Windstorm Simulation & Modeling Project

Manatee County Digital Elevation Models

Preliminary Report

Prepared for:
The Manatee County
Public Safety Department
1112 Manatee Avenue West, Suite 525
Bradenton, Florida 34205
(941) 749-3022

Florida International University
International Hurricane Research Center
11200 SW 8th Street, MARC 360
Miami, FL 33199
(305) 348-1607

June 30, 2003

Executive Summary

The following is an interim report describing acquisition parameters and coverage areas as part of the Windstorm Simulation & Modeling Project per the contract agreement established December 4, 2002 between, Florida International University International Hurricane Center (IHC) and Manatee County.

On April 5-7 and 12-16, an Optech Airborne Laser Terrain Mapper (ALTM) 1233 LIght Detection And Ranging (LIDAR) mapping system mounted in a Cessna 337 aircraft was used to collect topographic data in Manatee County. Data was collected at a nominal altitude of 1100 m (3600 feet) with the survey consisting of 58 overlapping 650-m-wide swaths. Ground control was provided by 2 Ashtech Z-12 GPS receivers equipped with choke ring antennas. The total coverage of low-lying areas exceeded 130,000 acres and included all areas depicted in Figure 1. Over 100 million irregularly spaced ground surface elevations were measured with a nominal point spacing of 2.5 m (8.2 feet). Initial review of the data depicted complete and accurate data sets, revealing no foreseeable problems with future data processing.

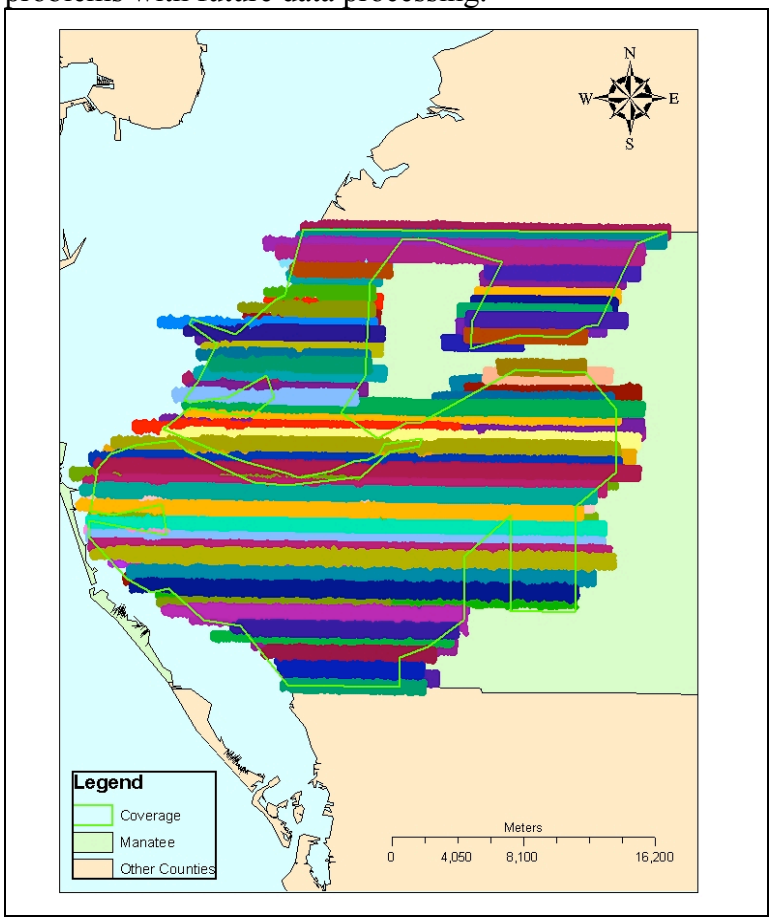

Figure 1. Area of data acquisition for Manatee County LIDAR study.

Introduction

In 2000- 2001, The International Hurricane Research Center (IHC) was awarded grant funding by Federal Emergency Management Division (FEMA) and the Florida Department of Community Affairs (FLDCA), for a program entitled the Windstorm Simulation and Modeling project. Four tasks under this three year project included 1) the re-evaluation of existing storm surge models including SLOSH, CMEPS and TAOS, 2) data acquisition of high-resolution elevation data via LIDAR technology for participating South Florida counties 3) computer simulation of findings for researchers and the general public and 4) development of public awareness and education programs in regards to human vulnerabilities to hurricanes and the means to mitigate the risks. This project is also supported partially from matching funds provided from participating counties including Broward, Miami-Dade, Palm Beach, and Manatee Counties.

On December 4, 2002, Manatee County and the IHC reached a final contract agreement about participating in this project and as part, use Airborne Laser Terrain Mapper (ALTM) technology for their evacuation zone revision project. Following this agreement initial field reconnaissance was conducted, base stations were established, and the ALTM system was used to collect detailed topographic data in Manatee County in April 2003. This report describes field procedures, data acquisition, preliminary processing, and the results of preliminary error analysis.

Establishment of Base Stations

The establishment of base stations is needed for LIDAR data collection and processing. Survey monuments were High Accuracy Reference Network (HARN) stations, other 1st order vertical accuracy National Geodetic Survey (NGS) benchmarks, or Palm Beach County primary control network stations. The accuracy of published control stations was checked. The IHC collected at least three five-hour static GPS data sets for each control station. The collected GPS data was differenced from local Manatee Continuously Operating Reference Stations (CORS). Poorly collected GPS data was identified and discarded. Good data were averaged to produce a position for each control site.

Data Acquisition

The goal of this project was to acquire data in all areas of Manatee County that could possibly be affected by storm surge. In order to maximize coverage area per flight pass while maintaining data quality, the following acquisition parameters were planned: height above ground angle, 1100m; ground speed, 191 km/hr (100 Knots); scan angle (FOV), ±15°; scan rate of 21 Hz; a pulse rate, 10kHz. These parameters produce a 650-meter-wide swath of 30 cm wide laser footprints spaced approximately every 2.5 beneath the flight path. A schematic diagram of the nominal acquisition parameters used in this project is shown in Figure 2.

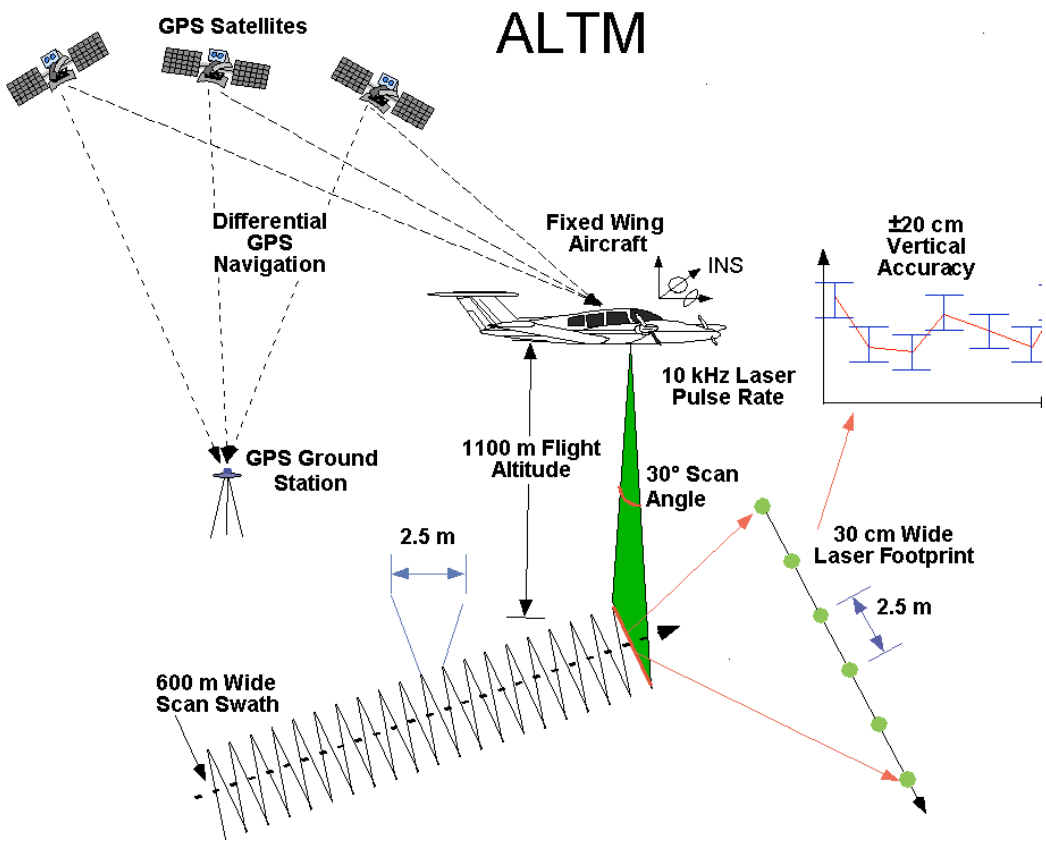

Figure 2. Schematic diagram showing data acquisition parameters used for the Manatee County ALTM survey.

Data was collected on seven separate days. In order to insure quality GPS data, flight schedules were planned to coincide with periods of low Position Dilution of Precision (PDOP). The system was initially deployed during night hours on April 5-7, 2003. The system was re-deployed on April 12-16 to survey areas not covered during the first data acquisition. Due to clouds and air space restrictions, flight heights varied between 1000 and 1300 m. The scan angle and frequency were adjusted as necessary to maintain a 600 m-wide swath and a nominal 2.5 m point spacing. Each deployment typically took 4-5 hours during which GPS data was continuously recorded on both the aircraft and on the 2 stations on the ground. A detailed log of all flight and derived ground spacing parameters is given in Appendix A.

For the Manatee County data collect a total of 58 E-W trending swaths were collected (Figure 3). In total, the project measured over 100 million irregularly spaced ground elevations.

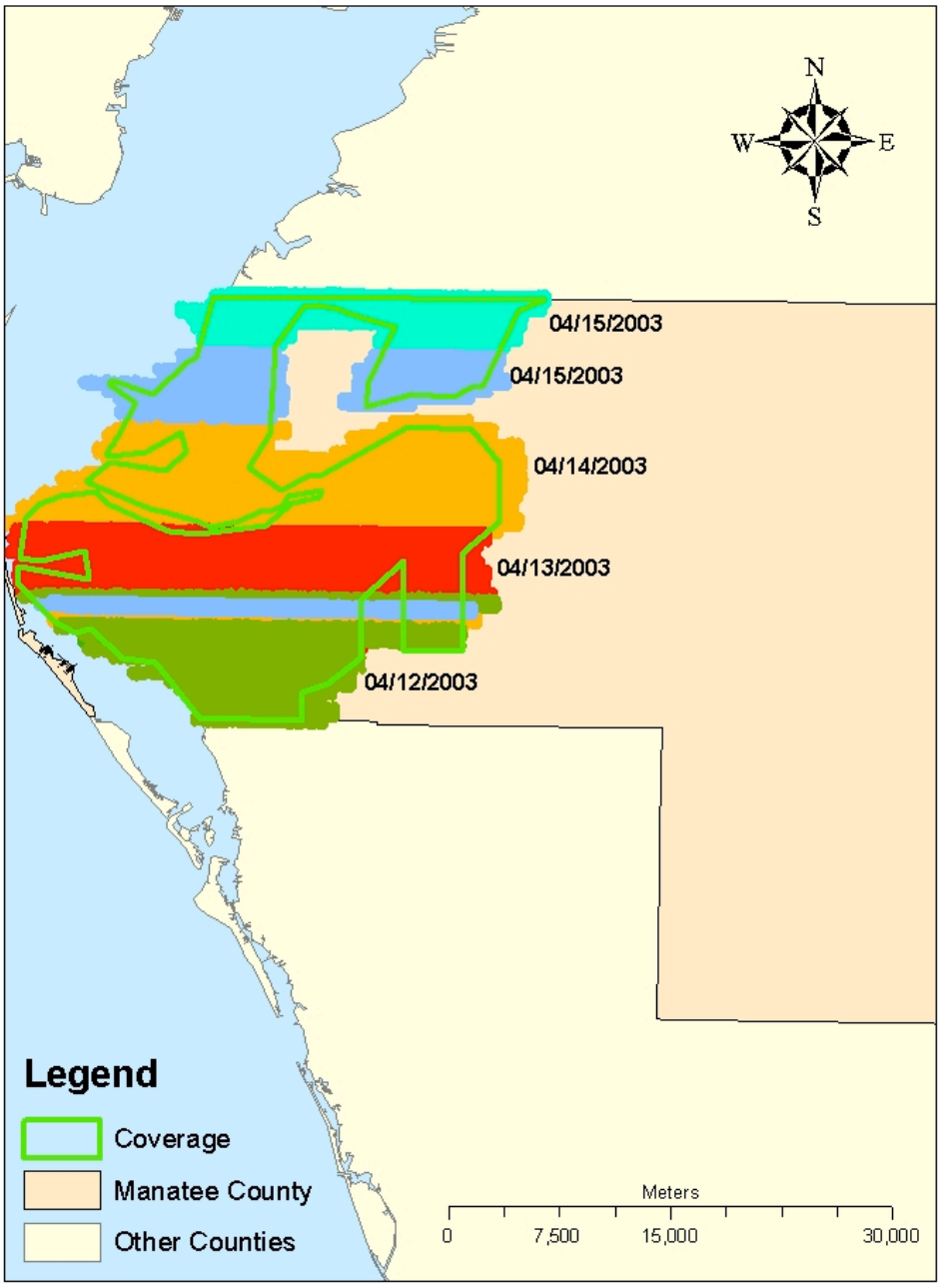

Figure 3. Index map of Manatee County showing separate days of data collection.

Ground GPS data were recorded at 1 sample per second by Ashtech Z-12 receivers equipped with choke ring antennas and operated by FIU staff and graduate students. The GPS antennas were fixed atop 2-meter-high fixed height tripods placed over previously surveyed monuments. All deployments utilized two independent ground stations. Details and coordinates of the GPS ground control station locations are given in Appendix B.

Preliminary Data Processing

After each flight, LIDAR and GPS data are downloaded to a computer and processed by the Optech/Topscan proprietary software. Operation of this software proceeds in several steps. First, ground station coordinate information is entered and the aircraft and ground station GPS data are differentially processed to produce a kinematic aircraft trajectory. The trajectory information is combined with the range, scan, and IMU data to produce laser return coordinates. Output consists of 9 column ASCII text files containing the UTM zone 17 eastings and northings, the ellipsoidal heights, and the return intensity for both the first and last laser detection for each pulse. We replaced the Optech/Topscan proprietary software trajectory with one computed using the NGS Kinematic and Rapid Static (KARS) program. This program uses both L1 and L2 carrier phase data as well as precise satellite ephemeris. Dr. Gerry Mader of NGS computed the KARS trajectories for this project through a consulting agreement with FIU.

Summary and Conclusions

This interim report presents the initial findings of the LIDAR study for Manatee County initiated in Spring 2003. The summary of these finding is as follows:

- Data acquisition for the subject areas outlined in the contract agreement were completed successfully
- Review of initial data sets did not identify any foreseeable problems with further analysis and revealed data of excellent quality

Future Activities

Future activities for this project include the following:

- An additional day of data collect will be scheduled during Summer 2003 to fill in experienced data gaps
- Delivery of preliminary error analysis for the entire data set
- Delivery of Final Report with complete analysis
- Delivery of reprocessed data sets and merged data sets in a GIS compatible format
- Preliminary report indicating the findings of the reevaluation of storm surge models including recommendations on use of new data to model storm surge event flooding

Appendices

Appendix A: Flight, System, and Derived Laser Parameters

Date	Julian Date	Strip Name	Start Time (UTC)	Stop Time (UTC)	Heading (Degrees)	Flight Height (Meters)	Scan Angle _ FOV (Degrees)	PDOP	Swath Width (Meters)	Footprint Size (Meters)	Nominal Resolution Transverse/ Longitudinal	
4/12/2003	102	A1	18:31:58	18:34:49	274	1081	20	1	787	0.27	1.32	2.00
4/12/2003	102	A2	18:39:06	18:43:24	87	1080	20	1	786	0.27	1.32	2.00
4/12/2003	102	A3	18:47:05	18:49:50	272	1078	20	1	785	0.27	1.32	2.00
4/12/2003	102	A4	18:54:34	18:58:37	80	1087	20	1	791	0.27	1.33	2.00
4/12/2003	102	A5	19:02:14	19:05:03	272	1054	20	2	767	0.26	1.29	2.00
4/12/2003	102	A6	19:11:25	19:16:31	83	1086	20	2	791	0.27	1.33	2.00
4/12/2003	102	A7	19:20:32	19:23:23	272	1076	20	2	783	0.27	1.32	2.00
4/12/2003	102	A8	19:30:01	19:35:41	88	1075	20	2	783	0.27	1.31	2.00
4/12/2003	102	A9	19:38:58	19:42:15	273	1077	20	3	784	0.27	1.32	2.00
4/12/2003	102	A10	19:50:10	19:54:25	85	1100	20	2	801	0.28	1.35	2.00
4/12/2003	102	A11	19:59:46	20:04:00	269	1072	20	2	780	0.27	1.31	2.00
4/12/2003	102	A12	20:10:05	20:17:49	87	1105	20	1	804	0.28	1.35	2.00
4/12/2003	102	A13	20:21:00	20:31:07	266	1104	20	2	804	0.28	1.35	2.00
4/12/2003	102	A14	20:35:15	20:43:26	86	1100	20	1	801	0.28	1.35	2.00
4/12/2003	102	B1	20:51:55	21:02:29	268	1074	20	1	782	0.27	1.31	2.00
4/12/2003	102	B2	21:05:37	21:14:33	81	1097	20	1	799	0.27	1.34	2.00
4/12/2003	102	B3	21:17:26	21:26:10	268	1091	20	1	794	0.27	1.33	2.00
4/13/2003	103	C1	18:53:56	19:03:36	272	1240	16	2	711	0.31	1.45	1.65
4/13/2003	103	C2	19:07:38	19:17:06	85	1250	16	2	717	0.31	1.46	1.65
4/13/2003	103	C3	19:21:34	19:31:36	271	1233	16	2.04	707	0.31	1.44	1.65
4/13/2003	103	C4	19:36:05	19:45:43	84	1229	16	3.31	705	0.31	1.44	1.65
4/13/2003	103	C5	19:49:55	20:00:02	272	1243	16	2.37	713	0.31	1.45	1.65
4/13/2003	103	C6	20:04:47	20:14:16	88	1235	16	1.93	708	0.31	1.44	1.65
4/13/2003	103	C7	20:17:35	20:27:39	269	1237	16	1.97	709	0.31	1.45	1.65
4/13/2003	103	D1	20:38:13	20:48:10	84	1232	16	1.64	707	0.31	1.44	1.65
4/13/2003	103	D2	20:51:57	21:01:25	267	1231	16	1.74	706	0.31	1.44	1.65
4/13/2003	103	D3	21:07:05	21:10:18	84	1231	16	1.74	706	0.31	1.44	1.65
4/14/2003	104	E1	18:29:16	18:40:00	85	1224	16	1.65	702	0.31	1.43	1.65
4/14/2003	104	E2	18:48:35	18:58:45	267	1225	16	1.95	703	0.31	1.43	1.65
4/14/2003	104	E3	19:10:43	19:20:42	86	1233	16	2.07	707	0.31	1.44	1.65
4/14/2003	104	E4	19:26:54	19:36:51	269	1211	16	3.47	694	0.30	1.42	1.65
4/14/2003	104	E5	19:46:29	19:56:36	82	1241	16	2.36	712	0.31	1.45	1.65
4/14/2003	104	F1	20:03:51	20:12:42	271	1259	16	1.87	722	0.31	1.47	1.65
4/14/2003	104	F2	20:20:03	20:26:25	83	1236	16	1.77	709	0.31	1.45	1.65
4/14/2003	104	F3	20:35:50	20:44:54	270	1254	16	1.63	719	0.31	1.47	1.65
4/14/2003	104	F4	20:52:36	21:00:53	84	1223	16	1.73	701	0.31	1.43	1.65
4/14/2003	104	F5	21:07:57	21:16:18	273	1204	16	1.58	690	0.30	1.41	1.65
4/14/2003	104	F6	21:23:07	21:26:48	82	1222	16	1.82	701	0.31	1.43	1.65

Date	Julian Date	Strip Date	Start Time (UTC)	Stop Time (UTC)	Heading (Degrees)	Flight Height (Degrees)	Scan Angle (Degrees)	PDOP	Swath Width (Meters)	Footprint Size (Meters)	Nominal Resolution Transverse/ Longitudinal	
4/14/2003	104	F7	21:28:14	21:31:46	82	1218	16	1.88	699	0.30	1.42	1.65
4/14/2003	104	G1	21:39:19	21:42:29	268	1289	16	1.70	739	0.32	1.51	1.65
4/14/2003	104	G2	21:44:09	21:47:23	268	1228	16	1.74	704	0.31	1.44	1.65
4/14/2003	104	G3	21:55:16	21:58:57	84	1233	16	1.85	707	0.31	1.44	1.65
4/14/2003	104	G4	22:00:34	22:03:30	84	1228	16	1.90	704	0.31	1.44	1.65
4/14/2003	104	G5	22:10:24	22:12:38	269	1230	16	2.56	705	0.31	1.44	1.65
4/14/2003	104	G6	22:14:29	22:18:02	269	1220	16	2.56	700	0.31	1.43	1.65
4/14/2003	104	G7	22:26:43	22:29:59	83	1155	16	2.38	662	0.29	1.35	1.65
4/14/2003	104	G8	22:32:40	22:34:33	83	1212	16	2.26	695	0.30	1.42	1.65
4/14/2003	104	G9	22:40:49	22:45:39	270	1261	16	1.76	723	0.32	1.48	1.65
4/14/2003	104	G10	22:55:29	23:04:25	83	1217	16	1.61	698	0.30	1.42	1.65
4/14/2003	104	G11	23:09:08	23:17:30	269	1268	16	151	727	0.32	1.48	1.65
4/15/2003	105F1	H1	5:35:56	5:39:34	88	1218	16	1.85	699	0.30	1.42	1.65
4/15/2003	105F1	H2	5:47:01	5:50:26	270	1212	16	1.92	695	0.30	1.42	1.65
4/15/2003	105F1	H3	5:59:30	6:06:01	86	1222	16	2.04	701	0.31	1.43	1.65
4/15/2003	105F1	H4	6:04:06	6:05:40	86	1229	16	2.09	705	0.31	1.44	1.65
4/15/2003	105F1	H5	6:13:51	6:16:08	270	1223	16	2.17	701	0.31	1.43	1.65
4/15/2003	105F1	H6	6:17:34	6:21:20	270	1218	16	2.53	699	0.30	1.42	1.65
4/15/2003	105F1	H7	6:27:50	6:32:09	85	1220	16	2.31	700	0.31	1.43	1.65
4/15/2003	105F1	H8	6:33:39	6:36:30	85	1259	16	2.45	722	0.31	1.47	1.65
4/15/2003	105F1	H9	6:43:56	6:47:01	271	1219	16	1.76	699	0.30	1.43	1.65
4/15/2003	105F1	H10	6:48:33	6:51:16	271	1209	16	1.81	693	0.30	1.41	1.65
4/15/2003	105F1	H11	6:59:09	7:01:47	84	1212	16	1.92	695	0.30	1.42	1.65
4/15/2003	105F1	H12	7:03:20	7:06:16	84	1235	16	1.96	708	0.31	1.44	1.65
4/15/2003	105F1	I1	7:13:29	7:16:30	269	1210	16	2.03	694	0.30	1.42	1.65
4/15/2003	105F1	I2	7:18:04	7:20:10	269	1230	16	2.05	705	0.31	1.44	1.65
4/15/2003	105F1	I3	7:29:00	7:31:05	85	1217	16	2.03	698	0.30	1.42	1.65
4/15/2003	105F1	I4	7:32:56	7:35:54	85	1228	16	2.00	704	0.31	1.44	1.65
4/15/2003	105F1	I5	7:45:50	7:55:07	269	1217	16	1.92	698	0.30	1.42	1.65
4/15/2003	105F2	J1	17:54:06	17:55:53	85	1237	16	1.89	709	0.31	1.45	1.65
4/15/2003	105F2	J2	17:57:39	18:00:25	85	1232	16	1.90	707	0.31	1.44	1.65
4/15/2003	105F2	J3	18:07:45	18:10:40	269	1214	16	1.92	696	0.30	1.42	1.65
4/15/2003	105F2	J4	18:12:30	18:14:23	269	1230	16	1.58	705	0.31	1.44	1.65
4/15/2003	105F2	J5	18:21:24	18:23:35	85	1237	16	1.73	709	0.31	1.45	1.65
4/15/2003	105F2	J6	18:25:18	18:27:59	85	1258	16	1.65	721	0.31	1.47	1.65
4/15/2003	105F2	J7	18:35:58	18:42:41	268	1220	16	1.84	700	0.31	1.43	1.65
4/15/2003	105F2	J8	18:49:47	18:57:56	85	1245	16	1.99	714	0.31	1.46	1.65
4/15/2003	105F2	J9	19:04:37	19:11:30	271	1212	16	2.07	695	0.30	1.42	1.65
4/15/2003	105F2	J10	19:18:46	19:26:49	88	1223	16	2.00	701	0.31	1.43	1.65
4/15/2003	105F2	K1	19:35:05	19:36:48	266	491	18	2.35	319	0.12	0.61	1.75
4/15/2003	105F2	K2	19:42:41	19:45:38	85	199	18	2.35	129	0.05	0.25	1.75
4/15/2003	105F2	K3	19:50:26	19:52:34	267	486	18	2.17	316	0.12	0.61	1.75
4/15/2003	105F2	K4	19:59:56	20:07:58	South	494	20	1.88	360	0.12	0.60	2.00
4/15/2003	105F2	K5	20:12:02	20:21:16	North	504	20	1.94	367	0.13	0.62	2.00

Appendix B: Ground Station Parameters

Site	Easting	Northing	Ellip. Ht	X	Y	Z
FDOT	345526.596	3042859.746	-23.132 m	732716.342 m	-5613850.994 m	2927521.141 m
SARI	346091.675	3031078.473	-18.010 m	734126.682 m	-5619144.759 m	2917074.446 m