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Local Tie Information Report

ITRF Network Site: Richmond, Florida

Kendall L. Fancher
Steven E. Breidenbach
Charles E. Geoghegan

Date of Survey: February 2015
Date of Report: November 2015

UNITED STATES DEPARTMENT OF COMMERCE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
NATIONAL GEODETIC SURVEY
GEODETIC SERVICES DIVISION
INSTRUMENTATION & METHODOLOGIES BRANCH

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Introduction

In the spirit of scientific cooperation, the U.S. National Oceanic and Atmospheric Administration's (NOAA) National Geodetic Survey (NGS) contributes to future realizations of the International Terrestrial Reference Frame (ITRF) by providing the International Earth Rotation and Reference Systems Service (IERS) with local tie information for geodetic technique instruments co-located at IERS Network Sites considered a priority by that service. Within NOAA, these type surveys are the responsibility of the NGS's IERS Site Survey (ISS) program.

During February, 2015 the NGS ISS team conducted a local tie vector survey at IERS network site RICHMOND. Two new GNSS tracking stations have been installed. This survey ties them together and to three instrument reference marks (IRM) from past site surveys that included SLR, VLBI, GPS, and DORIS positioning techniques. Those instruments have since been removed and only the three IRMs remain.

This report documents the instrumentation, procedures, data analysis, and resultant local tie vectors from this survey.

1. Site Description

Site Name: RICHMOND
Country Name: UNITED STATES OF AMERICA
Longitude: 279°37'
Latitude: 25°37'
Tectonic plate: NOAM
Epoch date of survey (edos): 2015/02/13
Survey reference frame: ITRF2008(edos)

SGT Instr.	DOMES#	Code	Description
GNSS	40499M007	FLF1	Dimple in antenna mount 0.0083 m below ARP
GNSS	40499M008	FLF2	Dimple in brass disk atop central pier
(SLR)	40499M002	RCM2	SLR Mark
(GPS)	40499M005	RCM4	Stainless steel plate (Richmond 1993)
(VLBI)	40499M001		Timer 1962

Table 1 – Space geodetic technique (SGT) instruments co-located at the Richmond ITRF site. ()=SGT has been removed.

2. Instrumentation

2.1. Tacheometers

2.1.1. Description

Two (2) Leica TDM5005
S/Ns: 441698 and 441773
Specifications
Angular measurement uncertainty: ± 0.7"
Distance standard deviation of a single measurement: 1 mm + 2 ppm

2.1.2 Calibrations
Tacheometers calibrated by Leica Geosystem AG Heerbrugg, Switzerland.
Inspection date: 08/15/2008 / 08/20/2008
Both instruments were found to be within factory specifications

2.1.3 Auxiliary Equipment
Wild NL Collimator, S/N: 40145, Pointing accuracy, 1: 200,000
Hygrometer: Omega RH83
Thermometer: Digital thermometer, thermistor sensor, assembled by NGS
Barometer: Leitz AIR-HB-1L, S/N: 1L1890

2.2 GPS units

2.2.1 Receivers
Four (4) Trimble NetR5
P/N: 62800-00
S/Ns: 4624K01583, 584, 590, and 631
<u>Mfr. Specifications for Static GPS Surveying</u>
Horizontal: +/- 5 mm + 0.5 ppm RMS
Vertical: +/- 5 mm + 1 ppm RMS

2.2.2 Antennas
Four (4) Topcon GPS/GLONASS/Galileo choke ring antenna, model CR-G3
P/N: 1-044301-01
S/Ns: 383-1613, 614, 626 and 628

2.2.3 Analysis software, mode of operation
Post-processing and adjustment were undertaken using NGS's Online Positioning User Service (OPUS) Projects, an interactive web page. OPUS Projects uses NGS's Program for Adjustment of GPS Ephemerides (PAGES) software as an underlying multiple-baseline processor.

2.3 Leveling

2.3.1 Leveling instruments
Leica DNA03 digital level, P/N: 723289, S/N: 332228.
Height measurement accuracy: +/-0.3 mm per km, double-run.

2.3.2 Leveling rods
Leica GWCL92 92-cm Invar Bar Code Rod
S/N: 30721
Leica 3-m Invar Bar Code Rod (2)
S/N: 27226 and 27227

2.3.3 Checks carried out before measurements
Instrument collimation test procedures using the Kukkamaki method were undertaken daily, prior to data collection. Leveling rod bubbles were checked daily, prior to use.

2.4 Tripods

Three 1.5-m wooden observing stands were erected over main-scheme marks FLF1 RM 1, RM 2, and RM 3. One 3.5-m wooden observing stand was erected over temporary mark FLT1. Leica Type II wooden tripods were used to occupy IRM FLF2 (BigAnt) and supplemental marks 7295 (RCM2), JPL GPS RICHMOND (RCM4) and TIMER (TABV).

Translation plates were affixed to the top of the observing stands to facilitate centering over the survey mark disks.

2.5 Forced centering devices

At each ground network mark, a Leica GDF321 tribrach was fastened to a conventional tripod (or a stand's translation plate). It was then centered precisely over a survey mark disk using a Wild/Leica NL collimator. The tribrach was leveled up using a GZR3 carrier with longitudinal level vial. "Leveled up" means the carrier's standing axis was brought into alignment with the local gravity vector using the carrier's level vial and the tribrach's foot screws.

To facilitate precise measurement of the height of instruments/reflectors above each mark, a tribrach adapter was attached to the tribrach, the top of which served as a vertical point of reference. Digital leveling equipment was used to transfer a height difference from the survey mark disk to the vertical point of reference associated with the tribrach adapter. A vertical offset constant of 0.1675m was then added, the total being the actual height of the instrument or target above the mark. The constant represents a predetermined distance from the tribrach adapter's top (horizontal) surface, a.k.a. vertical point of reference, to either the center of the tilt axis of the tacheometer telescope or the center of a reflector.

2.6 Targets, reflectors

Five (5) Leica GPH1P reflectors, model #555631
<u>Specifications</u>
Centering of Optics: $\leq \pm$ 0.03mm
Distance Offset: -34.4 mm

Leica GRT144, Carrier with Stub
Centering Accuracy: ± 1.0 mm

Except for intersection procedure measurements to FLF1's IRM, all tacheometer observations were made to Leica GPH1P precision reflectors, serving as both target and reflector. The manufacturer-provided offset value of -34.4 mm for the GPH1P was validated prior to the survey. Reflectors were affixed to tribrachs using GRT144 carriers.

3. Measurement Setup

3.1 Ground network

The ground network consisted of two categories of survey marks; main-scheme and SGT instrument reference marks (IRM). The main-scheme and supplemental marks are monumented for future use. Main-scheme marks were tied together in a local network with repeated and extremely precise triangulation and leveling observations. These marks were used to tie the GNSS antenna reference points (ARPs) and instrument reference marks (IRMs) directly to the ground network, and indirectly to each other. Historic IRMs were included in this survey to provide an indirect tie to past surveys of since-retired SGT instruments. An unmonumented mark, FLT1, was used to facilitate ties to two IRMs.

3.1.1 Listing

Current Survey	DOMES	IERS 4-char code	Current Survey id	Previous Survey Point Name	NGS PID
Main-scheme Marks					
FLF1 RM 1	None	None	FLR1	(new point)	n/a
FLF1 RM 2	None	None	FLR2	(new point)	n/a
FLF1 RM 3	None	None	FLR3	(new point)	n/a
SGT Instrument Reference Marks (IRMs)					
7295	40499M002	RCM2	RCM2	Survey not found	AC4624
JPL GPS RICHMOND	40499M005	RCM4	RCM4	Survey not found	n/a
TIMER	40499M001		TABV	Survey not found	AC2087
FLF1	40499M007	n/a	FLF1	(new point)	DP6859
FLF2	40499M008	n/a	FLF2	(new point)	n/a

Table 2 - Listing of Ground Network Marks and SGT instrument marks common to both the current survey and historical surveys.

Main-Scheme Marks

Figure 1 - FLF1 RM 1 (FLR1)

FLR1 is a NGS reference mark disk stamped ---FLF1 NO 1 2014---, set flush with the ground in the top of a 30-cm (in diameter) poured-in-place concrete post extending to a depth of 130 cm.

Figure 2 - FLF1 RM 2 (FLR2)

FLR2 is a NGS reference mark disk stamped ---FLF1 NO 2 2014---, set flush with the ground in the top of a 30-cm (in diameter) poured-in-place concrete post extending to a depth of 130 cm.

Figure 3 - FLF1 RM 3 (FLR3)

FLR3 is a NGS reference mark disk stamped ---FLF1 NO 3 2014---, set flush with the ground in the top of a 30-cm (in diameter) poured-in-place concrete post extending to a depth of 130 cm.

IRMs, historic

Figure 4 - 7295 (RCM2)

RCM2 is a NGS horizontal control mark disk stamped ---7295 1988--- and cemented into a drill hole in the center of a concrete pad.

IRMs, historic (cont.)

Figure 5 - JPL GPS RICHMOND (RCM4)

RCM4 is a 36-cm (in diameter) stainless steel plate engraved ---JPL GPS RICHMOND 4015-3 1993--- and appears to be anchored to a concrete pad by three metal screw-type fasteners.

Figure 6 - TIMER (TABV)

TIMER is a USC&GS triangulation station disk stamped ---TIMER 1962---, recessed 5 cm below the ground and in the top of a square concrete post extending to a depth of 90 cm.

Figure 7 - FL FOUNDATION 1 (FLF1)

FLF1 is a dimple within the GNSS antenna adapter of a short drilled braced monument and is centered 0.0083 m beneath the ARP. For more information, enter CORS SiteID *FLF1* at NGS's CORS webpage.

Figure 8 - FL FOUND 2 BIGANT (FLF2)

FLF2 is a brass disk set into the top of a concrete pier encased in 30-cm PVC pipe projecting 120 cm above the ground and extending to a depth of 150 cm below the ground. The central pier is surrounded by eight smaller groundplane support piers. For more information, enter CORS SiteID *FLF2* at NGS's CORS webpage.

3.1.2 Map of Network

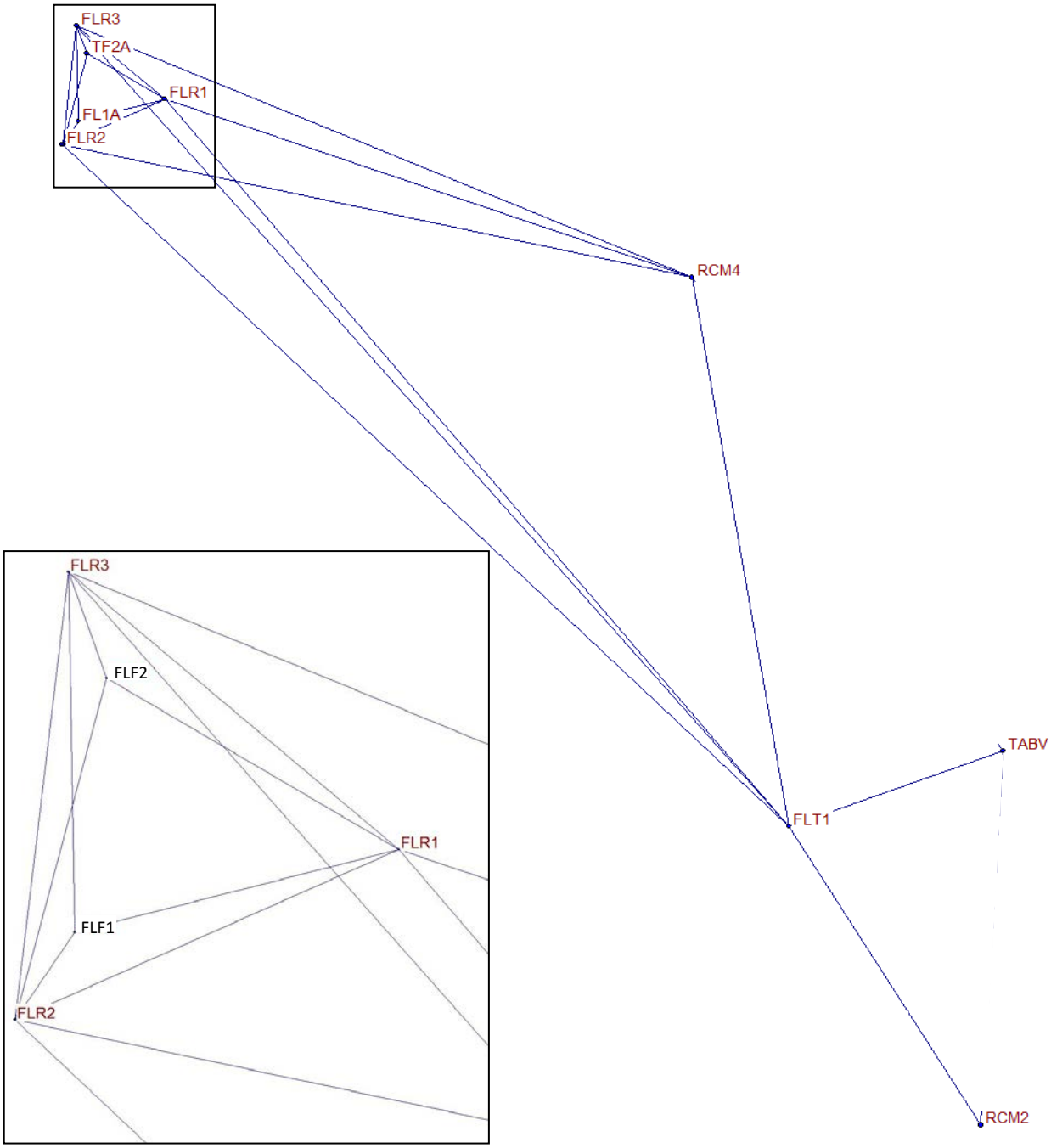

Figure 9 – Sketch of tacheometer observations.

3.2 GPS Technique Reference Points

GPS stations ***FLF1*** and ***FLF2*** are new installations that will provide data to national and international GNSS networks. The instrument reference marks (IRM) and antenna reference points (ARP) were tied to the ground network, which also includes existent marks with historical ties to past SGT instruments here at Richmond. FLF1 is the first of many Foundation CORS Network sites to be installed and operated by NOAA's National Geodetic Survey. The site will also be used as a tracking station for the International GNSS Service. FLF2 is an experimental large format antenna nicknamed BigAnt for its unusual size.

Figures 10 – FLF1, short drilled braced monument

Figure 11 – FLF2, large format GNSS antenna, a.k.a. BigAnt.

4. Observations

4.1 Conventional Survey

The conventional survey consisted of measuring horizontal/vertical angles and distances using a high precision tacheometer, employing traverse and intersection procedures between and/or to all features of interest. All angular and distance measurements were observed a minimum of three times with the instrument alternating between phase I and phase II (direct and reverse faces). Meteorological readings (temperature, barometric pressure and relative humidity) were entered into the tacheometer and an atmospheric correction was applied to each distance measurement inside the instrument. Data collection software GeoObs v1.04.02 was used for recording field measurements and performing data quality field checks. A complete list of unadjusted and adjusted tacheometer field observations consisting of directions, zenith distances, slope distances and instrument/target heights are available in Star*Net output file Richmond.lst. All Star*Net-related files referenced in this report can be found in a compressed file under the "Richmond Data Products" link at the NGS ISS webpage.

4.2 Leveling

Leveling consisted of measuring height differences between main-scheme and supplemental marks, IRMs and ARPs using a digital bar-code leveling system. All leveling between these points was conducted in accordance with the highest standard of the U.S. Federal Geodetic Control Subcommittee, first-order, class I. Complete lists of unadjusted leveling observations are available in TRANSLEV 4.17 output files L28186.bok and L28186.hgz in a compressed file under the "Richmond Data Products" link at NGS ISS webpage.

4.3 GPS

GPS data collection consisted of simultaneous, long-session observations, conducted over multiple days providing redundant occupation of six ground network marks. GPS data was collected to produce high-precision 3-dimensional coordinates for aligning the complete terrestrial survey network to ITRF2008(edos), the epoch date of the survey.

A report detailing the GPS campaign for this survey is available in file RichGPS.pdf, in a compressed format under the "Richmond Data Products" link at the NGS ISS webpage.

4.4 General Comments

The intersection method is an indirect procedure for tying in a point that cannot be occupied by a tacheometer, nor be adequately represented by a GPH1P target. This method was used on FLF1, allowing the tracking station to operate uninterrupted while the tie to its IRM/ARP was made. Left and right tangents were observed to the antenna's base from ground marks FLF1 RM 1, RM 2, and RM 3. The GNSS antenna had not yet been installed over IRM FLF2 (BigAnt), allowing direct occupation of the mark with a tall tripod.

Leveled height differences were used to reduce slope distance measurements, except for the temporary mark, FLT1, where zenith distance observations were used.

5. Data Analysis and Results

5.1 Terrestrial Survey

Terrestrial observations were adjusted in a geocentric reference frame using a starting coordinate for FLF1 RM 2 and azimuth to JPL GPS RICHMOND (subsequently, the azimuth was switched to the temporary mark, FLT1, provided better error distribution). These geodetic values were derived from the current IGS08(edos) GPS campaign (see Section 4.3). Examination of the latest geoid and deflection-of-vertical (DOV) models, and the GPS-derived ellipsoid heights and leveled heights showed a favorable comparison in the gravity field across the area.

Transformation to ITRF2008 takes place in a later, separate operation.

5.1.1 Analysis software

Star*Net version 7.2.2.7 was used to perform a classical 3-dimensional least-squares adjustment of the terrestrial data in a geocentric reference frame. The adjustment used terrestrial observations of all ground network marks and intersection observations on FLF1's GNSS antenna to produce coordinate and variance-covariance information. The adjustment included differentially leveled heights between the ground marks, IRMs and ARPs. Terrestrial adjustment parameters and results can be found in the Star*Net output file Richmond.lst. Variance-covariance estimates can be found in the Star*Net output file Richmond.dmp.

AXIS 1.07, developed by Geoscience Australia (GA), contains the alignment and SINEX-generating routines used in this project. All AXIS-related files referenced in this report can be found in a compressed file under the "Richmond Data Products" link at the NGS ISS webpage.

NGS's program, chksnx.exe that tests the veracity of the matrix; whether it will invert and its condition.

5.1.2 Topocentric coordinates and covariance

Topocentric coordinates and covariance information from the classical adjustment of the terrestrial data can be found in section 2. INPUT SOLUTION of the AXIS output file, output.axs.

5.1.3 Correlation matrix

Correlation matrix information can be found in section 5. SINEX GENERATION of the AXIS output file output.axs.

5.2 GPS Observations

Using GPS, seven local network points were positioned from five IGS tracking stations located in the U.S., Mexico, Cuba and Bermuda. NGS's Online Positioning User's Service (OPUS)-Projects was used to post-process and analyze GPS data collected, and to estimate IGS08 (edos) positions. Two of these points provided a starting coordinate and azimuth for the least-squares adjustment of the terrestrial network in Star*Net.

The seven local GPS points were used by AXIS 1.07 to re-align the terrestrial network, described below in Section 5.3. Additional details concerning post-processing parameters and adjustment results of GPS observations can be found in document RichGPS.doc located in a compressed file under the "Richmond Data Products" link at the NGS ISS webpage.

5.3 Transformation

Local tie vectors from the terrestrial survey were accurately aligned or transformed from NAD83 to IGS08(edos) using AXIS 1.07 software. In the alignment sequence, AXIS requires a minimum of three points that are common to both reference frames. These common points are referred to as alignment stations. GPS-derived coordinates at the epoch date of the survey are used as input at the alignment stations. The spatial integrity of the terrestrial survey is maintained throughout the transformation process. The IGS08 point listing can be found in OPUS Projects output file network-mch.pos located in a compressed file under the "Richmond Data Products" link at the NGS ISS webpage.

The high quality spatial relationships of the alignment stations in the GNSS network solution was further validated by noting the very similar spatial relationships of the same stations produced by terrestrial observations.

Results can be found in Section 3. APRIORI FRAME ALIGNMENT of the AXIS output file output.axs located in a compressed file, RichDataProducts.zip, at the NGS ISS webpage.

5.4 Description of SINEX generation

AXIS 1.07 was used to generate a final solution output file in SINEX format with full variance-covariance matrix information. The following SINEX naming convention, adopted by GA for local survey data, was also used for this survey.

XXXNNNNYYMMFV.snx

Where:

XXX is a three-character organization designation
NNNN is a four-character site designation
YY is the year of the survey
MM is the month of the survey
F is the frame code (G for global, L for local)
V is the file version

The final SINEX file, NGSRICH1502GA.snx, is included as an Appendix. The file is also available in a compressed file under the "Richmond Data Products" link at the NGS ISS webpage.

5.6 Discussion of Results

Least-Squares Estimates of Terrestrial Observations

A classical geocentric adjustment of terrestrial observations using software Star*Net 7.2.2.7was conducted in NAD83(2011) (propagated to the epoch date of the survey). The adjustment produced 3-dimensional geocentric coordinates for all marks in the survey, including IRMs and ARPs associated with GNSS stations FLF1 and FLF2. Additionally, variance-covariance estimates were computed for all points. A statistical summary from the adjustment is included in Table 3.

```
                    Adjustment Statistical Summary
                    ==============================

                   Iterations              =      2

                   Number of Stations      =     12

                   Number of Observations  =    367
                   Number of Unknowns      =     69
                   Number of Redundant Obs =    298

      Observation   Count   Sum Squares         Error
                              of StdRes        Factor
      Coordinates       3         0.000         0.000
       Directions     159        19.984         0.393
        Distances     141         3.733         0.181
      Az/Bearings       1         0.000         0.000
          Zeniths      42       173.664         2.257
       Level Data      21        24.275         1.193

            Total     367       221.655         0.862

 Warning: The Chi-Square Test at 5.00% Level Exceeded Lower Bound
                  Lower/Upper Bounds (0.920/1.080)Lower/Upper Bounds
```

Table 3 – Statistical summary from classical adjustment of terrestrial survey.

For additional details concerning the classical adjustment of the terrestrial survey, see Star*Net output file Richmond.lst.

Final Coordinate Listing

AXIS 1.07 software was used to compute final coordinate estimates (Table 4), aligned to reference frame ITRF 2008(edos), for the SINEX file to be submitted the IERS. Final coordinates and variance-covariance matrix information is contained in SINEX format file NGSRICH1502GA.snx.

ITRF2008(EPOCH DATE OF SURVEY)
CARTESIAN COORDINATES - EARTH CENTRE ORIGIN (METRES) - VARIANCE-COVARIANCE

SITE	X	Y	Z	SX	SY	SZ
FLF1	961107.2156	-5674030.5085	2740689.2143	0.0004	0.0003	0.0005
FLF2 (BIGANT)	961107.9476	-5674023.7145	2740702.5710	0.0003	0.0002	0.0003
TIMER (TABV)	961317.5550	-5674054.8238	2740563.7840	0.0006	0.0004	0.0007
JPS GPS RICHMOND (RCM4)	961242.6195	-5674021.6335	2740657.6942	0.0003	0.0003	0.0006
7295 (RCM2)	961318.7120	-5674090.9604	2740489.6443	0.0006	0.0003	0.0006
FLF1 RM 1 (FLR1)	961125.3599	-5674024.0306	2740692.9954	0.0002	0.0001	0.0002
FLF1 RM 2 (FLR2)	961103.8839	-5674031.9122	2740683.9347	0.0001	0.0001	0.0002
FLF1 RM 3 (FLR3)	961105.1082	-5674020.3528	2740707.6495	0.0003	0.0001	0.0002

Table 4 – Final coordinate estimates aligned to ITRF2008(edos)

Local tie vector information is provided in Table 5. It was computed through a separate iteration of AXIS, where the REFMK parameter in the setup file was temporarily changed to reflect the primary GPS technique, FLF1.

From – To	East	North	Up		sE	sN	sU
FLF1 - FLR2	-3.5193	-5.1185	-1.5364	+/-	0.0001	0.0001	0.0001
FLF1 - FLF2	1.8565	14.8870	-0.1556	+/-	0.0003	0.0003	0.0001
FLF1 - FLR3	-0.3815	21.1044	-1.3766	+/-	0.0003	0.0002	0.0001
FLF1 - FLR1	18.9715	4.8605	-1.3917	+/-	0.0002	0.0002	0.0001
FLF1 - TF2A	1.8573	14.8871	-0.0604	+/-	0.0003	0.0003	0.0001
FLF1 - RCM4	134.9841	-34.4168	-1.1224	+/-	0.0003	0.0006	0.0001
FLF1 - TABV	203.3233	-138.6558	-0.9269	+/-	0.0007	0.0010	0.0001
FLF1 - RCM2	198.4283	-220.9957	-0.6772	+/-	0.0010	0.0009	0.0001

Table 5 – Local tie vectors from FLF1, primary GNSS tracking station

5.7 Comparison with Previous Surveys

Only two points remain from previous survey work found at the IERS's Site Information and Selection website. The geocentric vector from 7295 (RCM2) to JPL GPS RICHMOND (RCM4) at IGN's ITRF website is in local tie file 40499.tie. The tie had been used in the IRTF2000 primary combination.

RCM2 to RCM4	dX	dY	dZ
2000tie	-76.090	69.330	168.048
Current survey	-76.0925	69.3269	168.0499
Current survey – 2000tie	+0.003 m	+0.003 m	+0.002 m

Table 6 – Comparison of local tie vectors measured prior to 2000 with those determined during the 2015 NGS survey.

RCM2 to TABV	dX	dY	dZ
ASTS1993	-82.3401	-4.8975	0.2531
Current survey	-76.0925	69.3269	168.0499
Current survey – 2000tie	+0.003 m	+0.003 m	+0.002 m

6. Planning Aspects

The GNSS instruments are inside a controlled access fence on U.S. Coast Guard property at the address below. Contact:
U.S. Coast Guard Communication Station Miami (NMA)
Officer in Charge (ETCM Daryl Davis)
16001 SW 117th Ave
Miami, Florida 33177-1699
Telephone: +1 305 233 9655, extension 111

The historical IRMs for the extracted VLBI and SLR instruments are inside a controlled access fence on the University of Miami, Richmond Campus at the address below. Contacts:

Center for Southeastern Tropical Advanced Remote Sensing – University of Miami
CSTARS Station Manager (Raymond E. Turner)
11811 SW 168TH Street
Miami, FL 33177, USA
Telephone: +1 305 421 4962
Email: rturner@rsmas.miami.edu

University of Miami, Rosenstiel School of Marine and Atmospheric Science
RSMAS Building Facility Coordinator (Frank Martone)
Richmond Campus
11811 SW 168 Street
Miami, Florida 33177
fmartone@rsmas.miami.edu
Mobile: +1 305 281 1668

7. References

Johnston, G., Dawson, J. and Naebkhil, S., 2004. The 2003 Mount Stromlo Local Tie Survey. *Geoscience Austrailia Record*, 2004/20, 25pp. *Available online: http://www.ga.gov.au/image_cache/GA5653.pdf*

7.1 Name of person responsible for observations

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7.3 Location of observation data and results archive

National Geodetic Survey
Instrumentation & Methodologies Branch
15351 Office Drive
Woodford, VA 22580
Telephone: +1 540 373 1243
http://www.ngs.noaa.gov/corbin/iss/index.shtml

Attachment: SINEX Format File NGSRICH1502GA.snx

```
%=SNX 1.00 AUS 16:014:55544 AUS 15:044:00000 15:045:00000 C 00015 2 X
+FILE/REFERENCE
 DESCRIPTION        Richmond (FL/USA) Terrestrial Survey Tie
 OUTPUT             SSC SINEX
 CONTACT            Kendall.Fancher@noaa.gov, Charles.Geoghegan@noaa.gov
 SOFTWARE           axis version 1.07
 HARDWARE           ____________________________________________________
 INPUT              Terrestrial Survey Solution
-FILE/REFERENCE
+FILE/COMMENT
* axis software by John Dawson Geoscience Australia
-FILE/COMMENT
+SITE/ID
 FLF1  A 40499M007 C FL Foundation 1        -80 23  9.9  25 36 55.3   -22.1
 FLF2  A 40499M008 C FL Foundation 2 (bigan -80 23  9.9  25 36 55.7   -22.3
 TABV  A 40499M001 C TIMER                  -80 23  2.6  25 36 50.8   -23.0
 RCM4  A 40499M005 C JPL GPS RICHMOND       -80 23  5.1  25 36 54.1   -23.2
 RCM2  A 40499M002 C 7295                   -80 23  2.8  25 36 48.1   -22.8
-SITE/ID
+SITE/DATA
 FLF1  A    P FLF1  A    P 15:044:00000 15:045:00000 --- 15:044:43200
 FLF2  A    P FLF2  A    P 15:044:00000 15:045:00000 --- 15:044:43200
 TABV  A    A TABV  A    A 15:044:00000 15:045:00000 --- 15:044:43200
 RCM4  A    A RCM4  A    A 15:044:00000 15:045:00000 --- 15:044:43200
 RCM2  A    A RCM2  A    A 15:044:00000 15:045:00000 --- 15:044:43200
-SITE/DATA
+SOLUTION/EPOCHS
 FLF1  A    P C 15:044:00000 15:045:00000 15:044:43200
 FLF2  A    P C 15:044:00000 15:045:00000 15:044:43200
 TABV  A    A C 15:044:00000 15:045:00000 15:044:43200
 RCM4  A    A C 15:044:00000 15:045:00000 15:044:43200
 RCM2  A    A C 15:044:00000 15:045:00000 15:044:43200
-SOLUTION/EPOCHS
+SOLUTION/STATISTICS
 VARIANCE FACTOR                8.620000000000000e-01
 SQUARE SUM OF RESIDUALS        2.568760000000000e+02
 NUMBER OF OBSERVATIONS                           313
 NUMBER OF UNKNOWNS                                15
-SOLUTION/STATISTICS
+SOLUTION/ESTIMATE
     1 STAX   FLF1  A    P 15:044:43200 m    2  9.61107215593486e+05 4.52509e-04
     2 STAY   FLF1  A    P 15:044:43200 m    2 -5.67403050854327e+06 2.84941e-04
     3 STAZ   FLF1  A    P 15:044:43200 m    2  2.74068921434717e+06 4.89774e-04
     4 STAX   FLF2  A    P 15:044:43200 m    2  9.61107947580892e+05 3.61395e-04
     5 STAY   FLF2  A    P 15:044:43200 m    2 -5.67402371453584e+06 1.85299e-04
     6 STAZ   FLF2  A    P 15:044:43200 m    2  2.74070257100043e+06 3.02970e-04
     7 STAX   TABV  A    A 15:044:43200 m    2  9.61317554958444e+05 6.09964e-04
     8 STAY   TABV  A    A 15:044:43200 m    2 -5.67405482376375e+06 4.47598e-04
     9 STAZ   TABV  A    A 15:044:43200 m    2  2.74056378395439e+06 7.60025e-04
    10 STAX   RCM4  A    A 15:044:43200 m    2  9.61242619470109e+05 2.77976e-04
    11 STAY   RCM4  A    A 15:044:43200 m    2 -5.67402163353045e+06 3.28451e-04
    12 STAZ   RCM4  A    A 15:044:43200 m    2  2.74065769415778e+06 6.17161e-04
    13 STAX   RCM2  A    A 15:044:43200 m    2  9.61318712039841e+05 6.07816e-04
    14 STAY   RCM2  A    A 15:044:43200 m    2 -5.67409096040547e+06 3.73808e-04
    15 STAZ   RCM2  A    A 15:044:43200 m    2  2.74048964434259e+06 6.32184e-04
-SOLUTION/ESTIMATE
+SOLUTION/MATRIX_ESTIMATE U COVA
     1     1  2.04764463873356e-07  7.04456803914457e-08  7.46322232264865e-08
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     1     4 -2.67317640554332e-08 -1.69135261704365e-08 -2.57959169602367e-08
     1     7 -2.47153401076802e-08  2.83551669919859e-09  1.73847695654162e-08
     1    10 -2.76782821221089e-08 -5.65908879509805e-09  2.61689033299499e-09
     1    13 -1.42658087627295e-08  3.49885235314626e-09  8.49533858168630e-09
     2     2  8.11915625764677e-08  1.26523757076578e-07 -1.74501431528420e-08
     2     5 -1.32546174378149e-08 -2.14129931634659e-08 -6.72323246008467e-09
     2     8 -7.28277718446807e-09 -1.31255828865536e-08 -1.72220255201703e-08
     2    11 -1.76489198070378e-08 -2.66032501107891e-08  2.85947268967900e-08
     2    14  9.36997019783957e-09  8.10459019918396e-09
     3     3  2.39878313515746e-07 -2.62210930215158e-08 -2.12801080713968e-08
     3     6 -3.47138793519511e-08 -4.52032009025860e-09 -1.76777288346780e-08
     3     9 -3.12788470351104e-08 -2.52606257766805e-08 -3.40188996905250e-08
     3    12 -5.47336981979735e-08  6.29003361644072e-08  1.94765534290496e-08
     3    15  1.17342124429071e-08
     4     4  1.30606053012655e-07  1.92438483692401e-08 -1.48584781943501e-09
     4     7 -1.17624865995364e-08  1.21624386218767e-09  6.26084444110790e-09
     4    10  5.33933880110037e-09 -1.53201511597670e-09 -6.27864212203930e-09
     4    13 -6.51809478050947e-09  3.82848332288654e-09  1.08260527698769e-08
     5     5  3.43357750975545e-08  3.83813677033378e-08 -7.82718998131442e-09
     5     8 -6.33946540523815e-09 -1.09372809299743e-08 -1.68628150118458e-09
     5    11 -7.68984515903221e-09 -1.56394001532923e-08  1.46114639592525e-08
     5    14  7.97237440618467e-09  1.20317138990329e-08
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     6     9 -2.44300286990144e-08 -5.23906492719209e-09 -1.49936391562786e-08
     6    12 -3.00828286679275e-08  3.20774483425884e-08  1.52817710103586e-08
     6    15  2.09497989261765e-08
     7     7  3.72056448539906e-07  1.91703550873249e-07  2.63901605931391e-07
     7    10 -1.05886325954915e-08 -6.12605685962859e-10 -2.55404761084108e-10
     7    13 -2.75219387493493e-07 -1.56619125668569e-07 -2.24726709647739e-07
     8     8  2.00344395510189e-07  3.21188315630857e-07  3.34073864325747e-09
     8    11 -2.38237583286403e-08 -3.45061593916687e-08 -2.10161175934682e-07
     8    14 -1.45174889615774e-07 -2.12112669544557e-07
     9     9  5.77637586747670e-07  7.25976162126681e-09 -3.22227544481259e-08
     9    12 -7.92564801083904e-08 -3.34461196120737e-07 -2.31381609800641e-07
     9    15 -3.62363076768116e-07
    10    10  7.72706629549225e-08  3.79790360925253e-08  5.17423241773342e-08
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    14    14  1.39732438713855e-07  2.25552857314197e-07
    15    15  3.99656855654201e-07
-SOLUTION/MATRIX_ESTIMATE U COVA
%ENDSNX
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