639
DF4639 *CURRENT SURVEY CONTROL
DF4639 _____
DF4639* NAD 83(2007)- 40 45 32.75708(N) 111 50 41.20721(W) ADJUSTED
DF4639* NAVD 88 - 1435.8 (meters) 4711. (feet) GPS OBS
DF4639 _____
DF4639 EPOCH DATE - 2002.00
DF4639 X - -1,800,624.891 (meters) COMP
DF4639 Y - -4,491,699.205 (meters) COMP
DF4639 Z - 4,143,122.647 (meters) COMP
DF4639 LAPLACE CORR- 13.98 (seconds) DEFLEC09
DF4639 ELLIP HEIGHT- 1419.232 (meters) (02/10/07) ADJUSTED
DF4639 GEOID HEIGHT- -16.52 (meters) GEOID09
DF4639
DF4639 ------- Accuracy Estimates (at 95% Confidence Level in cm) --------
DF4639 Type PID Designation North East Ellip
DF4639 ----------
DF4639 NETWORK DF4639 OLYMPIC 0.78 0.51 1.35
DF4639 ----------
DF4639
DF4639.The horizontal coordinates were established by GPS observations
DF4639.and adjusted by the National Geodetic Survey in February 2007.
DF4639
DF4639.The datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).
DF4639.See National Readjustment for more information.
DF4639.The horizontal coordinates are valid at the epoch date displayed above.
DF4639.The epoch date for horizontal control is a decimal equivalence
DF4639.of Year/Month/Day.
DF4639
DF4639.The orthometric height was determined by GPS observations and a
DF4639.high-resolution geoid model.
DF4639
DF4639.Photographs are available for this station.
DF4639
DF4639.The X, Y, and Z were computed from the position and the ellipsoidal ht.
DF4639
DF4639.The Laplace correction was computed from DEFLEC09 derived deflections.
DF4639
DF4639.The ellipsoidal height was determined by GPS observations
DF4639.and is referenced to NAD 83.
DF4639
DF4639.The geoid height was determined by GEOID09.
DF4639
DF4639; North East Units Scale Factor Converg.
DF4639;SPC UT C - 2,269,375.194 470,885.759 MT 1.00002897 -0 13 15.1
DF4639;SPC UT C - 7,445,441.78 1,544,897.69 sFT 1.00002897 -0 13 15.1
DF4639;UTM 12 - 4,512,358.561 428,694.293 MT 0.99966258 -0 33 05.6
DF4639
DF4639! - Elev Factor x Scale Factor = Combined Factor
DF4639!SPC UT C - 0.99977742 x 1.00002897 = 0.99980639
DF4639!UTM 12 - 0.99977742 x 0.99966258 = 0.99944008
DF4639

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DF4639 SUPERSEDED SURVEY CONTROL
DF4639
DF4639 NAD 83(1994)- 40 45 32.75679(N) 111 50 41.20679(W) AD( ) 1
DF4639 ELLIP H (03/31/03) 1419.243 (m) GP( ) 4 2
DF4639
DF4639.Superseded values are not recommended for survey control.
DF4639.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
DF4639.See file dsdata.txt to determine how the superseded data were derived.
DF4639
DF4639_U.S. NATIONAL GRID SPATIAL ADDRESS: 12TVL2869412358(NAD 83)
DF4639_MARKER: DD = SURVEY DISK
DF4639_SETTING: 7 = SET IN TOP OF CONCRETE MONUMENT
DF4639_STAMPING: SALT LAKE 2002
DF4639_MARK LOGO: NOAA
DF4639_PROJECTION: FLUSH
DF4639_MAGNETIC: O = OTHER; SEE DESCRIPTION
DF4639_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
DF4639_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
DF4639+SATELLITE: SATELLITE OBSERVATIONS - October 07, 2002
DF4639
DF4639 HISTORY - Date Condition Report By
DF4639 HISTORY - 20021007 MONUMENTED SLCS
DF4639
DF4639 STATION DESCRIPTION
DF4639
DF4639'DESCRIBED BY SALT LAKE COUNTY SURVEYOR 2002 (VEB)
DF4639'THE STATION IS LOCATED ON THE UNIVERSITY OF UTAH CAMPUS, SALT LAKE
DF4639'CITY UTAH. MARK IS A 10 IN DIAMETER COMMEMORATIVE OLYMPIC BRASS SET IN
DF4639'A 2FT DIAMETER CONCRETE CYLINDIRCAL MONUMENT, 5FT DEEP IN THE GROUND.
DF4639'
DF4639'TO REACH THE STATION FROM THE JUNCTION OF INTERSTATE 80 AND INTERSTATE
DF4639'15, GO EAST 5.5 MILES ON INTERSTATE 80, TO THE FOOTHILL BLVD EXIT,
DF4639'THEN GO NORTH ON FOOTHILL BLVD (HWY 186 WEST) 4.2 MILES TO 1580 EAST
DF4639'CAMPUS CENTER ROAD, TURN RIGHT AND GO 150 FT. MONUMENT IS 75 FT EAST
DF4639'OF THE EAST CURB ON TOP OF A GRASS KNOLL, AT GROUND LEVEL.
DF4639'
DF4639'

*** retrieval complete.
Elapsed Time = 00:00:00