# NOAA Technical Report NOS NGS 56

## Local Tie Information Report
## IERS Network Site: Washington, D.C.

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

Dates of Survey: June – August, 2012
Date of Report: September, 2012

**U.S. DEPARTMENT OF COMMERCE**
**NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION**
**NATIONAL OCEAN SERVICE**
**NATIONAL GEODETIC SURVEY**
**GEODETIC SERVICES DIVISION**
**INSTRUMENTATION & METHODOLOGIES BRANCH**

**INTERNATIONAL EARTH ROTATION & REFERENCE SYSTEMS SERVICE**

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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 techniques co-located at IERS Network Sites considered a priority by that service. Within NOAA, these types of surveys are the responsibility of the NGS's IERS Site Survey (ISS) program.

During June, July and August of 2012, the NGS ISS program conducted a local tie vector survey at IERS network site WASHINGTON. Eight space geodetic technique instruments are co-located at this site, consisting of two very long baseline interferometry (VLBI) radio telescopes, two satellite laser ranging (SLR) systems and three GNSS antennas, all owned by the U.S. National Aeronautics and Space Administration (NASA). Prior to the survey, the French National Institute of Geographic and Forest Information (IGN) installed a new Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) antenna, replacing GREB (DOMES# 40451S176).

This report documents the instrumentation, procedures, data analysis, and local tie information results associated with this survey.

# 1. Site description

IERS network site WASHINGTON is located in the United States of America at NASA's Goddard Geophysical and Astronomic Observatory (GGAO), N39$^{o}$-01'/W283$^{o}$-10', near the town of Greenbelt, MD. Eight instruments representing four space geodetic techniques are co-located at this site.

| SGT Instrument | Name | DOMES# 40451 | Description | Code/ 4-CID |
|---|---|---|---|---|
| DORIS Starec Antenna (2012) | DORIS RM 1 | M006 | Bottom-center of a 5/8-11 stud of self-centering device securing DORIS antenna bracket to the top of a concrete pier | DOR1 |
| MOBLAS-7 GODL | CDP STATION 7105 | M105 | MOBLAS -7 7105-1981 standard NASA disk | 7105 |
| (ground network mark) | NORTH GEOS PIER | M110 | Greenbelt north GEOS(GSFC) GORF | NORG |
| NGSLR GO1L | CDP STATION 7125 | M114 | SLR mark 7125 1985 standard NASA disk | 7125 |
| (tie to previous site survey) | 7130 | M116 | SLR mark 7130 1985 standard NASA disk NGSIDB PID: DE5260 | 7130 |
| (tie to previous site survey) | CDP STATION 7918 | M120 | SLR mark standard NASA disk | 7918 |
| GNSS choke ring antenna | GODDARD GODE JPL 4006 | M123 | GPS Mark East (JPL 4006) | GODE |
| Mobile VLBI 3m (MV-3) | SGP 7108-1993 | M125 | Mark SGP 7108-1993 | 7108 |
| GNSS choke ring antenna | GODN | M127 | Reference point of a forced centering SCIGN antenna mount on top of a deep-drilled, braced monument | GODN |
| GNSS choke ring antenna | GODS | M128 | Reference point of a forced centering SCIGN antenna mount on top of a deep-drilled, braced monument | GODS |
| REGINA GNSS | REGINA 2707 | M129 | Reference point of a forced SCIGN antenna mount on top of a steel pillar | GODG |
| DORIS Starec Antenna | DORIS RM 2 | M130 | Top-center of a 5/8-11 stud of self-centering device securing DORIS antenna bracket to the top of a concrete pier | DOR2 |
| VLBI2010 (12m) | VLBI 2010 | S177 | Intersection of axes of a permanent VLBI2010 12m antenna | 7622 |
| DORIS antenna | DORIS ANTENNA 2012 | S178 | DORIS antenna ref. pt (Starec type) | GRFB |

**Table 1 – IERS Network site information can be found at http://itrf.ign.fr/doc_ITRF/iers_sta_list.txt**

# 2. Instrumentation

## 2.1. Tacheometers, EDMI, Theodolites

### 2.1.1. Description

Two (2) Leica TDM5005 Electronic Tacheometer, 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

Instruments calibrated by Leica Geosystem AG Heerbrugg, Switzerland.
Inspection date: 08/15/2008 / 08/20/2008
Both instruments were found to be within factory specifications (see Attachment A).

### 2.1.3 Auxiliary Equipment

Wild NL4 Collimator, S/N: 40145 pointing accuracy, 1: 200,000
Thermometer/hygrometer: Omega RH83, checked against thermistors maintained at the Instrumentation and Methodologies Branch (IMB) of NGS's Geodetic Services Division (GSD).
Barometer: Leitz AIR-HB-1L, S/N: 1L1890

## 2.2 GPS units

### 2.2.1 Receivers

Four (4) Trimble NetR5 GPS L1 C/A Code, L2C, L1/L2/L51 Full Cycle Carrier, GLONASS L1 C/A Code, L1 P Code, L2 P Code, L1/L2 Full Cycle Carrier with Maxwell™ Custom Survey GNSS Chip. P/N: 62800-00, S/Ns: 4619K01307, 4624K01584, 4624K01631 and 4624K01648

Specifications for Static GPS Surveying:
Horizontal: +/- 5 mm + 0.5 ppm RMS
Vertical: +/- 5 mm + 1 ppm RMS

### 2.2.2 Antennas

Four (4) TPSCR.G3, Topcon GPS/GLONASS/Galileo choke ring antenna, model CR-G3, P/N: 1-044301-01, S/Ns 383-1613, -1614, -1626 and -1628

### 2.2.3 Analysis software, mode of operation

Post-processing and adjustment were undertaken using NGS's beta version of Online Positioning User Service (OPUS) Projects, an interactive web page. Data is tagged with a project identifier and on the OPUS web page and uploaded normally. OPUS Projects sorts the data into sessions. User must log in, select a session and reconfigure it if desired before starting the processing. Processing reports are generated and interactive tables display a summary of results. Processed base lines are made available for the adjustment phase. The user is allowed limited flexibility in setting adjustment parameters. Processing and adjustment results are automatically forwarded to user via email.

## 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

Single-piece Leica 2-meter invar rod, P/N: 563660 S/N: 30721

### 2.3.3 Checks carried out before measurements

Daily instrument collimation test procedures were undertaken on-site prior to data collection. Leveling rod bubbles were checked daily, prior to use.

## 2.4 Tripods

Wooden stands, designed by the U.S. Coast and Geodetic Survey and built on-site by the survey team, were installed over survey marks GODDARD, NORTH GEOS PIER and SOUTH GEOS PIER (Figure 1).

A Wild Type II tall wooden tripod was used on GODDARD GODE JPL 4006 in lieu of a stand.

Target/reflector and tacheometer heights were measured by differential leveling at time of set up; centering achieved using the NL4 Collimator. Heights and collimation were checked for any disparity before taking down the tripod.

Custom-made aluminum trivets were used to center targets/reflectors on 7130, CDP STATION 7105, CDP STATION 7125, CDP STATION 7918 and SGP 7108 1993 (Figure 2). Target/reflector heights were measured by differential leveling.

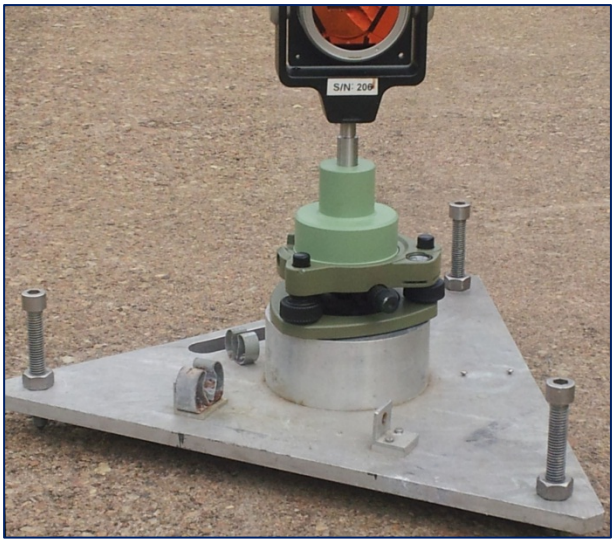

**Figure 2 - Custom-made trivet allows precise centering of targets in tight places.**

**Figure 1 - Typical U.S Coast and Geodetic Survey wooden stand built over SOUTH GEOS PIER. The three-legged stand is anchored solidly into the ground and surrounded by a completely detached observer's platform.**

## 2.5 Forced centering devices

At the time of installation, observing piers were topped with a 5/8-11 stud protruding up from a flat stainless steel base (Figures 3 and 4).

**Figure 3 – NGS 1 equipped with 5/8-11 stud.**

**Figure 4 – CAL PIER D2 equipped with 5/8-11 stud.**

Wild GDF21 tribrachs (Figure 7), designed to accommodate both the tacheometer and target/reflector, were threaded tightly onto the stud, resting solidly on the stainless steel base. All observing piers, with the exception of CAL PIER A, were of a self-centering design. Target/reflector and tacheometer heights were measured by differential leveling at time of set up.

CAL PIER A was modified to accept a temporary transition plate, allowing a tribrach to be precisely centered over an SLR's calibration point. The reference point is the top center of a stainless steel cup embedded into the top of the monument. SLR personnel use the cup to hold a reflector during calibration of their instrument (Figures 5 and 6). The translation plate allowed the survey team to precisely collimate over the same point (Figure 7).

**Figure 5 - CAL PIER A with NGSLR calibration reflector not installed. Cup embedded into top of pier is shown surrounded by three newly installed threaded inserts for attaching the survey team's translation plate and tribrach (Figure 7).**

**Figure 6 - Reflector installed.**

**Figure 7 - Translation plate with (green) Wild GDF21 tribrach.**

## 2.6 Targets, reflectors

Except for the intersection observations at GNSS stations GODN and GODS, Leica GPH1P precision reflectors were used as needed for tacheometer observations, acting as both target and reflector. For each reflector, the manufacturer-provided offset values of -34.4 mm were validated at the IMB facility. To minimize the loss of precision in distance measurement, the GPH1P must be precisely pointed back to the tacheometer. To that end, the GPH1Ps used on the SLR and radio telescope measurements were mounted to sturdy, radio-controlled, pan-tilt units. The pan-tilt units were then remotely pointed to the tacheometer by the observer after each motion of the SLR/radio telescope.

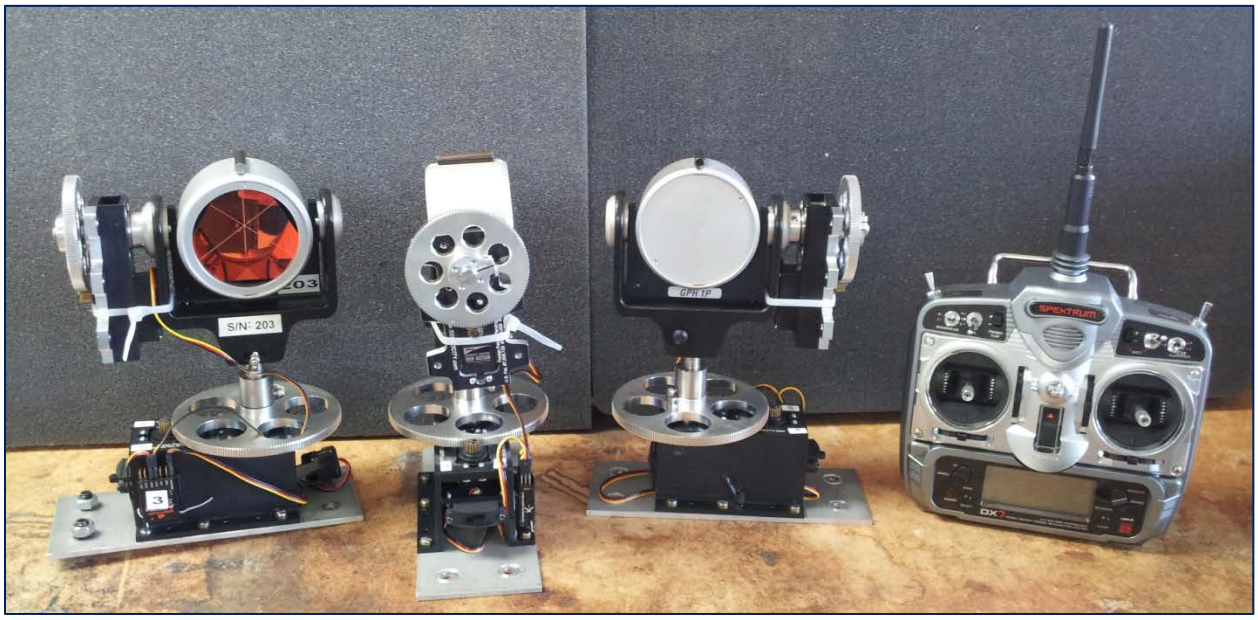


**Figure 8 – GPH1P outfitted with two R/C servos (pan and tilt axes) to allow precise pointing of target from remote location (tacheometer).**

# 3. Measurement Setup

## 3.1 Ground network

The ground network consists of two categories of marks; main scheme and supplemental. Main scheme marks are tied together in a local coordinate system with repeated and extremely precise horizontal and vertical angle measurements and distance measurements. These marks are used to tie the SGT instruments directly to the network, and indirectly, to each other. Supplemental marks are accurately positioned relative to the network, but do little or nothing to enhance the network. Supplemental marks may be reference marks for the SGT instruments, marks of special interest, or marks from a previous site survey. Tying to marks from previous surveys provides additional information about past and present ground networks.

The following marks were found in a SINEX file (Table 2) stored at the IERS web site (http://itrf.ign.fr/ties/40451.snx). Of the 16 marks listed, six were recovered and included in the current survey. The remaining 10 had either been destroyed or are inaccessible for various reasons.

```
*-----------------------------------------------------------------------------
+FILE/COMMENT
* File created on February 6, 2001 by software ratmix version 1.00
* CONTACT            altamimi[at]ensg.ign.fr
-FILE/COMMENT
*-----------------------------------------------------------------------------
+SITE/ID
*CODE PT __DOMES__ T _STATION DESCRIPTION__ APPROX_LON_ APPROX_LAT_ _APP_H_
 7101  A 40451M101                          283 10 42.9  39 01 16.2     8.6
 7102  A 40451M102                          283 10 18.9  39 01 14.3    18.0
 7103  A 40451M103                          283 10 18.9  39 01 14.6    17.9
 7104  A 40451M104                          283 10 36.9  39 01 17.0    10.0
 7105  A 40451M105                          283 10 20.3  39 01 14.1    19.2
 7100  A 40451M106                          283 10 47.7  39 01 15.4     9.8
 7065  A 40451M108                          283 10 19.1  39 01 14.4    18.0
 7899  A 40451M111                          283 10 48.1  39 01 15.3    10.0
 7063  A 40451M112                          283 10 19.9  39 01 13.3    19.3
 7106  A 40451M113                          283 10 17.7  39 01 17.3    19.4
 7125  A 40451M114                          283 10 21.1  39 01 12.9    18.5
 7130  A 40451M116                          283 10 21.1  39 01 15.2    18.6
 7920  A 40451M117                          283 10 21.0  39 01 12.9    18.5
 7918  A 40451M120                          283 10 19.7  39 01 14.5    18.7
 GODE  A 40451M123                          283 10 23.4  39 01 18.2    14.5
 7108  A 40451M125                          283 10 24.4  39 01 18.9    13.7
```

**Table 2 – Site information can be found at http://itrf.ign.fr/ties/40451.snx. Highlighted points were tied into the current survey.**

GODE (GODDARD GODE JPL 4006) was occupied directly as a ground network mark in the current survey. Its "permanently" installed GNSS antenna had been removed for repair at this time, allowing direct measurements to and from the mark. The five remaining marks were included in the current survey as supplemental.

### 3.1.1 Listing

| Current Survey Main-Scheme Marks | DOMES 40451 | IERS 4-char code | Current Survey 4-char | HTSI2007 Survey Point Name | HTSI2007 Adjustment Name | NGS PID |
|---|---|---|---|---|---|---|
| CAL PIER A | | | CALA | CAL-PIER A | CAL(A)01 | |
| CAL PIER A VPR | | | CLAV | | | |
| CAL PIER B3 | | | CALB | CAL-PIER B3 (2002) | CALB | |
| CAL PIER B3 VPR | | | CLBV | | | |
| CAL PIER D2 | | | CAL2 | | | |
| GGAO 1 | | | GGA1 | | | |
| GGAO 2 | | | GGA2 | | | |
| GGAO VLBI RM PIER A | | | GGAA | GGAO VLBI FRM PIER A | VLBA | AH5618 |
| GGAO VLBI RM PIER B | | | GGAB | GGAO VLBI RM PIER B | PIER(B)95 | AH5615 |
| GGAO VLBI RM PIER C | | | GGAC | GGAO VLBI RM PIER C | PIER(C)95 | AH5617 |
| GODDARD | | | GODD | GODDARD 1962 | | |
| GODDARD GODE JPL | M123 | GODE | GODE | JPL 4006 (GGAO GPS | GODE | AA3496 |
| NGS 1 | | | NGS1 | | | |
| NGS 2 | | | NGS2 | | | |
| NGS 3 | | | NGS3 | | | |
| NORTH GEOS PIER | M110 | | NORG | NORTH GEOS PIER 1979 | NGEO | JV5895 |
| SOUTH GEOS PIER | | | SOUG | SOUTH GEOS PIER 1976 | SGEOS | JV5894 |
| **Supplemental Marks** | | | | | | |
| CAL PIER C | | | CALC | CAL-PIER C | CALC | |
| CAL PIER C VPR | | | CLCV | | | |
| CAL PIER D | | | CALD | | | |
| CDP STATION 7105 | M105 | 7105 | 7105 | CDP STATION 7105 | 7105 | |
| CDP STATION 7125 | M114 | 7125 | 7125 | CDP STATION 7125 | 7125 | |
| CDP STATION 7130 | M116 | 7130 | 7130 | | | |
| CDP STATION 7918 | M120 | 7918 | 7918 | | | |
| DORIS RM 1 | M006 | | DOR1 | | DORIS(07)MK | |
| DORIS RM 2 | M180 | | DOR2 | | | |
| GODN | M127 | | GODN | | | |
| GODN ARP | | | GONA | | | |
| GODN VPR | | | GONV | | | |
| GODS | M128 | | GODS | | | |
| GODS ARP | | | GOSA | | | |
| GODS VPR | | | GOSV | | | |
| REGINA 2707 | | | 2707 | | | |
| SGP 7108 1993 | M125 | 7108 | 7108 | SGP 7108-1993 | 7108(93) | |
| **Conv. Ref. Points** | | | | | | |
| DORIS ANTENNA 2012 | S178 | GRFB | GRFB | | | |
| VLBI2010 CRP (IVP_02) | S177 | 7622 | 7622 | VLBI2010 | | |
| NGSLR CRP (IVP_06) | | | NGSLR | NG2000 (NOV 2007) | NG2000(07) | |
| MOBLAS-7 CRP (IVP_10) | | | MOB7 | | MOB7(07) | |
| MV-3 CRP (IVP_14) | | | MV-3 | | MV3(07) | |

**Table 3 – Cross-referenced Listing of Points including those from the 2007 survey by Honeywell Technology Solutions, Inc. (HTSI2007)**

**Main-Scheme Marks**

**CAL PIER A** is defined by the top center of a stainless steel cup set into the top of a 30-cm (dia.) concrete observing pier. A temporary self-centering device was fabricated to allow survey equipment to be attached securely to the top of the pier and plumbed directly over the center of the cup. To expedite tacheometer/target tribrach set up, a socket-head bolt, CAL PIER A VPR, was drilled and epoxied into the southeast side of the pier. It is 0.13004 meter lower than CAL PIER A.

**CAL PIER B3** is defined horizontally by a self-centering device (stainless steel plate w/5/8-11 stud) embedded in the top of a 30-cm (dia.) concrete observing pier. To expedite tacheometer/target tribrach set up, a socket-head bolt, CAL PIER B3 VPR, was drilled and epoxied into the west side of the pier. It is 0.14295 meter lower than CAL PIER B3.

**CAL PIER D2** is defined horizontally by a self-centering device (stainless steel plate w/5/8-11 stud) embedded in the top of a 30-cm (dia.) concrete observing pier. The vertical point of reference is the head of a socket-head bolt protruding from the south side of the pier and about 20 cm below the top.

**GGAO 1** is defined horizontally by a self-centering device (stainless steel plate w/5/8-11 stud) embedded in the top of a 30-cm (dia.) concrete observing pier. The vertical point of reference is the top surface of the plate at the base of the stud. The pier and its buried base, a 60 cm (dia.) x 3 m, is a steel reinforced monolith installed about two months prior to the start of the current survey.

**GGAO 2** is defined horizontally by a self-centering device (stainless steel plate w/5/8-11 stud) embedded in the top of a 30-cm (dia.) concrete observing pier. The vertical point of reference is the top surface of the plate at the base of the stud. The pier and its buried base, a 60 cm (dia.) x 3 m, is a steel reinforced monolith installed about two months prior to the start of the current survey.

**GGAO VLBI RM PIER A** is defined horizontally by a self-centering device (stainless steel plate w/5/8-11 stud) embedded in the top of a 30-cm (dia.) concrete observing pier. The vertical point of reference is the top surface of the plate at the base of the stud.

**GGAO VLBI RM PIER B** is defined horizontally by a self-centering device (stainless steel plate w/5/8-11 stud) embedded in the top of a 30-cm (dia.) concrete observing pier. The vertical point of reference is the top surface of the plate at the base of the stud.

**GGAO VLBI RM PIER C** is defined horizontally by a self-centering device (stainless steel plate w/5/8-11 stud) embedded in the top of a 30-cm (dia.) concrete observing pier. The vertical point of reference is the top surface of the plate at the base of the stud.

**GODDARD** is defined horizontally and vertically by a small divot in the top-center of a brass disk stamped GODDARD 1962, set into the top of a 30-cm (dia.) concrete post recessed 5 cm below ground level.

**GODDARD GODE JPL 4006** is defined horizontally and vertically by a small divot in the top-center of a stainless steel plate stamped GODDARD GORF EAST FLYNN GPS STATION MARK JPL 4006 1992, set into the top of a 60-cm (dia.) concrete post projecting about 30 cm above ground level.

**NGS 1** is defined horizontally by a self-centering device (stainless steel plate w/5/8-11 stud) anchored in the top of a 15-cm (dia.) concrete observing pier encased in PVC pipe. The vertical point of reference is the head of a socket-head bolt protruding from the east side of the pier and about 20 cm below the top. The pier and its buried base, a 45 cm (dia.) x 1 m, is a monolith installed about two months prior to the start of the current survey.

**NGS 2** is defined horizontally by a self-centering device (stainless steel plate w/5/8-11 stud) anchored in the top of a 15-cm (dia.) concrete observing pier encased in PVC pipe. The vertical point of reference is the head of a socket-head bolt protruding from the south side of the pier and about 20 cm below the top. The pier and its buried base, a 45 cm (dia.) x 1 m, is a monolith installed about two months prior to the start of the current survey.

**NGS 3** is defined horizontally by a self-centering device (stainless steel plate w/5/8-11 stud) anchored in the top of a 15-cm (dia.) concrete observing pier encased in PVC pipe. The vertical point of reference is the head of a socket-head bolt protruding from the southeast side of the pier and about 20 cm below the top. The pier and its buried base, a 45 cm (dia.) x 1 m, is a monolith installed about two months prior to the start of the current survey.

**NORTH GEOS PIER** is defined horizontally and vertically by a cross etched into the top-center of a brass disk stamped NORTH GEOS PIER 1979, set into the top of a 90-cm (on side) triangular concrete monument projecting 40 cm above ground level.

**SOUTH GEOS PIER** is defined horizontally and vertically by a cross etched into the top-center of a brass disk stamped SOUTH GEOS PIER 1976, set into the top of a 90-cm (on side) triangular concrete monument projecting 40 cm above ground level.

**Supplemental Marks**

**CAL PIER C** is defined horizontally by the center of a stainless steel cup set into the top of a 30-cm (dia.) concrete observing pier. A 5/8-11 self-centering adapter for the cup held the survey target during measurements. To expedite tacheometer/target tribrach set up, a socket-head bolt, CAL PIER C VPR, was drilled and epoxied into the west side of the pier. It is 0.15116 meter lower than CAL PIER C.

**CDP STATION 7105** is defined horizontally and vertically by a small divot in the top-center of a brass disk stamped MOBLAS STA 7105, set into a drill hole in the concrete pad currently occupied by MOBLAS 7's trailer. It is the reference mark for MOBLAS 7.

**CDP STATION 7125** is defined horizontally and vertically by a small divot in the top-center of a brass disk stamped GORF-MTLRS 7125 1985, set into a drill hole in the concrete pad occupied by the building housing NGSLR. It is the reference mark for NGSLR and is located east of the building.

**CDP STATION 7130** is defined horizontally and vertically by a small divot in the top-center of a brass disk stamped 7130 1985, set into a drill hole in a concrete pad. The mark formed part of the ground network from a previous survey on file at the ITRF web site (see Table 2).

**CDP STATION 7918** is defined horizontally and vertically by a small divot in the top-center of a brass disk stamped MOBLAS STA. 7918 1985, set into a drill hole in a concrete pad. The mark formed part of the ground network from a previous survey on file at the ITRF web site (see Table 2).

**DORIS RM 1** is defined horizontally by a self-centering device (stainless steel plate w/5/8-11 stud) embedded in the top of a 30-cm (dia.) concrete support pier for the DORIS antenna. The vertical point of reference is the top surface of the plate at the base of the stud.

**DORIS RM 2** is defined horizontally by a self-centering device (stainless steel plate w/5/8-11 stud) embedded in the top of a 30-cm (dia.) concrete support pier for the DORIS antenna. The vertical point of reference is the top surface of the stud. It is the reference mark for the DORIS antenna.

**GODN** is defined horizontally by a self-centering device (SCIGN GNSS antenna mount) attached to the head block of a DDBM. The vertical point of reference is typical with the SCIGN mounts; a divot (8.3 mm) below the top plate. It is the reference mark for GODN GNSS antenna.

**GODS** is defined horizontally by a self-centering device (SCIGN GNSS antenna mount) attached to the head block of a DDBM. The vertical point of reference is typical with the SCIGN mounts; a divot (8.3 mm) below the top plate. It is the reference mark for GODS GNSS antenna.

**REGINA 2707 RM** is defined horizontally by a self-centering device (SCIGN GNSS antenna mount) attached to the head block of a DDBM. The vertical point of reference is typical with the SCIGN mounts; a divot (8.3 mm) below the top plate. It is the reference mark for REGINA GNSS antenna. The antenna had not yet been installed at the time of the survey allowing direct measurements to the SCIGN mount.

**SGP 7108 1993** is defined horizontally and vertically by a small divot in the top-center of a brass disk stamped GGAO VLBI SGP 7108 1993, set into a drill hole in a concrete pad. The mark formed part of the ground network from a previous survey on file at the ITRF web site (see Table 2).

### 3.1.2 Map of Network

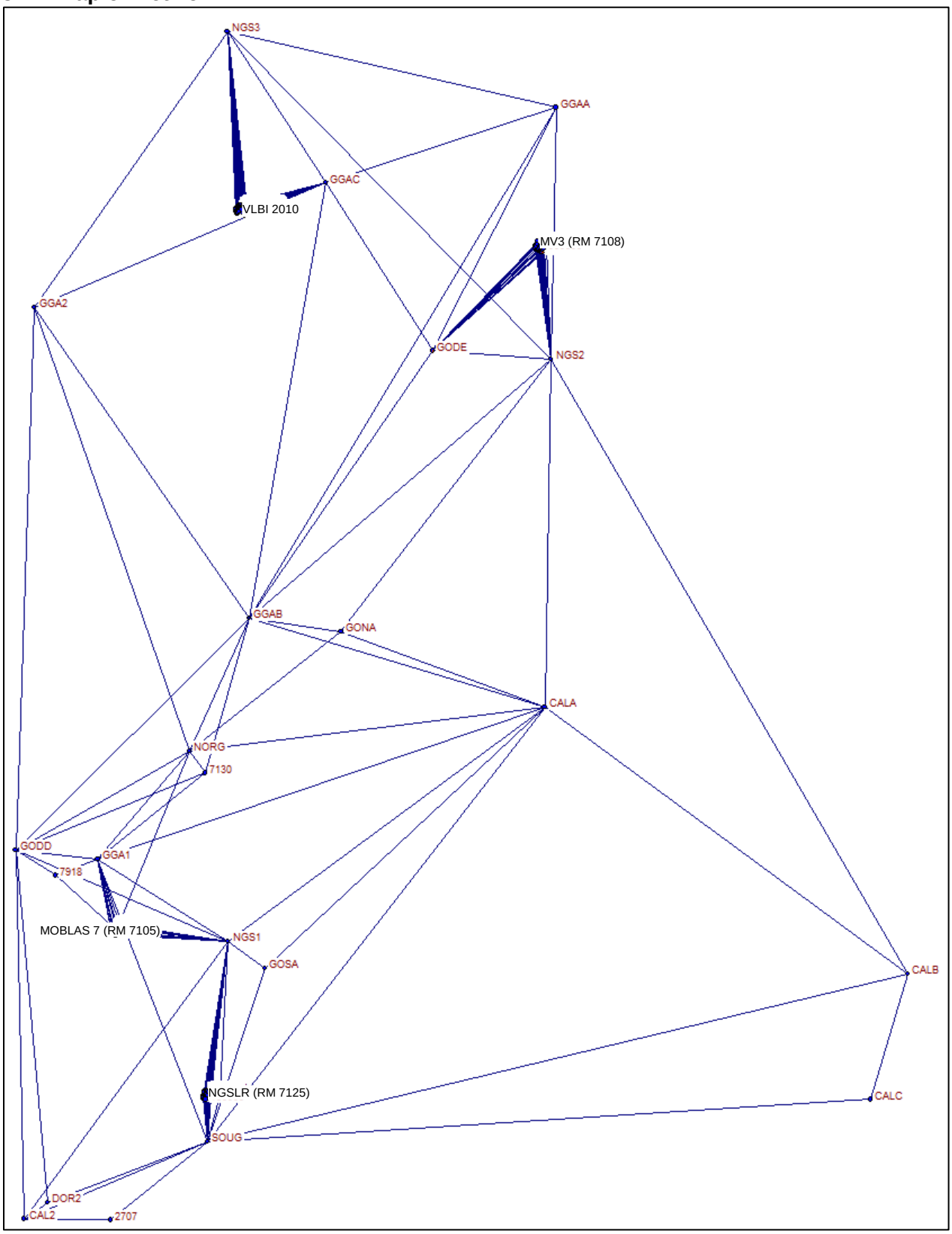


Figure 9. Map of Network Stations

## 3.2 Representation of Technique Reference Points

### 3.2.1 VLBI/VLBA

The conventional reference point (CRP), a.k.a. invariant reference point (IVP), is a theoretical point and is defined as the intersection of the azimuth axis with the common perpendicular of the azimuth and elevation axis (Johnston et al, 2004). An indirect approach was used to determine the CRP. NASA maintains two VLBI instruments at the Washington site.

The newer instrument, VLBI 2010, has a 12-meter dish perched atop a cylindrical pedestal. Almost the entire pedestal is encased in thermal shielding to mitigate solar thermal expansion. This unit does not have a reference mark.

The other instrument, MV-3, is much older and has a 5-meter dish. Both units were designed and constructed to have no azimuth/elevation axes offsets. Survey results agree with that assertion. While it was expected that MV-3 would have IVS reference mark offset values reported in the site log that could be compared with the current survey, none were readily available at this writing. However, offset values from Honeywell Technology Solutions, Incorporated's 2007 survey (HTSI2007) compare favorably with the current survey (Table 4).

Figure 10. VLBI 2010, 12 meters

Figure 11. MV3, 5 meters

| Sources: | HTSI2007 Survey | Current Survey | Diff. (cm) |
|---|---|---|---|
| SGP 7108 1993 – MV-3 CRP (dE) | +0.002 | +0.0014 | -0.1 |
| (dN) | +0.006 | +0.0073 | +0.1 |
| (dU) | +3.069 | +3.0694 | 0.0 |

**Table 4 – Offset Comparisons at MV-3 in meters. VLBI 2010 does not have a reference mark. Differences are listed in a new-minus-old format, where Diff. = Current Survey – IVS Offset.**

### 3.2.2 SLR

NASA maintains two SLR instruments at the Washington site. The indirect approach to measuring the CRP was used on both units. The electronics on and around the telescopes are very sensitive to rain and must be completely enclosed in advance of inclement weather. The new unit, known as the "next generation" SLR or NGSLR, is a permanent installation.

**Figure 12. NGSLR w/target bar mounted vertically to the telescope. Attached targets were positioned as they scribed circles about the vertical (azimuthal) axis.**

**Figure 13. MOBLAS-7 with target bar mounted horizontally. Targets were positioned as they scribed circles about the horizontal (elevation) axis.**

The International Laser Ranging Service (ILRS) publishes site information for the two SLRs operating at GGAO. The site logs for MOBLAS-7 (GODL) and NGSLR (GO1L), found at http://ilrs.gsfc.nasa.gov/stations/sitelist/GODL_sitelog.html and http://ilrs.gsfc.nasa.gov/stations/sitelist/GO1L_sitelog.html, provide offset information from the mark to the CRPs.

| Sources: | ILRS Offsets | HTSI2007 Survey | Current Survey | ILRS Diff. (cm) | 2007 Diff. (cm) |
|---|---|---|---|---|---|
| CDP STATION 7105 – MOBLAS-7 CRP (dE) | -0.008 | -0.007 | -0.0087 | -0.1 | -0.1 |
| (dN) | -0.032 | -0.034 | -0.0327 | -0.1 | +0.1 |
| (dU) | +3.139 | +3.138 | +3.1379 | -0.1 | -0.1 |
| CDP STATION 7125 – NGSLR CRP (dE) | -0.082 | N/A | -0.0814 | +0.1 | N/A |
| (dN) | -2.814 | N/A | -2.8147 | -0.1 | N/A |
| (dU) | +3.696 | N/A | -3.6972 | +0.1 | N/A |

**Table 5 – Offset Comparisons at MOBLAS-7 and NGSLR in meters. Measurements taken back in 1998 and 2008, respectively, appear to be holding well. Differences are listed in a new-minus-old format, where Diff. = Current Survey – ILRS Offset.**

### 3.2.3 GPS

NASA is currently maintaining three GNSS instruments plumbed over reference marks GODDARD GODE JPL 4006 (GODE), GODN and GODS. Historically, reference mark GODE has hosted the primary GNSS instrument. This is expected to change when a decision is made for either GODN or GODS to take over those duties. In the meantime, all three were included in the current survey.

GODDARD GODE JPL 4006 hosts an AOA choke ring antenna with an uncalibrated radome. At the time of the survey, the antenna had to come off the mark for repairs, allowing both the ARP and the mark to be tied directly to the ground network. Before removing the antenna, the ARP was positioned within the ground network. This included measuring the height of the ARP with a precise digital level instrument and leveling procedures. After removing the antenna, the mark itself was incorporated into the ground network, resulting in a new and independent determination of ARP offsets. Table 8 compares these offsets with those published by the IGS.

| Sources: | IGS Offsets | Current Survey | Diff. (mm) |
|---|---|---|---|
| GODDARD GODE JPL 4006 – GODE ARP (dE) | 0.0000 | -0.0002 | -0.2 |
| (dN) | 0.0000 | 0.0000 | 0.0 |
| (dU) | +0.0614 | +0.0611 | -0.3 |

**Table 6 – Offset Comparison at GODDARD GODE JPL 4006 in meters. Offset values from the site log compare favorably to the current survey. Differences are listed in a new-minus-old format, where Diff. = Current Survey – IGS Offset.**

GODN and GODS both host a Topcon choke ring antenna with a SCIGN short radome. Because the antennas could not be removed to access the reference marks, both were tied to the network using an indirect method. The ARPs were *intersected* from at least three main-scheme marks. The height of the antennas is reported to be 0.0083 m above the respective marks, divots within the SCIGN mounts. The SCIGN mount at GODS was found loose on the DDBM and reported to the responsible agency.

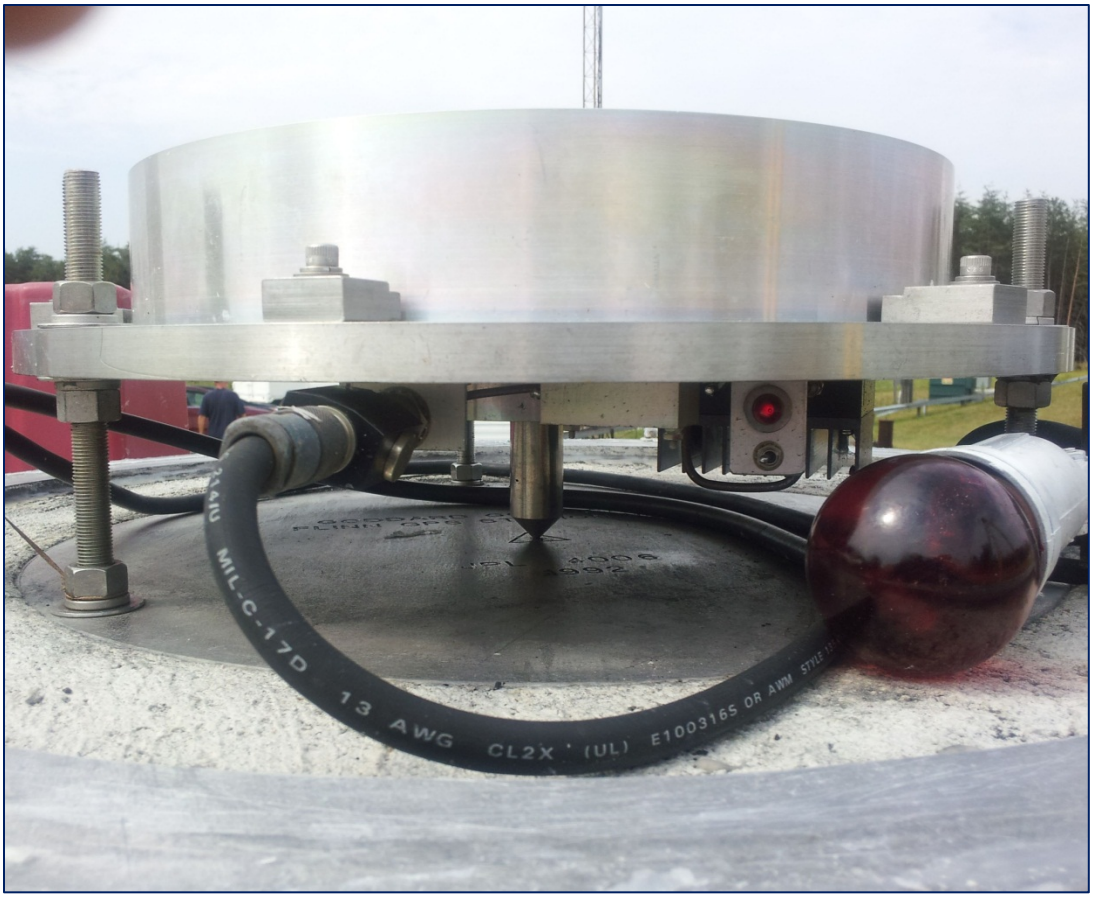


**Figure 14. The centering device at GODE with antenna in place, radome removed.**

**Figures 15 & 16. GODS and GODN, respectively.**

### 3.2.4 DORIS

The National Institute of the Geographic and Forest Information (IGN) maintains a DORIS Starec-type antenna at the Washington site. Three points associated with this instrument were tied to the network; the antenna's CRP and two reference marks. The CRP, DORIS ANTENNA 2012, has the four-character code of GRFB. DORIS RM 2 replaced DORIS RM 1 as the primary reference mark. Both RMs have DOMES numbers and were included in the current survey for continuity's sake.

**Figure 17. Carefully leveling to the DORIS ARP, the midpoint of a red band encircling the tube.**

**Figure 18. Both DORIS reference marks were tied to the network.**

Just prior to the start of the site survey, the IGN changed out the antenna, GREB, with a newer model, GRFB, and taller mount. The NGS survey team did not have an opportunity to tie to GREB. Also, a more accessible reference mark bearing a DOMES number was established to replace the original reference mark. For continuity, the original reference mark was tied to the current survey, as well as the new reference mark and the new antenna's CRP. For the purposes of this survey, the points were named as follows:

DORIS RM 1 – Original reference mark
DORIS RM 2 – New reference mark
DORIS ANTENNA 2012 – New Starec antenna

The IGN installation team measured the offsets from RM 2 to the antenna CRP. Those values are compared to the current survey in Table 7.

| Sources: | IDS Offset | Current Survey | Diff. (cm) |
|---|---|---|---|
| DORIS RM 2 – DORIS ANTENNA 2012 (GRFB) (dE) | -0.002 | -0.0025 | 0.0 |
| (dN) | +0.002 | +0.0011 | -0.1 |
| (dU) | +0.824 | +0.8244 | 0.0 |

**Table 7 – Offset Comparison at DORIS ANTENNA 2012 (GRFB). Measurements made by the installation team compare favorably to the current survey. Differences are listed in a new-minus-old format, where Diff. = Current Survey – IDS Offset.**

### 3.2.5 GLONASS (N/A)

This technique was not represented at this site.

# 4. Observations

## 4.1 Conventional Survey

A complete list of unadjusted and adjusted tacheometer field observations consisting of directions, zenith distances, slope distances, and instrument and target heights are available at http://dev.ngs.noaa.gov/corbin/ISS/index.shtml.

## 4.2 Leveling

The leveling loop began at NORTH GEOS PIER and ran through GGAO VLBI RM PIER B, GGAO 2, NGS 3, GGAO VLBI RM PIER C, GGAO VLBI RM PIER A, NGS 2, CAL PIER A, CAL PIER B3, CAL PIER C, REGINA 2707 ARP, CAL PIER D2, SOUTH GEOS PIER, NGS 1, GGAO 1, CDP STATION 7918, GODDARD, 7130, closing back on NORTH GEOS PIER. Leveling spurs to the following marks were tied to the loop: DORIS ANTENNA 2012, CDP STATION 7125, CDP STATION 7105, SGP 7108 1993, GODE ARP, GODN ARP, GODN VPR, GODS ARP, GODS VPR, CAL PIER D, GORF, VLBI PIER B ARP, DORIS RM 2 and GODDARD GODE JPL 4006. See Attachment A. Abstract of Leveling Observations for leveled height differences.

## 4.3 GPS

GPS data were collected on four of the main-scheme marks in overnight sessions.

| Session 172A<br>Minimum 14 hours | Session 173A<br>Minimum 12 hours | Session 193A<br>Minimum 15 hours | Session 214A<br>Minimum 18 hours | Session 215A<br>Minimum 19 hours |
|---|---|---|---|---|
| | CAL PIER D2 | CAL PIER D2 | CAL PIER D2 | CAL PIER D2 |
| CAL PIER B3 | CAL PIER B3 | CAL PIER B3 | CAL PIER B3 | CAL PIER B3 |
| GGAO 2 | GGAO 2 | GGAO 2 | GGAO 2 | GGAO 2 |
| GGAO VLBI RM PIER A | GGAO VLBI RM PIER A | | GGAO VLBI RM PIER A | GGAO VLBI RM PIER A |

**Table 8 – GPS Session Summary**

## 4.4 General Comments

Data collection software GeoObs v1.04.02 was used for recording field measurements and for data quality checks.

Star*Net least-squares software was used to analyze thousands of extremely precise tacheometer measurements made to precision targets from the 15 main-scheme marks. The result is a very tight, very clean network of marks based in a local coordinate system.

As noted earlier, determining the local coordinates of the SLR and radio telescopes' CRP requires an indirect approach. The principle is straight-forward. A point, as it revolves about an axis, scribes an arc. An arc defines a circle and a circle defines an axis. Assigning coordinates to the points along the arc defines the parameters of the axis. Tacheometer measurements from the ground network to a target attached to a telescope will generate coordinates on the points along the arc.

The minimum number of points needed to define a circle, and therefore an axis, is three. The minimum number of measurements needed to extend local coordinates to three points is ten (four horizontal directions, three vertical angles, and three slope distances). Twenty measurements will define two axes and provide local coordinates for the CRP.

In practice, a complex system of observations involving three targets secured to the telescope, measurements from two ground network marks, and at least 1,080 total measurements per axis ensure sub-millimeter results. At least 2,160 measurements are run through Star*Net and into AXIS software to determine one CRP. CRPs for the two VLBI instruments and two SLR instruments were determined in this manner

Another indirect approach, intersection, allows certain SGT instruments to continue uninterrupted operation while the tie to their reference mark is made. This approach was used on GODN, GODS, DORIS ANTENNA 2012, DORIS RM1 and RM 2. The horizontal ties to these four marks and the DORIS antenna were made by intersection from at least three ground network marks. At GODN, GODS and DORIS ANTENNA 2012, left and right tangents to the antennas were measured as close to the ARP as possible. Tangent observations were later reduced to the center of the antenna. The horizontal ties to DORIS RMs 1 and 2 were accomplished by intersection, also. But the mark could be observed directly and did not require tangent observations. All heights for these intersection stations were determined by differential leveling.

Differential leveling was also conducted through all ground network marks. Leveled height differences were used in conjunction with GPS-derived ellipsoid heights to learn more about the local geoid, and also check the quality of trigonometric leveling observations between network stations. The ability to compare trig leveling against a standard while observing the SLR and radio telescope targets in the same data set provided quality assurance for those observations.

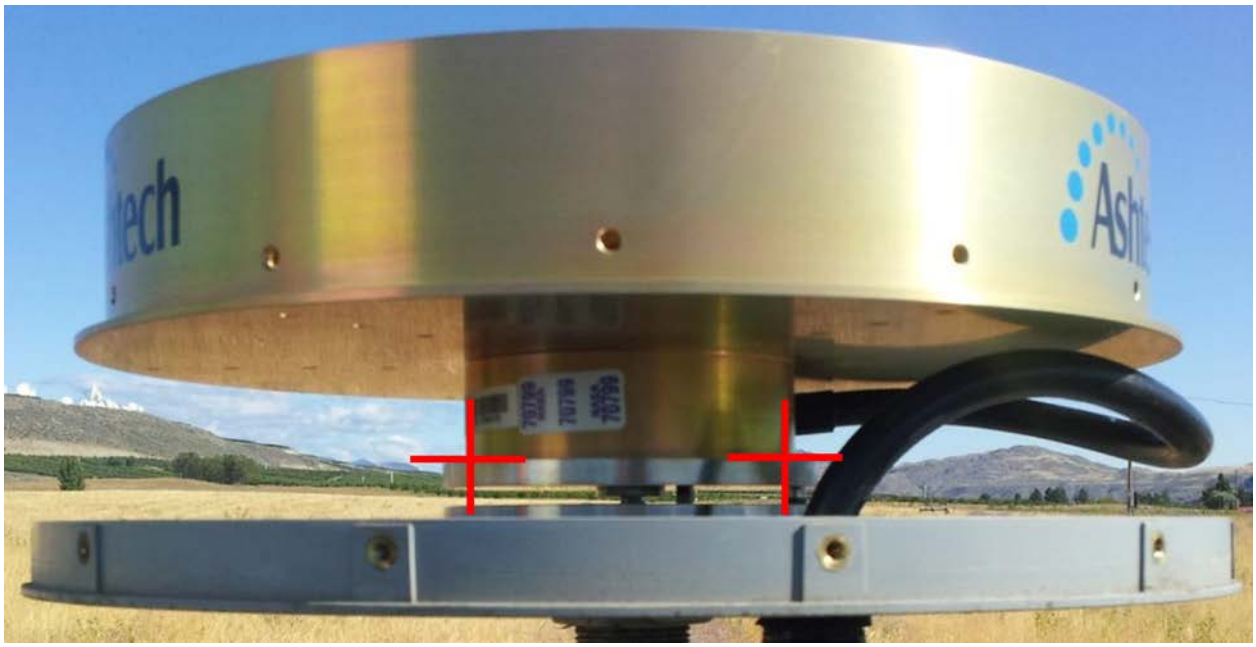

**Figure 19 – FILE PHOTO. Leveling to the ARP on a GNSS choke ring antenna is achieved by centering the level instrument reticle coincident with the ARP, indicated by the red cross marks on the image. Foresight measurements to the ARP were observed to one side, while backsights were observed to the opposite side of the ARP in order to account for any mis-leveling of the SCIGN mount.**

Leveling procedures adhered to Federal Geodetic Control Subcommittee (FCGS) first-order, class I field specifications. However, because site surveys do not benefit from ties to a vertical datum, network geometry requirements for a tie to existent vertical control were ignored. Translev v4.16 was used to facilitate the process of editing, formatting and checking of the digital leveling observation data, apply refraction corrections and create an abstract of observations.

# 5. Data Analysis and Results

## 5.1 Terrestrial Survey

### 5.1.1 Analysis software

A 3-D least squares adjustment was conducted on the terrestrial survey data using commercially available software Star*Net version no.7.1.0.5. The adjustment included leveling data. Results were reviewed for outliers in the survey observations and used to verify the accuracy of the survey.

The 3-D adjustment consisted of terrestrial observations of all ground network marks, intersection stations, and intermediate target points on the SLR and radio telescopes, producing local coordinates for all. See http://dev.ngs.noaa.gov/corbin/ISS/index.shtml for terrestrial 3-D adjustment results in the Star*Net output file Wash3D.lst. Note: web page is currently under development; URL is subject to change.

AXIS Software, developed by Geoscience Australia (GA), was used to determine the SLR and radio telescopes CRP. Coordinates for each target were computed during the 3-D adjustment, at each orientation of the radio telescope. These points were used to derive 3-D circles in space, which were used to determine the radio telescope CRP. The following excerpt was taken from a GA site survey report and edited to reflect the particular circumstances of this survey. In the following excerpt, the term IVP is interchangeable with CRP.

The StarNet .dmp file, generated by the 3-D adjustment, included the full variance-covariance matrix required by AXIS. The .dmp file was placed into a directory with the AXIS software along with a setup.axs file. The setup file was edited repeatedly to derive estimates of circle parameters for each target and each rotation sequence. Once initial estimates were refined for all target rotation sequences, geometric constraints were added. Initial constraints introduced included:

CDIST – used to constrain target coordinates so that target-to-target distances remain constant over all rotational sequences. ;
ENORMAL, NNORMAL, UNORMAL – used to constrain normal parameters together;
CENTRE – used to constrain together centre to centre distances (azimuth axis only)
RADIUS – used to constrain circle arc radius parameters together

With updated circle parameter estimates for each target rotation sequence, IVP coordinates were derived. Additional constraints were introduced to constrain separate IVP realizations. Constraints applied included:

OFFSET – used to constrain the computed offset to be identical for independent IVP estimates;
ORTHOG – used to constrain the orthogonality between three axes;
UIVP – used to constrain the individual IVP determination in the UP component together.

CRP computation results can be found at http://dev.ngs.noaa.gov/corbin/ISS/index.shtml in the AXIS file output.axs, Section 4.18 COMPUTED SOLUTION PARAMETER SUMMARY.

### 5.1.2 Topocentric coordinates and covariance

For topocentric coordinates and covariance information used in CRP computations, go to http://dev.ngs.noaa.gov/corbin/ISS/index.shtml, AXIS file output.axs, Section 2. INPUT SOLUTION.

### 5.1.3 Correlation matrix

For computed correlation matrix information, see Attachment F. SINEX File NGSWASH1207GA.SNX.

### 5.1.4 Reference temperature of radio telescopes [for thermal expansion]

A height correction for the CRP of MV-3 and VLBI2010 was computed based on the following procedure:

i) Compute a [30-day] temperature average and see to what extent it differs from the reference.
ii) Multiply the CRP height by 0.000012 and by the temperature difference
iii) Correct the CRP height if it is needed.

- **Telescope reference temperatures:** **+13.4$^{O}$C** for MV-3 from Antenna Information File Format Version of 2008.04.22 (A. Nothnagel, 2009) provided to NGS by the working group chair. See http://vlbi.geod.uni-bonn.de/IVS-AC/Conventions/antenna-info.txt. Because no reference temperature is provided for VLBI2010 at this time, the same value is used in computations for both telescopes
- **30-day temperature average.** Continuous 30-day range consists of average daily temperatures. It concludes on second (final) day of survey measurements to each respective telescope.
  - VLBI2010 (2012/05/24 – 2012/06/22): **+21.5$^{O}$ C**
  - MV-3 (2012/07/05 – 2012/08/03): **+25.2$^{O}$ C**
- **Temperature difference** (reference – observed)
  - VLBI2010: **-8.1$^{O}$ C**
  - MV-3: **-11.8$^{O}$ C**

- **Total height of elevation axis** (foundation + length of fixed axis)
  - VLBI2010: **6.8 meters**
  - MV-3: **4.4 meters**

VLBI2010 corr'n. = 6.8 m × 0.000012 m/m $^{O}$C × -8.1$^{O}$ C = **-0.0007 m**

MV-3 corr'n. = 4.4 m × 0.000012 m/m $^{O}$C × -11.80$^{O}$ C = **-0.0006 m**

Note: The 30-day temperature average is the best available approximation of the temperature of the structure at the time of observations. The correction is provided for informational purposes and was not applied to either telescope.

## 5.2 GPS Observations

### 5.2.1 Analysis Software

NGS's beta version of Online Positioning User's Service (OPUS) Projects was used to post-process and perform a least-squares 3-D adjustment of GPS data.

OPUS Projects uses NGS's PAGE5 v1203.27 for post-processing. Default settings were used with two exceptions; 1) GODN was set as a hub and 2) the cutoff elevation for processing was lowered to 10$^{o}$. The remaining default settings resulted in the:

- use of IGS08.atx absolute antenna calibration file
- use of IGS orbits (+/- 2 cm)
- use of IGS08solution coordinate reference system with coordinates updated to date of observations using velocities
- use of default (modeled) meteorological values
- use of dual-frequency ionospheric correction
- time parameters solved in data reduction
- double-difference, ionosphere-free (IF) combination solution, where

$$IF = \{f_{21}/(f_{21} - f_{22})\}L_1 - \{f_1 f_2/(f_{21} - f_{22})\}L_2$$

- not all integer biases were determinable resulting in partial, fixed integer estimate of biases

Intended accuracy of vectors is 0.1 ppm plus 0.5 cm (A-order). All base lines were measured at least twice, once on each of two days. Redundant vectors were checked against each other to ensure accuracy was met. See Attachment B. Redundant GPS Vectors.

OPUS Projects uses the program GPSCOM v1203.15, a simple Helmert Blocking normal equation processor which combines multiple GPS data sets that have initially been processed by the program PAGES, to form and partially reduce normal equations eliminating numerous nuisance parameters which are not generally of interest in a large global adjustment. The normal equation elements for the global parameters, those to be passed on to a combined adjustment, are written by PAGES into a normal equation file which becomes the basic input data for the program GPSCOM. One or more of these files as well as its own output normal equation files can then be processed by GPSCOM to provide a combined adjustment of the global parameters. This program was written in FORTRAN. Predominantly ANSI standard FORTRAN, a few isolated routines query the operating system for time and date, user and system identification. These "system" routines are inherently non-portable but, should be easily modified or disabled. For more information, go to http://www.ngs.noaa.gov/GRD/GPS/DOC/gpscom/gpscom.html

### 5.2.2 Results

A summary of redundant GPS vectors shows how well the repeated measurements agree. In the final adjustment, all vectors were reprocessed and weighted based on OPUS-Projects' estimate of quality.

| DOY SESS | REF | REM | DELTA X (meters) | $v_x$ (mm) | DELTA Y (meters) | $v_y$ (mm) | DELTA Z (meters) | $v_z$ (mm) | Length (meters) | $v_l$ (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| 12-172-A | calb | gga2 | -204.0543 | 0.4 | 54.7362 | -0.2 | 117.9681 | 0.3 | 241.9724 | -0.3 |
| 12-173-A | calb | gga2 | -204.0554 | -0.7 | 54.7298 | -6.6 | 117.9745 | 6.7 | 241.9751 | 2.4 |
| 12-193-A | calb | gga2 | -204.0558 | -1.1 | 54.7415 | 5.1 | 117.9626 | -5.2 | 241.9722 | -0.5 |
| 12-214-A | calb | gga2 | -204.0542 | 0.5 | 54.7372 | 0.8 | 117.9673 | -0.5 | 241.9722 | -0.5 |
| 12-215-A | calb | gga2 | -204.0536 | 1.1 | 54.7372 | 0.8 | 117.9665 | -1.3 | 241.9714 | -1.3 |
| | Std. | Dev. | 0.9 mm | | 4.2 mm | | 4.3 mm | | 1.4 mm | |
| 12-172-A | ggaa | gga2 | -107.9519 | 0.8 | -50.6727 | -0.9 | -30.6050 | 0.3 | 123.1179 | -0.4 |
| 12-173-A | ggaa | gga2 | -107.9548 | -2.1 | -50.6757 | -3.9 | -30.6001 | 5.2 | 123.1204 | 2.1 |
| 12-214-A | ggaa | gga2 | -107.9523 | 0.4 | -50.6700 | 1.8 | -30.6076 | -2.3 | 123.1177 | -0.6 |
| 12-215-A | ggaa | gga2 | -107.9519 | 0.8 | -50.6688 | 3.0 | -30.6086 | -3.3 | 123.1171 | -1.2 |
| | Std. | Dev. | 1.4 mm | | 3.1 mm | | 3.8 mm | | 1.5 mm | |
| 12-173-A | cal2 | gga2 | -19.6357 | -1.8 | 129.8593 | -3.8 | 151.958 | 5.4 | 200.8488 | 1.8 |
| 12-193-A | cal2 | gga2 | -19.6337 | 0.2 | 129.8648 | 1.7 | 151.9498 | -2.7 | 200.8460 | -1.0 |
| 12-214-A | cal2 | gga2 | -19.6330 | 0.9 | 129.8633 | 0.2 | 151.9521 | -0.5 | 200.8466 | -0.4 |
| 12-215-A | cal2 | gga2 | -19.6333 | 0.6 | 129.8651 | 2.0 | 151.9503 | -2.3 | 200.8465 | -0.5 |
| | Std. | Dev. | 1.2 mm | | 2.7 mm | | 3.8 mm | | 1.2 mm | |

**Table 9 - Redundant vectors compare well with each other. Estimates used in the final adjustment were weighted based on the quality of the post-processed data. Above, *v* = variance from the mean.**

The final GPS coordinates were computed independently using NGS's OPUS-Projects web-based software. See Attachment B. GPS Geocentric Coordinates and Covariances for the OPUS Projects output SINEX file. AXIS output Section 5.4 Transformation (http://dev.ngs.noaa.gov/corbin/ISS/index.shtml), reflects a high level of precision between the GPS and terrestrial surveys.

## 5.3 Additional Parameters

In addition to the CRP positions, AXIS software computed an azimuthal/elevation axes offset value for the four telescopes included in the current survey. The offsets, found in Section 3.7 of the output file (output.axs) available at http://dev.ngs.noaa.gov/corbin/ISS/index.shtml, are provided in Table 10. Note the current survey shows the MV-3 radio telescope axes to be offset by +0.7 mm (+/- 1.2 mm). The International VLBI Service (IVS) reports the length of the axis offset to be -2.1 mm (A. Nothnagel, 2009), a difference of +2.8 mm. See http://vlbi.geod.uni-bonn.de/IVS-AC/Conventions/antenna-info.txt for VLBI axes offset information.

| CRP for: | Offset provided by Service (mm) | Offset from current survey (mm) | Difference (mm) |
|---|---|---|---|
| VLBI 2010 | N/A | +1.8 (+/-1.7) | N/A |
| NGSLR | N/A | +0.8 (+/- 1.1) | N/A |
| MOBLAS-7 | N/A | +1.5 (+/- 2.6) | N/A |
| MV-3 | -2.1 | +0.7 (+/- 1.2) | +2.8 |

**Table 10 - Telescope Axes Offsets. The published axes offset for MV-3 falls outside of the accuracy estimate for the value determined in the current survey.**

## 5.4 Transformation

The GPS data collected on marks near the four corners of the project were used exclusively for transformation from a topocentric to geocentric reference frame. NGS's OPUS-Projects GNSS processing and adjustment utility produced geocentric coordinates propagated to ITRF2008 (2012/07/14), the midterm of the current survey. AXIS transforms without distortion to the terrestrial survey.

The following is the AXIS summary of the transformation:

```
TRANSFORMATION PARAMETERS: ARBITRARY TO GLOBAL (OR REFERENCE SET)

CARTESIAN SYSTEM         : CENTROID ORIGIN

VARIANCE FACTOR          :          4.43384e-08
SIGMA                    :          2.10567e-04

          TX         TY         TZ         RX         RY         RZ
           M          M          M         AS         AS         AS

      -0.0003     0.0007    -0.0004       3.79       6.60       7.16
```

**Table 11 – AXIS Transformation Summary. T represents translation in meters and R is rotation in arc seconds.**

## 5.5 Description of SINEX generation

The SINEX file was directly generated by AXIS. For details, see AXIS output file, output.axs, Section 6.1 USER INPUT SINEX INFORMATION at http://dev.ngs.noaa.gov/corbin/ISS/index.shtml. The following SINEX naming convention, adopted by GSA 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

See Attachment C. for SINEX file NGSWASH1207GA.SNX.

A concerted effort was made to tie to all points at the site that currently have DOMES numbers, along with the CRPs of five SGT instruments. This resulted in a total of 17 points in the SINEX file.

| Code | DOMES# | Description | Longitude | Latitude | Ht. |
|---|---|---|---|---|---|
| (DOR1) | 40451M006 | DORIS RM 1 TOP OF STUD | -76 49 40.4 | 39 1 12.3 | 19.9 |
| 7105 | 40451M105 | MOBLAS-7 CDP STA 7105 | -76 49 39.7 | 39 1 14.2 | 19.2 |
| (NORG) | 40451M110 | NORTH GEOS PIER (GSFC) | -76 49 39.0 | 39 1 15.4 | 18.9 |
| 7125 | 40451M114 | NGSLR CDP STATION 7125 | -76 49 38.8 | 39 1 13.0 | 18.5 |
| 7130 | 40451M116 | 7130 1985 NGS# DE5260 | -76 49 38.8 | 39 1 15.3 | 18.6 |
| 7918 | 40451M120 | CDP STATION 7918 | -76 49 40.2 | 39 1 14.6 | 18.7 |
| GODE | 40451M123 | GODDARD GODE JPL 4006 | -76 49 36.6 | 39 1 18.2 | 14.5 |
| 7108 | 40451M125 | MV-3 SGP 7108-1993 | -76 49 35.6 | 39 1 18.9 | 13.7 |
| GODN | 40451M127 | GODN SCIGN MOUNT DIVOT | -76 49 37.5 | 39 1 16.2 | 17.9 |
| GODS | 40451M128 | GODS SCIGN MOUNT DIVOT | -76 49 38.4 | 39 1 13.9 | 19.1 |
| GODG | 40451M129 | REGINA SCIGN MT DIVOT | -76 49 39.9 | 39 1 12.1 | 20.0 |
| (DOR2) | 40451M130 | DORIS RM 2 BOT OF STUD | -76 49 40.4 | 39 1 12.3 | 19.9 |
| 7622 | 40451S177 | VLBI 2010 12M CRP | -76 49 38.3 | 39 1 19.3 | 18.5 |
| GRFB | 40451S178 | DORIS ANTENNA 2012 CRP | -76 49 40.4 | 39 1 12.3 | 20.7 |
| GO1L | --------- | NGSLR NEW GEN SLR CRP | -76 49 38.9 | 39 1 13.0 | 22.2 |
| GODL | --------- | MOBLAS-7 SLR CRP | -76 49 39.7 | 39 1 14.2 | 22.3 |
| (MV-3) | --------- | MV-3 MOB VLBI 5M CRP | -76 49 35.6 | 39 1 18.9 | 16.8 |

**Table 12 - SINEX File Listing. Includes any/all surveyed points with DOMES numbers and/or SGT instrument CRPs.**

## 5.6 Discussion of Results

Repeated GNSS observations on the four corners of the site consistently showed a significant difference between the GPS-derived ellipsoid heights and the differential leveling, indicating geoid slope. Two geoid models, USGG2012 and the hybrid Geoid09, substantiated a significant slope in the geoid. Simply put, the local reference frame of the terrestrial survey was "tipped" slightly in a southeasterly direction when compared to the ITRF (Figure 20). However, AXIS software accounts for any geoid slope during the transformation from the topocentric to the geocentric reference system.

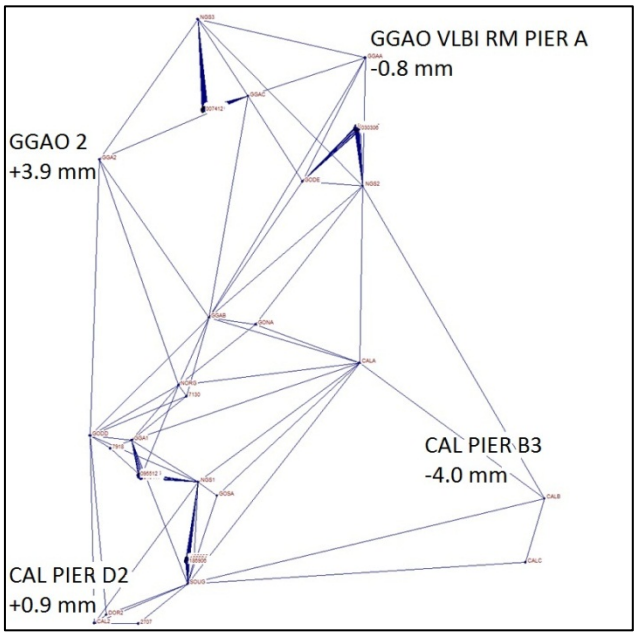


**Figure 20 - Geoid Slope. Comparison of GPS-derived elipsoid heights to leveling.**

| | Ellips. Ht. | Leveling | Difference | *v* (mm) |
|---|---|---|---|---|
| GGAO 2 | 13.6901 | 0.0000 | 13.6901 | 0.0039 |
| CAL PIER B3 | 16.9532 | 3.2710 | 13.6822 | -0.0040 |
| GGAO VLBI RM PIER A | 13.7431 | 0.0577 | 13.6854 | -0.0008 |
| CAL PIER D2 | 19.7335 | 6.0464 | 13.6871 | 0.0009 |

**Table 13 – Comparison of Ellipsoidal and Leveled Heights. Ellipsoidal heights are derived from the same GPS adjustment used in the transformation .**
**Variance (*v*) = Difference – the average of all differences.**

<u>Least-Squares Estimates of Terrestrial Observations</u>

A minimally constrained 3-D adjustment of tacheometer observations was run. Assumed local coordinates and height at GGAO VLBI RM PIER B, an azimuth to GGAO VLBI RM PIER C, and all leveled height differences were weighted heavily, but not constrained.

- The residuals of the distances, zenith distances and directions were highly consistent among the vast majority of points; "fringe" values were not rejected, but simply assigned an appropriately higher standard error estimate instead.
- Star*Net reports the sum squares of standard residuals is 4695.356 with a total error factor of 0.985. This passed the Chi-square test at 5 % level.

See Wash3D.lst at http://dev.ngs.noaa.gov/corbin/ISS/index.shtml for additional details.

Least-Squares Estimates of Conventional Reference Points

AXIS solved for four SGT instrument CRPs using position and variance-covariance estimates from Star*Net. AXIS reports the following solution statistics:

```
LEAST SQUARES SOLUTION

# OF TARGETS                  :                    48
# OF IVP ESTIMATES            :                    16
# OF COORDINATE-OBSERVATIONS  :                  1002
# OF UNKNOWNS                 :                   464
# OF CONDITIONS               :                   813
# OF CONSTRAINTS              :                   176
# OF ADD. CONSTRAINTS         :                   176
# OF CONSTRAINTS TOTAL        :                   352
DEGREES OF FREEDOM            :                  1703

ITERATIONS TO COMPLETE        :                     2
MAXIMUM RESIDUAL (METRE)      :               0.00338
VARIANCE (CONDITIONS)         :               4.00104
VARIANCE (CONSTRAINTS)        :               0.02973
VARIANCE (APRIORI)            :               0.00000
VARIANCE FACTOR               :               4.03076
SIGMA                         :               2.00768
```

**Table 14 – AXIS Least-squares Summary.**

CRP model (circle) fit residuals were 0.5 mm Root Mean Square Error (RMS) for the in-plane residuals and 0.9 mm for the out-of-plane residuals.

See http://dev.ngs.noaa.gov/corbin/ISS/index.shtml for AXIS output file output.axs, Section 3. LEAST SQUARES ESTIMATION for additional details.

Table 15 contains a complete listing of final geocentric coordinate estimates from the current survey.

| Point Name | X (meters) | Y (meters) | Z (meters) | Xσ (m) | Yσ (m) | Xσ (m) |
|---|---|---|---|---|---|---|
| GGAO 2 | 1130686.6676 | -4831264.8265 | 3994210.0947 | 0.0002 | 0.0002 | 0.0002 |
| GODDARD | 1130695.7318 | -4831343.2273 | 3994120.2134 | 0.0001 | 0.0000 | 0.0001 |
| CDP STATION 7918 | 1130704.9823 | -4831345.4362 | 3994116.0323 | 0.0003 | 0.0003 | 0.0003 |
| CAL PIER D2 | 1130706.3004 | -4831394.6894 | 3994058.1436 | 0.0002 | 0.0002 | 0.0002 |
| DORIS RM 1 | 1130710.9662 | -4831391.5291 | 3994060.8891 | 0.0004 | 0.0004 | 0.0004 |
| DORIS RM 2 | 1130710.9694 | -4831391.5430 | 3994060.9007 | 0.0004 | 0.0004 | 0.0004 |
| DORIS ANTENNA 2012 | 1130711.1128 | -4831392.1667 | 3994061.4206 | 0.0004 | 0.0004 | 0.0004 |
| GGAO 1 | 1130713.9947 | -4831342.4032 | 3994119.4535 | 0.0002 | 0.0001 | 0.0001 |
| CDP STATION 7105 | 1130719.4003 | -4831350.5727 | 3994106.5798 | 0.0005 | 0.0004 | 0.0004 |
| MOBLAS-7 CRP | 1130719.9255 | -4831352.9594 | 3994108.5486 | 0.0002 | 0.0003 | 0.0003 |
| NGS 3 | 1130721.4484 | -4831216.1310 | 3994254.1844 | 0.0001 | 0.0001 | 0.0000 |
| REGINA 2707 RM | 1130724.9693 | -4831391.1826 | 3994057.5603 | 0.0004 | 0.0003 | 0.0003 |
| VLBI 2010 CRP | 1130729.9884 | -4831245.9543 | 3994228.2788 | 0.0002 | 0.0006 | 0.0005 |
| NORTH GEOS PIER | 1130731.0978 | -4831322.6039 | 3994136.5353 | 0.0002 | 0.0002 | 0.0002 |
| 7130 | 1130734.9770 | -4831324.6714 | 3994132.4400 | 0.0003 | 0.0003 | 0.0003 |
| GGAO VLBI RM PIER B | 1130740.7195 | -4831300.8728 | 3994158.0087 | 0.0001 | 0.0001 | 0.0001 |
| NGSLR CRP | 1130743.3656 | -4831371.5203 | 3994079.4522 | 0.0002 | 0.0005 | 0.0004 |
| SOUTH GEOS PIER | 1130743.8821 | -4831375.3042 | 3994069.4594 | 0.0002 | 0.0000 | 0.0001 |
| NGS 1 | 1130743.9177 | -4831347.5633 | 3994104.1162 | 0.0001 | 0.0001 | 0.0001 |
| CDP STATION 7125 | 1130745.4398 | -4831368.0320 | 3994077.1877 | 0.0004 | 0.0003 | 0.0003 |
| GGAO VLBI RM PIER C | 1130746.4533 | -4831233.9124 | 3994228.7513 | 0.0001 | 0.0001 | 0.0000 |
| GODS | 1130752.3006 | -4831349.1073 | 3994098.9369 | 0.0004 | 0.0004 | 0.0004 |
| GODS ARP | 1130752.3020 | -4831349.1137 | 3994098.9422 | 0.0004 | 0.0004 | 0.0004 |
| GODN | 1130760.8641 | -4831298.6748 | 3994155.1780 | 0.0004 | 0.0005 | 0.0005 |
| GODN ARP | 1130760.8657 | -4831298.6811 | 3994155.1833 | 0.0004 | 0.0005 | 0.0005 |
| GODDARD GODE JPL 4006 | 1130773.6322 | -4831253.5647 | 3994200.4398 | 0.0002 | 0.0002 | 0.0002 |
| GODE ARP | 1130773.6429 | -4831253.6111 | 3994200.4783 | 0.0003 | 0.0003 | 0.0003 |
| SGP 7108 1993 | 1130794.5278 | -4831233.8110 | 3994217.0848 | 0.0004 | 0.0004 | 0.0004 |
| GGAO VLBI RM PIER A | 1130794.6203 | -4831214.1570 | 3994240.7028 | 0.0002 | 0.0002 | 0.0002 |
| VLBI MV-3 CRP | 1130795.0717 | -4831236.1281 | 3994219.0229 | 0.0004 | 0.0004 | 0.0003 |
| NGS 2 | 1130799.5745 | -4831250.2264 | 3994198.8440 | 0.0001 | 0.0001 | 0.0001 |
| CAL PIER A | 1130806.3254 | -4831298.8583 | 3994139.8765 | 0.0002 | 0.0002 | 0.0002 |
| CAL PIER C | 1130885.6467 | -4831338.7126 | 3994071.0914 | 0.0003 | 0.0003 | 0.0003 |
| CAL PIER B3 | 1130890.7221 | -4831319.5637 | 3994092.1281 | 0.0002 | 0.0002 | 0.0002 |

**Table 15 - Adjusted coordinates transformed to ITRF2008 (2012/07/14) using AXIS software.**

Table 16 lists tie-vectors determined in the current survey. The vectors emanate from the current IGS tracking station to all marks with DOMES numbers and to the CRPs of all SGT instruments.

| From/To | ΔX | ΔY | ΔZ |
|---|---|---|---|
| GODDARD GODE JPL 4006 (GODE) 40451M123<br>CDP STATION 7918 (7918) 40451M120 | -68.6499 | -91.8715 | -84.4075 |
| GODDARD GODE JPL 4006 (GODE) 40451M123<br>DORIS RM 1 (N/A) 40451M006 | -62.6660 | -137.9644 | -139.5507 |
| GODDARD GODE JPL 4006 (GODE) 40451M123<br>DORIS RM 2 (N/A) 40451M130 | -62.6628 | -137.9783 | -139.5391 |
| GODDARD GODE JPL 4006 (GODE) 40451M123<br>DORIS ANTENNA 2012 (GRFB) 40451S178 | -62.5194 | -138.6020 | -139.0192 |
| GODDARD GODE JPL 4006 (GODE) 40451M123<br>CDP STATION 7105 (7105) 40451M105 | -54.2319 | -97.0080 | -93.8600 |
| GODDARD GODE JPL 4006 (GODE) 40451M123<br>MOBLAS-7 CRP (GODL) N/A | -53.7067 | -99.3947 | -91.8912 |
| GODDARD GODE JPL 4006 (GODE) 40451M123<br>REGINA 2707 RM (N/A) 40451M129 | -48.6629 | -137.6179 | -142.8795 |
| GODDARD GODE JPL 4006 (GODE) 40451M123<br>VLBI 2010 CRP (7622) 40451M177 | -43.6438 | 7.6104 | 27.8390 |
| GODDARD GODE JPL 4006 (GODE) 40451M123<br>NORTH GEOS PIER (N/A) 40451M110 | -42.5344 | -69.0392 | -63.9045 |
| GODDARD GODE JPL 4006 (GODE) 40451M123<br>7130 (7130) 40451M116 | -38.6552 | -71.1067 | -67.9998 |
| GODDARD GODE JPL 4006 (GODE) 40451M123<br>NGSLR CRP (GO1L) N/A | -30.2666 | -117.9556 | -120.9876 |
| GODDARD GODE JPL 4006 (GODE) 40451M123<br>CDP STATION 7125 (7125) 40451M114 | -28.1924 | -114.4673 | -123.2521 |
| GODDARD GODE JPL 4006 (GODE) 40451M123<br>GODS (GODS) 40451M128 | -21.3316 | -95.5426 | -101.5029 |
| GODDARD GODE JPL 4006 (GODE) 40451M123<br>GODN (GODN) 40451M127 | -12.7681 | -45.1101 | -45.2618 |
| GODDARD GODE JPL 4006 (GODE) 40451M123<br>SGP 7108 1993 (7108) 40451M125 | 20.8956 | 19.7537 | 16.6450 |
| GODDARD GODE JPL 4006 (GODE) 40451M123<br>VLBI MV-3 CRP (N/A) N/A | 21.4395 | 17.4366 | 18.5831 |

**Table 16 – Tie-Vectors, Current Survey in ITRF2008 (2012/07/14). A listing of tie vectors determined in the current survey. From/to key: CURRENT SURVEY POINT NAME (4-character ID) DOMES#. N/A – not available**

Vector Comparison: Survey-derived Versus IERS-derived

Table 17 contains topocentric vector comparisons. A SINEX file of six points common to the current survey was obtained from the IERS website (http://itrf.ensg.ign.fr/site_info_and_select/solutions_extraction.php). The request stipulated coordinates in ITRF2008, propagated to the epoch date of the current survey, 2012\07\14. NGS's interactive program, INVERS3D (http://www.ngs.noaa.gov/cgi-bin/Inv_Fwd/invers3d.prl), used the geocentric coordinates to derive local vectors starting from MOBLAS-7's reference mark, CDP STATION 7105, to each of the remaining five marks. The results agree with the noted discrepancy between the reference marks at MOBLAS-7 (CDP STATION 7105) and GODDARD GODE JPL 4006. Additionally, the comparisons suggest discrepancies greater than 5 mm to the four remaining marks, most notably the reference mark for NGSLR (CDP STATION 7125). IERS reported discrepancies are found in ITRF2008 Tie-Residuals.dat at http://itrf.ensg.ign.fr/ITRF_solutions/2008/doc/ITRF2008-Tie-Residuals.dat.

| Source: | IERS derived | Current Survey | Diff. (mm) | IERS Reported Discrepancy (mm) |
|---|---|---|---|---|
| 7130 (dE) | 21.0844 | 21.0693 | -15.1 | N/A |
| (dN) | 33.7447 | 33.7348 | -9.9 | |
| (dU) | -0.5887 | -0. 5544 | +34.3 | |
| CDP STATION 7125 (dE) | 21.3604 | 21. 3758 | +15.4 | N/A |
| **-RM for NGSLR** (dN) | -37.2652 | -37. 2744 | -9.2 | |
| (dU) | -0.6675 | -0. 6858 | -18.3 | |
| CDP STATION 7918 (dE) | -12.8690 | -12. 8681 | +0.9 | N/A |
| (dN) | 12.5646 | 12. 5612 | -3.4 | |
| (dU) | -0.4795 | -0. 4879 | -8.4 | |
| GODDARD GODE JPL 4006 (dE) | 74.9143 | 74. 9115 | -2.8 | -3.2 |
| **-RM for GNSS** (dN) | 124.6118 | 124. 6099 | -1.9 | +1.2 |
| (dU) | -4.6818 | -4. 6886 | -6.8 | -6.1 |
| SGP 7108 1993 (dE) | 99.7581 | 99. 7588 | +0.7 | N/A |
| **-RM for MV-3** (dN) | 146.6438 | 146. 6535 | +9.7 | |
| (dU) | -5.4781 | -5. 4522 | +25.9 | |

**Table 17 – Topocentric Vector Comparisons. Differential vectors derived from ITRF2008 published coordinates are compared with the current survey. Differences are listed in a new-minus-old format, where Diff. = Current Survey – IERS-published. For an additional comparison, the last column shows the discrepancy currently recognized by the ITRS, where Residual = Space Geodesy – Terrestrial Tie.**

## 5.7 Comparison with Previous Surveys

Honeywell Technology Solutions, Inc., under contract with NASA, surveyed this site in 2007 (HTSI2007). The local reference frame survey results were not available; the geocentric coordinates taken directly from the HTSI2007 report of that survey were used for this comparison. AXIS software was used to transform the current survey coordinates to the HTSI2007 reference frame so a direct comparison could be made between local vectors. Available for comparison between the two surveys were three of the current eight SGT instruments and ten of the current ground network marks. Table 18 compares common points from the two surveys after transforming the current survey to the reference frame of the HTSI2007 survey. All vectors emanate from the CRP of MOBLAS-7.

| **Current local vector minus HTSI2007 local vector** | **E (mm)** | **N (mm)** | **U (mm)** |
|---|---|---|---|
| NORTH GEOS PIER | +0.2 | 0.0 | -0.7 |
| GGAO VLBI RM PIER C | -1.6 | +0.4 | 0.0 |
| GGAO VLBI RM PIER A | -0.5 | +0.9 | -0.7 |
| SOUTH GEOS PIER | -0.1 | +0.6 | +0.5 |
| CDP STATION 7125 **(RM for NGSLR)** | -1.6 | +0.6 | +0.4 |
| CDP STATION 7105 **(RM for MOBLAS-7)** | +1.2 | -2.0 | -0.1 |
| SGP 7108 1993 **(RM for MV-3)** | -0.1 | +0.5 | +0.1 |
| DORIS RM 1 | 0.0 | +0.6 | -1.1 |
| GGAO VLBI RM PIER B | -0.2 | +0.2 | +0.1 |
| GODDARD GODE JPL 4006 **(RM for IGS tracking sta.)** | +1.7 | +0.5 | +0.5 |
| VLBI 2010 CRP | -0.9 | +0.5 | -0.7 |
| MV-3 CRP | +0.6 | -0.2 | -0.9 |

**Table 18 - Differences between results of the current survey and Honeywell TSI's 2007 survey compare favorably. Vectors emanate from the CRP of MOBLAS-7. ENU = Current local vector minus HTSI2007 local vector**

For the following geocentric vector comparisons, once again the current survey was transformed to the reference frame of the HTSI2007 survey. For each survey, vectors were computed from the CRP of MOBLAS-7 to each of the remaining 12 points. The computed vectors are shown in Table 19 along with the differences for each component.

| Source: | | HTSI 2007 | Current Survey | Diff. (mm) |
|---|---|---|---|---|
| MOBLAS-7 CRP to CDP STATION 7105 | (dX) | -0.5237 | -0.5252 | -1.5 |
| **-RM for MOBLAS-7** | (dY) | 2.3857 | 2.3866 | 0.9 |
| | (dZ) | -1.9703 | -1.9688 | 1.5 |
| MOBLAS-7 CRP to SGP 7108 1993 | (dX) | 74.6015 | 74.6016 | 0.1 |
| **-RM for MV-3** | (dY) | 119.1485 | 119.1483 | -0.2 |
| | (dZ) | 108.5371 | 108.5366 | -0.5 |
| MOBLAS-7 CRP to CDP STATION 7125 | (dX) | 25.5127 | 25.5142 | 1.5 |
| **-RM for NGSLR** | (dY) | -15.0722 | -15.0720 | 0.2 |
| | (dZ) | -31.3606 | -31.3614 | -0.8 |
| MOBLAS-7 CRP to DORIS RM 1 | (dX) | -8.9596 | -8.9593 | 0.3 |
| | (dY) | -38.5682 | -38.5695 | -1.3 |
| | (dZ) | -47.6600 | -47.6599 | 0.1 |
| MOBLAS-7 CRP to GODDARD GODE JPL 4006 | (dX) | 53.7078 | 53.7061 | -1.7 |
| **-RM for GNSS** | (dY) | 99.3948 | 99.3944 | -0.4 |
| | (dZ) | 91.8924 | 91.8916 | -0.8 |
| MOBLAS-7 CRP to MV-3 VLBI CRP | (dX) | 75.1461 | 75.1455 | -0.6 |
| | (dY) | 116.8319 | 116.8312 | -0.7 |
| | (dZ) | 110.4740 | 110.4747 | 0.7 |
| MOBLAS-7 CRP to NGSLR CRP | (dX) | 23.4390 | 23.4400 | 1.0 |
| | (dY) | -18.5597 | -18.5604 | -0.7 |
| | (dZ) | -29.0969 | -29.0969 | 0.0 |
| MOBLAS-7 CRP to NORTH GEOS PIER | (dX) | 11.1723 | 11.1722 | -0.1 |
| | (dY) | 30.3559 | 30.3553 | -0.6 |
| | (dZ) | 27.9864 | 27.9867 | 0.3 |
| MOBLAS-7 CRP to GGAO VLBI RM PIER A | (dX) | 74.6933 | 74.6940 | 0.7 |
| | (dY) | 138.8031 | 138.8021 | -1.0 |
| | (dZ) | 132.1552 | 132.1549 | -0.3 |
| MOBLAS-7 CRP to GGAO VLBI RM PIER B | (dX) | 20.7936 | 20.7937 | 0.1 |
| | (dY) | 52.0864 | 52.0863 | -0.1 |
| | (dZ) | 49.4606 | 49.4603 | -0.3 |
| MOBLAS-7 CRP to GGAO VLBI RM PIER C | (dX) | 26.5259 | 26.5274 | 1.5 |
| | (dY) | 119.0461 | 119.0462 | 0.1 |
| | (dZ) | 120.2037 | 120.2033 | -0.4 |
| MOBLAS-7 CRP to SOUTH GEOS PIER | (dX) | 23.9566 | 23.9567 | 0.1 |
| | (dY) | -22.3441 | -22.3441 | 0.0 |
| | (dZ) | -39.0889 | -39.0897 | -0.8 |

**Table 19 - Geocentric Vector Comparisons in ITRF2008(2012/07/14).**

# 6. Planning Aspects

Establish a point-of-contact (POC) at NASA to coordinate access to the site and schedule time on the SLR and VLBI instruments. At the time of the current survey, Mr. James Long was the NASA POC, NASA Goddard Space Flight Center, FMD Engineering Branch, Code 224, Tel: 301.286.9836.

- Contact the IGS Tracking Station Responsible Agency Primary Contact before tampering with the antenna at GODDARD GODE JPL4006. Contact information is provided in the IGS Tracking Station Site Log for station GODE (http://igscb.jpl.nasa.gov/igscb/station/log/brew_20101021.log). The responsible agency at the time of the current survey was the Jet Propulsion Laboratory. The primary contact at the time of the survey was David Stowers, Jet Propulsion Laboratory/Caltech, Product Delivery Manager, Global Observing System – GNSS, Tracking Systems and Applications Section - 3350
  4800 Oak Grove Drive, M/S 238-600, Pasadena, CA, USA
  Tel. +1 818-354-7055, fax +1 818-393-4965, E-mail dstowers[at]jpl.nasa.gov
- Coordinate in advance with the on-site technicians to take advantage of radio telescope down time. Site personnel drives the radio telescope under survey team direction during observations.
- Suggestions for optimizing surveying conditions:
  - Plan measurements over longer lines to be observed earlier in the day to mitigate heat shimmer on targets.
  - Line-of-sight between NGS 2 and CAL PIER B3, GODDARD and GGAO 2, NGS3 and GGAO VLBI RM PIER C was obstructed by local vegetation and required extensive pruning.
  - Consideration should be given to installing wooden observing stands over any points not serviced by an observing pier.
- The SLR telescopes cannot be exposed to inclement weather. Observations to these instruments should be planned on days when the probability of rain is low.
- A lift and safety training is required to place targets on VLBI2010. The POC should be able to help arrange training in advance.

# 7. References

Axel Nothnagel (2009) Conventions on thermal expansion modelling of radio telescopes for geodetic and astrometric VLBI; Journal of Geodesy, Vol. 83(3), 787-792, DOI: 10.1007/s00190-008-0284-z

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 Names of persons responsible for observations

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Phone – (540) 373-1243

## 7.2 Names of persons responsible for analysis

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Woodford, VA  22580
Phone – (540) 373-1243

## 7.3 Location of observation data and results archive

National Geodetic Survey
Instrumentation & Methodologies Branch
15351 Office Drive
Woodford, VA  22580
Phone – (540) 373-1243

# ATTACHMENTS

## A. GPS Geocentric Coordinates and Covariances

```
%=SNX 1.00 NOA 12:276:39568 NOA 12:172:74190 12:216:86370 P    33 2 X - -
*------------------------------------------------------------------------------
+FILE/REFERENCE
 DESCRIPTION    OPUS-Projects : NOAA/NOS/NGS
 OUTPUT         network-final
 CONTACT        charles.geoghegan[at]noaa.gov
 SOFTWARE       pages.e & gpscom.e
 HARDWARE       fermi (SunOS i86pc)
 INPUT          Washington IERS Site (GGAO) Survey GNSS data
-FILE/REFERENCE
*------------------------------------------------------------------------------
+FILE/COMMENT
 This combined adjustment was made from internal NGS files
 of partially reduced normal equations (information matricies).
 The data sets included in this solution are shown below.
     ../12172/Results/2012-172-A.nrm                                  0
     ../12173/Results/2012-173-A.nrm                                  0
     ../12193/Results/2012-193-A.nrm                                  0
     ../12214/Results/2012-214-A.nrm                                  0
     ../12215/Results/2012-215-A.nrm                                  0
-FILE/COMMENT
*------------------------------------------------------------------------------
+SOLUTION/STATISTICS
 NUMBER OF OBSERVATIONS                        225287.
 NUMBER OF UNKNOWNS                               1259
 NUMBER OF CONSTRAINT EQUATIONS                     21
 NUMBER OF DEGREES OF FREEDOM                  224049.
 VARIANCE FACTOR                     0.562166699517410
-SOLUTION/STATISTICS
*------------------------------------------------------------------------------
+SITE/ID
*CODE PT DOMES____ T STATION DESCRIPTION___ APPROX_LON_ APPROX_LAT_ _APP_H_
 gga2  - --------- P gga2                  283 10 19.8  39  1 18.6    13.7
 calb  - --------- P calb                  283 10 27.5  39  1 13.6    16.8
 ggaa  - --------- P ggaa                  283 10 24.6  39  1 19.9    13.7
 ANP5  A --------- P Annapolis 5           283 23 26.7  39  0 37.0    20.4
 COLA  A 23501S001 P Columbia              278 52 42.0  34  4 51.6    81.6
 LOYF  A --------- P Loyola F              283 28 40.1  38 58 28.1   -15.8
 LOYK  A --------- P LOYOLA LOYK           283 12 33.7  39  7 51.9    34.0
 NRL1  A 40451S301 P U.S. Naval Research La 282 58 32.2  38 49 14.7   -18.2
 UMBC  A --------- P U OF MD BALT COOP     283 17 18.5  39 15 24.4    64.7
 USNO  A 40451S003 P Washington, USA       282 56  1.6  38 55  8.3    48.9
 cal2  - --------- P cal2                  283 10 19.4  39  1 12.1    19.7
-SITE/ID
*------------------------------------------------------------------------------
+SITE/RECEIVER
*SITE PT SOLN T DATA_START__ DATA_END____ DESCRIPTION_________ S/N__ FIRMWARE___
 gga2  -    1 P 12:172:00000 12:215:86399 ----------------     ----- -----------
```

```
 calb  -    1 P 12:172:00000 12:215:86399 ----------------     ----- -----------
 ggaa  -    1 P 12:172:00000 12:215:86399 ----------------     ----- -----------
 ANP5  A    4 P 12:172:00000 12:215:86399 TRIMBLE NETRS        47441 1.2-5
 COLA  A    9 P 12:172:00000 12:215:86399 TRIMBLE NETR9        5207K 4.43
 LOYF  A    3 P 12:172:00000 12:215:86399 LEICA GRX1200+GNSS   49689 8.51/6.110
 LOYK  A    3 P 12:172:00000 12:215:86399 LEICA GRX1200GGPRO   35054 8.51/3.019
 NRL1  A    2 P 12:172:00000 12:215:86399 ASHTECH Z-XII3T      RT920 IL01-1D04-M
 UMBC  A    3 P 12:172:00000 12:215:86399 TRIMBLE NETR9        5133K 4.60
 USNO  A    3 P 12:172:00000 12:215:86399 ASHTECH Z-XII3T      RT919 1L01-1D04
 cal2  -    1 P 12:173:00000 12:215:86399 ----------------     ----- -----------
-SITE/RECEIVER
*-------------------------------------------------------------------------------
+SITE/ANTENNA
*SITE PT SOLN T DATA_START__ DATA_END____ DESCRIPTION_________ S/N__
 gga2  -    1 P 12:172:00000 12:215:86399 ----------------     -----
 calb  -    1 P 12:172:00000 12:215:86399 ----------------     -----
 ggaa  -    1 P 12:172:00000 12:215:86399 ----------------     -----
 ANP5  A    4 P 12:172:00000 12:215:86399 TRM41249USCG    SCIT -----
 COLA  A    9 P 12:172:00000 12:215:86399 TRM55971.00     NONE 30336
 LOYF  A    3 P 12:172:00000 12:215:86399 LEIAR10         NONE 15021
 LOYK  A    3 P 12:172:00000 12:215:86399 LEIAX1202GG     NONE 06180
 NRL1  A    2 P 12:172:00000 12:215:86399 ASH701945C_M    NONE CR620
 UMBC  A    3 P 12:172:00000 12:215:86399 TRM41249.00     NONE 11909
 USNO  A    3 P 12:172:00000 12:215:86399 AOAD/M_T        NONE 309
 cal2  -    1 P 12:173:00000 12:215:86399 ----------------     -----
-SITE/ANTENNA
*-------------------------------------------------------------------------------
+SITE/GPS_PHASE_CENTER
* Antenna information is from the file
*     /home/OPUS/files/ngs08.atx
* abbreviated below as  ant.info
*                            UP___  NORTH EAST_  UP___  NORTH  EAST_
*DESCRIPTION_________ S/N__ L1->ARP(m)__________ __L2->ARP(m)________ AZ_EL
 ----------------     ----- 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000   ant.info
 ----------------     ----- 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000   ant.info
 ----------------     ----- 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000   ant.info
 TRM41249USCG    SCIT ----- 0.0631 -.0028 -.0023 0.0612 -.0038 -.0021   ant.info
 TRM55971.00     NONE 30336 0.0667 0.0013 -.0002 0.0577 0.0004 0.0006   ant.info
 LEIAR10         NONE 15021 0.0888 0.0013 -.0007 0.0818 0.0005 0.0001   ant.info
 LEIAX1202GG     NONE 06180 0.0634 0.0016 -.0005 0.0621 -.0012 0.0002   ant.info
 ASH701945C_M    NONE CR620 0.0908 0.0007 -.0005 0.1198 0.0003 0.0014   ant.info
 TRM41249.00     NONE 11909 0.0559 0.0003 0.0005 0.0580 0.0002 0.0005   ant.info
 AOAD/M_T        NONE 309   0.0918 0.0006 -.0004 0.1203 -.0001 -.0006   ant.info
 ----------------     ----- 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000   ant.info
-SITE/GPS_PHASE_CENTER
*-------------------------------------------------------------------------------
+SITE/ECCENTRICITY
*SITE PT SOLN T DATA_START__ DATA_END____ AXE ARP->BENCHMARK(m)_________
 gga2  -    1 P 12:172:00000 12:215:86399 UNE   0.0000   0.0000   0.0000
 calb  -    1 P 12:172:00000 12:215:86399 UNE   0.0000   0.0000   0.0000
 ggaa  -    1 P 12:172:00000 12:215:86399 UNE   0.0000   0.0000   0.0000
 ANP5  A    4 P 12:172:00000 12:215:86399 UNE   0.0000   0.0000   0.0000
 COLA  A    9 P 12:172:00000 12:215:86399 UNE   0.0000   0.0000   0.0000
 LOYF  A    3 P 12:172:00000 12:215:86399 UNE   0.0000   0.0000   0.0000
```

```
 LOYK  A    3 P 12:172:00000 12:215:86399 UNE   0.0000   0.0000   0.0000
 NRL1  A    2 P 12:172:00000 12:215:86399 UNE   0.0000   0.0000   0.0000
 UMBC  A    3 P 12:172:00000 12:215:86399 UNE   0.0000   0.0000   0.0000
 USNO  A    3 P 12:172:00000 12:215:86399 UNE   0.0000   0.0000   0.0000
 cal2  -    1 P 12:173:00000 12:215:86399 UNE   0.0000   0.0000   0.0000
-SITE/ECCENTRICITY
*------------------------------------------------------------------------------
+SOLUTION/EPOCHS
*SITE PT SOLN T _DATA_START_ __DATA_END__ _MEAN_EPOCH_
 gga2  -    1 P 12:172:00000 12:215:86399 12:197:67720
 calb  -    1 P 12:172:00000 12:215:86399 12:197:58871
 ggaa  -    1 P 12:172:00000 12:215:86399 12:196:13804
 ANP5  A    4 P 12:172:00000 12:215:86399 12:197:51076
 COLA  A    9 P 12:172:00000 12:215:86399 12:205:67535
 LOYF  A    3 P 12:172:00000 12:215:86399 12:197:65573
 LOYK  A    3 P 12:172:00000 12:215:86399 12:198:01441
 NRL1  A    2 P 12:172:00000 12:215:86399 12:193:26229
 UMBC  A    3 P 12:172:00000 12:215:86399 12:197:08383
 USNO  A    3 P 12:172:00000 12:215:86399 12:209:64155
 cal2  -    1 P 12:173:00000 12:215:86399 12:208:26834
-SOLUTION/EPOCHS
*------------------------------------------------------------------------------
+SOLUTION/ESTIMATE
*INDEX TYPE   CODE PT SOLN _REF_EPOCH__ UNIT S  __ESTIMATED VALUE___ _STD_DEV___
     1 STAX   gga2  -    1 12:194:80280 m    2 0.113068666775623E+07 .180590E-03
     2 STAY   gga2  -    1 12:194:80280 m    2 -.483126482696530E+07 .533546E-03
     3 STAZ   gga2  -    1 12:194:80280 m    2 0.399421009554288E+07 .436131E-03
     4 STAX   calb  -    1 12:194:80280 m    2 0.113089072211075E+07 .209598E-03
     5 STAY   calb  -    1 12:194:80280 m    2 -.483131956400526E+07 .617251E-03
     6 STAZ   calb  -    1 12:194:80280 m    2 0.399409212861740E+07 .506504E-03
     7 STAX   ggaa  -    1 12:194:80280 m    2 0.113079462047075E+07 .219342E-03
     8 STAY   ggaa  -    1 12:194:80280 m    2 -.483121415594225E+07 .651990E-03
     9 STAZ   ggaa  -    1 12:194:80280 m    2 0.399424070259218E+07 .527408E-03
    10 STAX   ANP5  A    4 12:194:80280 m    0 0.114929844684349E+07 .253054E-04
    11 STAY   ANP5  A    4 12:194:80280 m    0 -.482770689039637E+07 .484342E-04
    12 STAZ   ANP5  A    4 12:194:80280 m    0 0.399321735917084E+07 .484317E-04
    13 STAX   COLA  A    9 12:194:80280 m    0 0.816177749243871E+06 .210904E-04
    14 STAY   COLA  A    9 12:194:80280 m    0 -.522493406498631E+07 .512319E-04
    15 STAZ   COLA  A    9 12:194:80280 m    0 0.355393702764078E+07 .487440E-04
    16 STAX   LOYF  A    3 12:194:80280 m    0 0.115720877060581E+07 .409394E-04
    17 STAY   LOYF  A    3 12:194:80280 m    0 -.482836054870224E+07 .424725E-04
    18 STAZ   LOYF  A    3 12:194:80280 m    0 0.399010440287580E+07 .421221E-04
    19 STAX   LOYK  A    3 12:194:80280 m    0 0.113208051316109E+07 .408783E-04
    20 STAY   LOYK  A    3 12:194:80280 m    0 -.482310288869867E+07 .424904E-04
    21 STAZ   LOYK  A    3 12:194:80280 m    0 0.400363711291432E+07 .421013E-04
    22 STAX   NRL1  A    2 12:194:80280 m    0 0.111724905900541E+07 .251293E-04
    23 STAY   NRL1  A    2 12:194:80280 m    0 -.484875868312464E+07 .490857E-04
    24 STAZ   NRL1  A    2 12:194:80280 m    0 0.397682121510515E+07 .492343E-04
    25 STAX   UMBC  A    3 12:194:80280 m    0 0.113671718632825E+07 .410621E-04
    26 STAY   UMBC  A    3 12:194:80280 m    0 -.481297584016303E+07 .425540E-04
    27 STAZ   UMBC  A    3 12:194:80280 m    0 0.401447151261989E+07 .422468E-04
    28 STAX   USNO  A    3 12:194:80280 m    0 0.111218966001737E+07 .381165E-04
    29 STAY   USNO  A    3 12:194:80280 m    0 -.484295502610145E+07 .443406E-04
    30 STAZ   USNO  A    3 12:194:80280 m    0 0.398535228394140E+07 .441937E-04
```

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    31 STAX   cal2  -    1 12:194:80280 m    2 0.113070630004551E+07 .221095E-03
    32 STAY   cal2  -    1 12:194:80280 m    2 -.483139468971540E+07 .659736E-03
    33 STAZ   cal2  -    1 12:194:80280 m    2 0.399405814248330E+07 .537854E-03
-SOLUTION/ESTIMATE
*-----------------------------------------------------------------------------
+SOLUTION/APRIORI
*INDEX TYPE   CODE PT SOLN _REF_EPOCH__ UNIT S  __A-PRIORI VALUE____ _STD_DEV___
    10 STAX   ANP5  A    4 12:194:80280 m    0 0.114929856100352E+07 .323031E+09
    11 STAY   ANP5  A    4 12:194:80280 m    0 -.482770689399806E+07 .323031E+09
    12 STAZ   ANP5  A    4 12:194:80280 m    0 0.399321734699467E+07 .323031E+09
    13 STAX   COLA  A    9 12:194:80280 m    0 0.816177849001241E+06 .437752E+08
    14 STAY   COLA  A    9 12:194:80280 m    0 -.522493408499971E+07 .437752E+08
    15 STAZ   COLA  A    9 12:194:80280 m    0 0.355393700699887E+07 .437752E+08
    16 STAX   LOYF  A    3 12:194:80280 m    0 0.115720888299637E+07 .674568E+13
    17 STAY   LOYF  A    3 12:194:80280 m    0 -.482836054200202E+07 .674568E+13
    18 STAZ   LOYF  A    3 12:194:80280 m    0 0.399010437899818E+07 .674568E+13
    19 STAX   LOYK  A    3 12:194:80280 m    0 0.113208062499738E+07 .674568E+13
    20 STAY   LOYK  A    3 12:194:80280 m    0 -.482310288200066E+07 .674568E+13
    21 STAZ   LOYK  A    3 12:194:80280 m    0 0.400363708999712E+07 .674568E+13
    22 STAX   NRL1  A    2 12:194:80280 m    0 0.111724916900307E+07 .119287E+09
    23 STAY   NRL1  A    2 12:194:80280 m    0 -.484875867900060E+07 .119287E+09
    24 STAZ   NRL1  A    2 12:194:80280 m    0 0.397682119000639E+07 .119287E+09
    25 STAX   UMBC  A    3 12:194:80280 m    0 0.113671729800447E+07 .674568E+13
    26 STAY   UMBC  A    3 12:194:80280 m    0 -.481297583400064E+07 .674568E+13
    27 STAZ   UMBC  A    3 12:194:80280 m    0 0.401447148900069E+07 .674568E+13
    28 STAX   USNO  A    3 12:194:80280 m    0 0.111218977299927E+07 .134610E+05
    29 STAY   USNO  A    3 12:194:80280 m    0 -.484295502600323E+07 .134610E+05
    30 STAZ   USNO  A    3 12:194:80280 m    0 0.398535226599612E+07 .134610E+05
-SOLUTION/APRIORI
*-----------------------------------------------------------------------------
+SOLUTION/MATRIX_ESTIMATE U COVA
     1     1 0.326126106541743E-07 -.742280569961329E-07 0.605506183617461E-07
     1     4 0.618108920696579E-08 -.141834310979952E-07 0.118031286562535E-07
     1     7 0.676659427762672E-08 -.154385043379259E-07 0.129291339650443E-07
     1    10 0.119057308741872E-09 -.659457472513876E-10 0.208964050624899E-10
     1    13 0.579564723491816E-10 -.592254813186496E-10 -.254543343970956E-10
     1    16 0.283301819728362E-09 0.508961818518854E-11 0.257998732722744E-10
     1    19 0.321175035793615E-09 0.847507702814664E-12 0.943563805504780E-11
     1    22 0.512096196773455E-10 -.326335645671731E-10 -.696428954620742E-11
     1    25 0.344504034644001E-09 -.122085755531918E-10 -.998970598587352E-11
     1    28 0.170774091809335E-09 -.416714049592067E-11 -.772366116611345E-11
     1    31 0.837882514309565E-08 -.195246228580603E-07 0.163219625258005E-07
     2     2 0.284671866789498E-06 -.215599609857563E-06 -.144284121985900E-07
     2     5 0.572320872808937E-07 -.436147548182831E-07 -.154658567992042E-07
     2     8 0.598302651502056E-07 -.458558472773290E-07 -.940107635392680E-10
     2    11 0.453953665766119E-09 0.204232549875456E-10 -.446565153776546E-10
     2    14 0.138619585603982E-09 -.156048003274177E-09 0.494214505838849E-10
     2    17 0.365881064203661E-09 0.105804766883236E-11 0.465053662753736E-10
     2    20 0.337638610591253E-09 -.358037859138033E-10 -.102827008392387E-10
     2    23 0.202584044838087E-09 0.630650843091599E-11 -.803812491227674E-11
     2    26 0.351227751593810E-09 -.148097734957895E-10 -.334179311869369E-10
     2    29 0.254288628374824E-09 0.126391600131520E-09 -.195679074007619E-07
     2    32 0.769755855277992E-07 -.592933211157123E-07
     3     3 0.190209983408973E-06 0.120130419650151E-07 -.436950416036441E-07
```

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| 3 | 6 | 0.388703200951053E-07 | 0.129355386608921E-07 | -.458073949653717E-07 |
| 3 | 9 | 0.412262939346219E-07 | 0.270431598129605E-10 | -.358587617979498E-10 |
| 3 | 12 | 0.401444768083981E-09 | -.100474202173869E-11 | -.411119758086707E-11 |
| 3 | 15 | 0.296918636400308E-09 | -.268173928649521E-10 | -.884503271587307E-11 |
| 3 | 18 | 0.347663101382862E-09 | -.228530345325104E-10 | 0.244085770674472E-11 |
| 3 | 21 | 0.367714657253190E-09 | -.186004412141959E-10 | -.843015192377737E-11 |
| 3 | 24 | 0.193698513158057E-09 | 0.178512738182714E-10 | -.259634079111815E-10 |
| 3 | 27 | 0.323890335876917E-09 | 0.390555890348441E-10 | 0.315344570680065E-10 |
| 3 | 30 | 0.180170589934011E-09 | 0.163457149138339E-07 | -.592976173337845E-07 |
| 3 | 33 | 0.523096878061062E-07 | | |
| 4 | 4 | 0.439314440094967E-07 | -.103221207555567E-06 | 0.842847713319807E-07 |
| 4 | 7 | 0.636500604896828E-08 | -.147410917402099E-07 | 0.121129271944090E-07 |
| 4 | 10 | 0.126938449713084E-09 | -.741346236256100E-10 | 0.121008383185656E-10 |
| 4 | 13 | 0.599609151578516E-10 | -.645962408133997E-10 | -.304957988791970E-10 |
| 4 | 16 | 0.303302701787929E-09 | 0.938430809468778E-12 | 0.200356359759034E-10 |
| 4 | 19 | 0.324862628611401E-09 | -.314416884258999E-12 | 0.913864287574281E-11 |
| 4 | 22 | 0.542297784839399E-10 | -.373903528898630E-10 | -.764029500801063E-11 |
| 4 | 25 | 0.310808869105062E-09 | -.859565866465398E-11 | 0.256903590425660E-12 |
| 4 | 28 | 0.150066717173227E-09 | 0.821270459181086E-11 | 0.746419744939179E-12 |
| 4 | 31 | 0.649339914305516E-08 | -.151690897796207E-07 | 0.124292915900983E-07 |
| 5 | 5 | 0.380998747263623E-06 | -.292289148037615E-06 | -.145787861973610E-07 |
| 5 | 8 | 0.587405276174421E-07 | -.443615936604074E-07 | -.103216267217896E-09 |
| 5 | 11 | 0.486673568891564E-09 | 0.438675198089366E-10 | -.484548545157095E-10 |
| 5 | 14 | 0.151899406622046E-09 | -.146961660365897E-09 | 0.442420190042463E-10 |
| 5 | 17 | 0.392300983635869E-09 | 0.133300356881226E-10 | 0.802681853743737E-10 |
| 5 | 20 | 0.358676712639763E-09 | -.357098400346832E-10 | -.132737287004469E-10 |
| 5 | 23 | 0.217862043228859E-09 | 0.487845407282991E-11 | 0.163456854865687E-10 |
| 5 | 26 | 0.346749929727905E-09 | -.923902554118100E-11 | -.556041661778736E-10 |
| 5 | 29 | 0.161803843255224E-09 | 0.780492263316168E-10 | -.149932009263161E-07 |
| 5 | 32 | 0.605041396736730E-07 | -.458119736241543E-07 | |
| 6 | 6 | 0.256546741269770E-06 | 0.119843695542396E-07 | -.443606434478729E-07 |
| 6 | 9 | 0.390942126415774E-07 | 0.306250705921708E-10 | -.441639300142482E-10 |
| 6 | 12 | 0.404679197981784E-09 | 0.147021642651311E-11 | -.166241755291272E-10 |
| 6 | 15 | 0.288482784771572E-09 | -.223538329346677E-10 | -.158238425338332E-10 |
| 6 | 18 | 0.355255498763055E-09 | -.528692132087787E-10 | -.171254667630087E-12 |
| 6 | 21 | 0.384415199274167E-09 | -.178373310451589E-10 | -.136846841982248E-10 |
| 6 | 24 | 0.204254918538821E-09 | 0.102500461819323E-10 | -.167975828547725E-10 |
| 6 | 27 | 0.320906626879194E-09 | 0.578013784340231E-10 | 0.497896196269722E-10 |
| 6 | 30 | 0.154369942003433E-09 | 0.122993663599486E-07 | -.458109477063805E-07 |
| 6 | 33 | 0.403289224139873E-07 | | |
| 7 | 7 | 0.481110880814724E-07 | -.109888210486550E-06 | 0.887012542104586E-07 |
| 7 | 10 | 0.126730046406148E-09 | -.723813949387058E-10 | 0.208612745940962E-10 |
| 7 | 13 | 0.564190129293371E-10 | -.556148355691351E-10 | -.261767339540670E-10 |
| 7 | 16 | 0.295356608612111E-09 | 0.298752451740888E-11 | 0.252803045074208E-10 |
| 7 | 19 | 0.341721355313405E-09 | -.150538423239776E-11 | 0.583303797379314E-11 |
| 7 | 22 | 0.459102500602195E-10 | -.308057852004864E-10 | -.646080596279013E-11 |
| 7 | 25 | 0.353679628111598E-09 | -.123606582174217E-10 | -.927387410928617E-11 |
| 7 | 28 | 0.135454274967566E-09 | 0.390032613798530E-11 | -.392123528557919E-11 |
| 7 | 31 | 0.650322415704679E-08 | -.149227617431378E-07 | 0.123346689434799E-07 |
| 8 | 8 | 0.425091591175560E-06 | -.317397827684054E-06 | -.980492321166505E-10 |
| 8 | 11 | 0.481661873586159E-09 | 0.133596748227586E-10 | -.458234268842256E-10 |
| 8 | 14 | 0.133929212651794E-09 | -.134245397395590E-09 | 0.745004358814750E-10 |
| 8 | 17 | 0.390294090924205E-09 | -.615423517400365E-11 | 0.275842703254606E-10 |
| 8 | 20 | 0.355419788427285E-09 | -.268554998489073E-10 | -.652718692867284E-11 |

| | | | | |
|---|---|---|---|---|
| 8 | 23 | 0.194218442306572E-09 | 0.858878952294566E-11 | -.852532799525794E-11 |
| 8 | 26 | 0.380102528878800E-09 | 0.613157509069255E-11 | -.352596288573840E-10 |
| 8 | 29 | 0.162694312346881E-09 | 0.870685604743757E-10 | -.149568979941020E-07 |
| 8 | 32 | 0.575264009352838E-07 | -.440860556540102E-07 | |
| 9 | 9 | 0.278158913402644E-06 | 0.258479027305134E-10 | -.384696189216328E-10 |
| 9 | 12 | 0.433329837400980E-09 | 0.661782001478918E-12 | -.285503914615876E-11 |
| 9 | 15 | 0.274902065406042E-09 | -.501192924179074E-10 | -.143374008343041E-10 |
| 9 | 18 | 0.371572676704628E-09 | -.100956438220458E-10 | 0.184430144295800E-11 |
| 9 | 21 | 0.377518124897075E-09 | -.181719605629592E-10 | -.151853909975521E-10 |
| 9 | 24 | 0.172644440727561E-09 | 0.282128338261504E-10 | -.236046357772283E-10 |
| 9 | 27 | 0.333898847370228E-09 | 0.379697055194115E-10 | 0.442064861194384E-10 |
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| 15 | 21 | 0.114774241693486E-10 | -.337636084939900E-11 | 0.666552168780978E-11 |

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| 15 | 24 | 0.110971206418847E-10 | -.116323099652911E-10 | 0.266268284880733E-11 |
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| 15 | 30 | 0.394991182820052E-10 | -.296307030923974E-10 | -.142251766795373E-09 |
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| 16 | 22 | 0.685569483725714E-11 | -.160924995081593E-12 | -.439033369279696E-11 |
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| 17 | 17 | 0.180391705708817E-08 | -.690016838623609E-10 | 0.809564884782152E-11 |
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| 21 | 30 | 0.138745325719009E-10 | 0.750438101995367E-11 | -.415426138645891E-10 |
| 21 | 33 | 0.396607557822672E-09 | | |
| 22 | 22 | 0.631483701973833E-09 | -.431573613793754E-09 | 0.448013625137790E-10 |
| 22 | 25 | 0.590028171287968E-11 | -.331964170911757E-12 | -.234019671306123E-11 |
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| 22 | 31 | 0.544150019175905E-10 | -.651980159799467E-11 | -.225642856532271E-10 |
| 23 | 23 | 0.240940907380684E-08 | -.173926289435715E-09 | -.106209780498891E-12 |
| 23 | 26 | 0.708296219984625E-11 | 0.781378894858281E-11 | -.350398127256697E-12 |
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| 24 | 27 | 0.111778117712449E-10 | -.197334173478179E-11 | 0.653478522625417E-11 |
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| 26 | 26 | 0.181084145504680E-08 | -.618835077862994E-10 | 0.285023333815978E-11 |
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    28    28 0.145286771064256E-08 -.110922307297716E-09 0.345011934131534E-10
    28    31 0.136936241686177E-09 -.222183030712641E-10 0.346450885940431E-10
    29    29 0.196609245278950E-08 -.727291402878385E-10 0.726488560343245E-11
    29    32 0.168534570683107E-09 0.412356195718167E-10
    30    30 0.195307929310445E-08 0.182883390516614E-11 0.792466948443945E-10
    30    33 0.148272986965625E-09
    31    31 0.488831827403483E-07 -.111668557685972E-06 0.914496580395287E-07
    32    32 0.435251497296869E-06 -.329376934888241E-06
    33    33 0.289286606002522E-06
-SOLUTION/MATRIX_ESTIMATE U COVA
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    11    11 0.244523165011945E-08 -.971499684278990E-10
    12    12 0.250979610936856E-08
    13    13 0.458441374768705E-09 -.355847049560726E-09 0.482490506039108E-10
    14    14 0.268088422283841E-08 -.308876361175211E-09
    15    15 0.248590935501676E-08
    16    16 0.187421183198801E-08 -.543288234581729E-26 0.886537286555959E-26
    17    17 0.187421183198801E-08 -.686498103948461E-25
    18    18 0.187421183198801E-08
    19    19 0.187421183198801E-08 -.138436207054508E-25 0.207881627834724E-25
    20    20 0.187421183198801E-08 -.781971350192949E-26
    21    21 0.187421183198801E-08
    22    22 0.644744268052091E-09 -.442176795808727E-09 0.258146791967988E-10
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    24    24 0.251336998805192E-08
    25    25 0.187421183198801E-08 -.854712871141130E-26 -.411444227863150E-25
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    27    27 0.187421183198801E-08
    28    28 0.158595670465253E-08 -.107907947830699E-09 0.101065235661785E-25
    29    29 0.203105329387286E-08 0.195584773376348E-24
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%ENDSNX
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## B. SINEX File NGSWASH1206GA.snx

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 CONTACT            ______________________________________________
 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
 DOR1  A 40451M006 C DORIS RM 1 TOP OF STUD -76 49 40.4  39  1 12.3    19.9
 7105  A 40451M105 C MOBLAS-7 CDP STA 7105  -76 49 39.7  39  1 14.2    19.2
 NORG  A 40451M110 C NORTH GEOS PIER (GSFC) -76 49 39.0  39  1 15.4    18.9
 7125  A 40451M114 C NGSLR CDP STATION 7125 -76 49 38.8  39  1 13.0    18.5
 7130  A 40451M116 C 7130 1985 NGS# DE5260  -76 49 38.8  39  1 15.3    18.6
 7918  A 40451M120 C CDP STATION 7918       -76 49 40.2  39  1 14.6    18.7
 GODE  A 40451M123 C GODDARD GODE JPL 4006  -76 49 36.6  39  1 18.2    14.5
 7108  A 40451M125 C MV-3 SGP 7108-1993     -76 49 35.6  39  1 18.9    13.7
 GODN  A 40451M127 C GODN SCIGN MOUNT DIVOT -76 49 37.5  39  1 16.2    17.9
 GODS  A 40451M128 C GODS SCIGN MOUNT DIVOT -76 49 38.4  39  1 13.9    19.1
 GODG  A 40451M129 C REGINA SCIGN MT DIVOT  -76 49 39.9  39  1 12.1    20.0
 DOR2  A 40451M130 C DORIS RM 2 BOT OF STUD -76 49 40.4  39  1 12.3    19.9
 7622  A 40451S177 C VLBI 2010 12M CRP      -76 49 38.3  39  1 19.3    18.5
 GRFB  A 40451S178 C DORIS ANTENNA 2012     -76 49 40.4  39  1 12.3    20.7
 GO1L  A --------- C NGSLR NEW GEN SLR CRP  -76 49 38.9  39  1 13.0    22.2
 GODL  A --------- C MOBLAS-7 SLR CRP       -76 49 39.7  39  1 14.2    22.3
 MV-3  A --------- C MV-3 MOB VLBI 5M CRP   -76 49 35.6  39  1 18.9    16.8
-SITE/ID
+SITE/DATA
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 7105  A    1 7105  A    1 12:196:00000 12:197:00000 --- 12:196:43200
 NORG  A    1 NORG  A    1 12:196:00000 12:197:00000 --- 12:196:43200
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 7130  A    1 7130  A    1 12:196:00000 12:197:00000 --- 12:196:43200
 7918  A    1 7918  A    1 12:196:00000 12:197:00000 --- 12:196:43200
 GODE  A    1 GODE  A    1 12:196:00000 12:197:00000 --- 12:196:43200
 7108  A    1 7108  A    1 12:196:00000 12:197:00000 --- 12:196:43200
 GODN  A    1 GODN  A    1 12:196:00000 12:197:00000 --- 12:196:43200
 GODS  A    1 GODS  A    1 12:196:00000 12:197:00000 --- 12:196:43200
 GODG  A    1 GODG  A    1 12:196:00000 12:197:00000 --- 12:196:43200
 DOR2  A    1 DOR2  A    1 12:196:00000 12:197:00000 --- 12:196:43200
 7622  A    1 7622  A    1 12:196:00000 12:197:00000 --- 12:196:43200
 GRFB  A    1 GRFB  A    1 12:196:00000 12:197:00000 --- 12:196:43200
 GO1L  A    1 GO1L  A    1 12:196:00000 12:197:00000 --- 12:196:43200
 GODL  A    1 GODL  A    1 12:196:00000 12:197:00000 --- 12:196:43200
 MV-3  A    1 MV-3  A    1 12:196:00000 12:197:00000 --- 12:196:43200
-SITE/DATA
+SOLUTION/EPOCHS
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 7105  A    1 C 12:196:00000 12:197:00000 12:196:43200
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 7918  A    1 C 12:196:00000 12:197:00000 12:196:43200
 GODE  A    1 C 12:196:00000 12:197:00000 12:196:43200
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 GODN  A    1 C 12:196:00000 12:197:00000 12:196:43200
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 GODG  A    1 C 12:196:00000 12:197:00000 12:196:43200
 DOR2  A    1 C 12:196:00000 12:197:00000 12:196:43200
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 GRFB  A    1 C 12:196:00000 12:197:00000 12:196:43200
 GO1L  A    1 C 12:196:00000 12:197:00000 12:196:43200
 GODL  A    1 C 12:196:00000 12:197:00000 12:196:43200
 MV-3  A    1 C 12:196:00000 12:197:00000 12:196:43200
-SOLUTION/EPOCHS
+SOLUTION/STATISTICS
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 SQUARE SUM OF RESIDUALS        6.864390128728168e+03
 NUMBER OF OBSERVATIONS                          1754
 NUMBER OF UNKNOWNS                                51
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+SOLUTION/ESTIMATE
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     2 STAY   DOR1  A    1 12:196:43200 m    2 -4.83139152909886e+06 1.73069e-04
     3 STAZ   DOR1  A    1 12:196:43200 m    2  3.99406088914738e+06 1.66501e-04
     4 STAX   7105  A    1 12:196:43200 m    2  1.13071940031098e+06 2.55500e-04
     5 STAY   7105  A    1 12:196:43200 m    2 -4.83135057274564e+06 2.01589e-04
     6 STAZ   7105  A    1 12:196:43200 m    2  3.99410657982990e+06 2.08957e-04
     7 STAX   NORG  A    1 12:196:43200 m    2  1.13073109779926e+06 1.22313e-04
     8 STAY   NORG  A    1 12:196:43200 m    2 -4.83132260389007e+06 1.10972e-04
     9 STAZ   NORG  A    1 12:196:43200 m    2  3.99413653526933e+06 1.11515e-04
    10 STAX   7125  A    1 12:196:43200 m    2  1.13074543977610e+06 2.09879e-04
    11 STAY   7125  A    1 12:196:43200 m    2 -4.83136803200202e+06 1.75602e-04
    12 STAZ   7125  A    1 12:196:43200 m    2  3.99407718767558e+06 1.73023e-04
    13 STAX   7130  A    1 12:196:43200 m    2  1.13073497703993e+06 1.78187e-04
    14 STAY   7130  A    1 12:196:43200 m    2 -4.83132467138021e+06 1.59176e-04
    15 STAZ   7130  A    1 12:196:43200 m    2  3.99413244000717e+06 1.66804e-04
    16 STAX   7918  A    1 12:196:43200 m    2  1.13070498233526e+06 1.85738e-04
    17 STAY   7918  A    1 12:196:43200 m    2 -4.83134543621962e+06 1.66627e-04
    18 STAZ   7918  A    1 12:196:43200 m    2  3.99411603228580e+06 1.75446e-04
    19 STAX   GODE  A    1 12:196:43200 m    2  1.13077363224661e+06 8.83042e-05
    20 STAY   GODE  A    1 12:196:43200 m    2 -4.83125356469974e+06 9.35861e-05
    21 STAZ   GODE  A    1 12:196:43200 m    2  3.99420043979286e+06 9.58232e-05
    22 STAX   7108  A    1 12:196:43200 m    2  1.13079452779638e+06 2.13815e-04
    23 STAY   7108  A    1 12:196:43200 m    2 -4.83123381096884e+06 1.93698e-04
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    30 STAZ   GODS  A    1 12:196:43200 m    2  3.99409893690367e+06 1.93614e-04
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-SOLUTION/MATRIX_ESTIMATE U COVA
%ENDSNX
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## C. IERS ITRS Product Center SINEX File (retrieval)

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 DESCRIPTION       IGN/ENSG/LAREG: IERS ITRS Product Center
 OUTPUT            ITRF2008 station positions and velocities
 CONTACT           Zuheir Altamimi (altamimi[at]ensg.ign.fr)
 SOFTWARE          CATREF
 INPUT             ITRF2008 solution

-FILE/REFERENCE
*------------------------------------------------------------------------------
+FILE/COMMENT
*
*
*
-FILE/COMMENT
*------------------------------------------------------------------------------
+SITE/ID
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 GODE  A 40451M123  Greenbelt, USA          283 10 23.4  39  1 18.2    14.5
 7918  A 40451M120  7918                    283 10 19.7  39  1 14.5    18.7
 7130  A 40451M116  7130                    283 10 21.1  39  1 15.2    18.6
 7125  A 40451M114  7125                    283 10 21.1  39  1 12.9    18.5
 7105  A 40451M105  7105                    283 10 20.2  39  1 14.1    19.2
 7108  A 40451M125  GGAO7108 ORION MV3 at   283 10 24.4  39  1 18.9    13.7
-SITE/ID
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     2 STAY   7105  A    1 12:196:00000 m    2 -.483135057400392E+07  .98246E-03
     3 STAZ   7105  A    1 12:196:00000 m    2  .399410657779250E+07  .86637E-03
     4 VELX   7105  A    1 12:196:00000 m/y  2 -.150225755221552E-01  .37507E-04
     5 VELY   7105  A    1 12:196:00000 m/y  2  .551516245400618E-05  .66744E-04
     6 VELZ   7105  A    1 12:196:00000 m/y  2  .238658210191364E-02  .62535E-04
     7 STAX   7125  A    1 12:196:00000 m    2  .113074542523054E+07  .15757E-01
     8 STAY   7125  A    1 12:196:00000 m    2 -.483136804630814E+07  .12648E-01
     9 STAZ   7125  A    1 12:196:00000 m    2  .399407720542546E+07  .11100E-01
    10 VELX   7125  A    1 12:196:00000 m/y  2 -.150225790160394E-01  .37611E-04
    11 VELY   7125  A    1 12:196:00000 m/y  2  .553369951426572E-05  .66802E-04
    12 VELZ   7125  A    1 12:196:00000 m/y  2  .238651482210473E-02  .62596E-04
    13 STAX   7130  A    1 12:196:00000 m    2  .113073498233130E+07  .35083E-02
    14 STAY   7130  A    1 12:196:00000 m    2 -.483132463730531E+07  .32784E-02
    15 STAZ   7130  A    1 12:196:00000 m    2  .399413242405875E+07  .28751E-02
    16 VELX   7130  A    1 12:196:00000 m/y  2 -.150225846765698E-01  .37714E-04
    17 VELY   7130  A    1 12:196:00000 m/y  2  .555588561372349E-05  .66860E-04
    18 VELZ   7130  A    1 12:196:00000 m/y  2  .238644740512753E-02  .62659E-04
    19 STAX   7918  A    1 12:196:00000 m    2  .113070498046399E+07  .14601E-02
    20 STAY   7918  A    1 12:196:00000 m    2 -.483134544138447E+07  .14947E-02
    21 STAZ   7918  A    1 12:196:00000 m    2  .399411603757582E+07  .13442E-02
    22 VELX   7918  A    1 12:196:00000 m/y  2 -.150225939058803E-01  .37919E-04
    23 VELY   7918  A    1 12:196:00000 m/y  2  .559269429820012E-05  .66976E-04
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    25 STAX   GODE  A    1 12:196:00000 m    2  .113077363396258E+07  .72659E-03
    26 STAY   GODE  A    1 12:196:00000 m    2 -.483125357460999E+07  .10682E-02
    27 STAZ   GODE  A    1 12:196:00000 m    2  .399420044585429E+07  .98893E-03
    28 VELX   GODE  A    1 12:196:00000 m/y  2 -.150226209882741E-01  .37206E-04
    29 VELY   GODE  A    1 12:196:00000 m/y  2  .152636231721840E-04  .66715E-04
    30 VELZ   GODE  A    1 12:196:00000 m/y  2  .239178152148217E-02  .62691E-04
    31 STAX   GODE  A    2 12:196:00000 m    2  .113077363429163E+07  .71511E-03
    32 STAY   GODE  A    2 12:196:00000 m    2 -.483125356949402E+07  .10165E-02
    33 STAZ   GODE  A    2 12:196:00000 m    2  .399420044353106E+07  .95084E-03
    34 VELX   GODE  A    2 12:196:00000 m/y  2 -.150226256979756E-01  .37200E-04
    35 VELY   GODE  A    2 12:196:00000 m/y  2  .152655191687681E-04  .66711E-04
    36 VELZ   GODE  A    2 12:196:00000 m/y  2  .239178195990370E-02  .62688E-04
    37 STAX   USNO  A    1 12:196:00000 m    2  .111218965980155E+07  .71468E-03
    38 STAY   USNO  A    1 12:196:00000 m    2 -.484295502572130E+07  .10194E-02
    39 STAZ   USNO  A    1 12:196:00000 m    2  .398535228386709E+07  .95113E-03
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    43 STAX   7108  A    1 12:196:00000 m    2  .113079452244506E+07  .41281E-02
    44 STAY   7108  A    1 12:196:00000 m    2 -.483123379936670E+07  .12158E-01
    45 STAZ   7108  A    1 12:196:00000 m    2  .399421705919191E+07  .10470E-01
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    47 VELY   7108  A    1 12:196:00000 m/y  2 -.354085497720500E-03  .71592E-03
    48 VELZ   7108  A    1 12:196:00000 m/y  2  .165393460527763E-02  .61137E-03
    49 STAX   7108  A    2 12:196:00000 m    2  .113079428869113E+07  .38460E-02
    50 STAY   7108  A    2 12:196:00000 m    2 -.483123286100158E+07  .11677E-01
    51 STAZ   7108  A    2 12:196:00000 m    2  .399421624141042E+07  .89452E-02
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    53 VELY   7108  A    2 12:196:00000 m/y  2 -.354085371053691E-03  .71592E-03
    54 VELZ   7108  A    2 12:196:00000 m/y  2  .165393475197479E-02  .61137E-03
-SOLUTION/ESTIMATE
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+SOLUTION/MATRIX_ESTIMATE L COVA
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     1     1  .502910367024301E-06
     2     1 -.995067522702380E-07  .965233308578683E-06
     3     1  .151367354840310E-06 -.655431446221393E-06  .750601795214078E-06
     4     1  .157171245461999E-07 -.894274871254000E-08  .874601480644246E-08
     4     4  .140682653979489E-08
     5     1 -.940578396566649E-08  .506209358497876E-07 -.343326782694093E-07
     5     4 -.815229716567862E-09  .445484660511466E-08
     6     1  .905415544784455E-08 -.336764496572488E-07  .437798572825693E-07
     6     4  .783121341091443E-09 -.302983619822471E-08  .391066262926138E-08
     7     1  .540602445132366E-06 -.113795317805583E-06  .156362705306019E-06
     7     4  .199619321369220E-07 -.105303154468814E-07  .947760972708423E-08
     7     7  .248303159423892E-03
     8     1 -.893293880147395E-07  .100690439488730E-05 -.632217538211961E-06
     8     4 -.805221537018049E-08  .546334055013705E-07 -.313244884138333E-07
     8     7 -.299732594627442E-04  .159978181624762E-03
     9     1  .153337247920753E-06 -.653628616689398E-06  .788178811858135E-06
     9     4  .881822551436846E-08 -.339561840712832E-07  .473758787972838E-07
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+SOLUTION/MATRIX_ESTIMATE L COVA (cont.)

| *PARA1 | PARA2 | ____PARA2+0_____ | ____PARA2+1_____ | ____PARA2+2_____ |
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| 9 | 7 | -.349122541016788E-05 | .301671860439686E-04 | .123214387469901E-03 |
| 10 | 1 | .157171482208815E-07 | -.894297367547249E-08 | .874621653933601E-08 |
| 10 | 4 | .140682942076310E-08 | -.815249409413912E-09 | .783138672194233E-09 |
| 10 | 7 | .201722447989061E-07 | -.805250510623696E-08 | .881842501362034E-08 |
| 10 | 10 | .141460108288603E-08 | | |
| 11 | 1 | -.940581191270716E-08 | .506210207201386E-07 | -.343328447437267E-07 |
| 11 | 4 | -.815232256704283E-09 | .445485572073483E-08 | -.302985176791582E-08 |
| 11 | 7 | -.105304801076983E-07 | .548438438481010E-07 | -.339563339425273E-07 |
| 11 | 10 | -.815251948436312E-09 | .446263357782253E-08 | |
| 12 | 1 | .905406829458937E-08 | -.336761697478809E-07 | .437795432943613E-07 |
| 12 | 4 | .783113538676419E-09 | -.302981078503532E-08 | .391063631341286E-08 |
| 12 | 7 | .947755187509605E-08 | -.313242252033163E-07 | .475858035077566E-07 |
| 12 | 10 | .783130867192975E-09 | -.302982630762274E-08 | .391837865663189E-08 |
| 13 | 1 | .451422789119016E-06 | -.974163893696234E-07 | .154838197578714E-06 |
| 13 | 4 | .134530742402157E-07 | -.897631523426070E-08 | .915962442105035E-08 |
| 13 | 7 | .469343032583980E-06 | -.880523793655676E-07 | .157741181899401E-06 |
| 13 | 10 | .135059101812384E-07 | -.897674357092925E-08 | .915993191245891E-08 |
| 13 | 13 | .123085010970946E-04 | | |
| 14 | 1 | -.108687622782642E-06 | .907449098816021E-06 | -.682119733805086E-06 |
| 14 | 4 | -.954245894257741E-08 | .480557425887082E-07 | -.356114528951294E-07 |
| 14 | 7 | -.123776901819630E-06 | .928778689052927E-06 | -.681089035452743E-06 |
| 14 | 10 | -.954288733139590E-08 | .481083584497180E-07 | -.356111224622781E-07 |
| 14 | 13 | .556646215459983E-06 | .107485583666390E-04 | |
| 15 | 1 | .154730289793502E-06 | -.667695636895460E-06 | .700924804827138E-06 |
| 15 | 4 | .892536906815685E-08 | -.347114666139319E-07 | .408956386908501E-07 |
| 15 | 7 | .159670120792647E-06 | -.644614790519425E-06 | .729235396911758E-06 |
| 15 | 10 | .892567653737537E-08 | -.347116216544047E-07 | .409480055334258E-07 |
| 15 | 13 | -.177980848399481E-05 | .282376274454181E-05 | .826653489062396E-05 |
| 16 | 1 | .157170784083224E-07 | -.894287253809935E-08 | .874613032145903E-08 |
| 16 | 4 | .140682351900054E-08 | -.815241652206406E-09 | .783131424256154E-09 |
| 16 | 7 | .201720297362089E-07 | -.805240877809612E-08 | .881834314201825E-08 |
| 16 | 10 | .141459510970349E-08 | -.815244190153922E-09 | .783123616698655E-09 |
| 16 | 13 | .135586368139887E-07 | -.954298590279637E-08 | .892569365773234E-08 |
| 16 | 16 | .142235791781528E-08 | | |
| 17 | 1 | -.940572581140139E-08 | .506206210108993E-07 | -.343324834799552E-07 |
| 17 | 4 | -.815225193137607E-09 | .445482096090865E-08 | -.302981953398727E-08 |
| 17 | 7 | -.105303952378432E-07 | .548432959952465E-07 | -.339559571268080E-07 |
| 17 | 10 | -.815244883563972E-09 | .446259870688364E-08 | -.302979402683059E-08 |
| 17 | 13 | -.897706241600229E-08 | .481604562345041E-07 | -.347112598656268E-07 |
| 17 | 16 | -.815237124172950E-09 | .447033257772260E-08 | |
| 18 | 1 | .905420832436483E-08 | -.336766780063957E-07 | .437799082236846E-07 |
| 18 | 4 | .783125844161393E-09 | -.302985693052116E-08 | .391067043643328E-08 |
| 18 | 7 | .947770769819357E-08 | -.313246976144591E-07 | .475859482711604E-07 |
| 18 | 10 | .783143170411964E-09 | -.302987240622110E-08 | .391841258597081E-08 |
| 18 | 13 | .916045381474785E-08 | -.356116018625290E-07 | .410010502670866E-07 |
| 18 | 16 | .783135917318189E-09 | -.302984007813805E-08 | .392621517480445E-08 |
| 19 | 1 | .505128464573077E-06 | -.102848351617900E-06 | .149884185895900E-06 |
| 19 | 4 | .178362082564340E-07 | -.962236705665907E-08 | .882153092367692E-08 |
| 19 | 7 | .595563358127080E-06 | -.944193934334031E-07 | .148236419260277E-06 |
| 19 | 10 | .179663067034270E-07 | -.962213186610696E-08 | .882057269008907E-08 |
| 19 | 13 | .458882988884283E-06 | -.111763145999587E-06 | .152901352689813E-06 |
| 19 | 16 | .180963277983023E-07 | -.962177909626159E-08 | .881984653881029E-08 |

+SOLUTION/MATRIX_ESTIMATE L COVA (cont.)

| *PARA1 | PARA2 | ____PARA2+0_____ | ____PARA2+1_____ | ____PARA2+2_____ |
|---|---|---|---|---|
| 19 | 19 | .213213638545624E-05 | | |
| 20 | 1 | -.963982703683532E-07 | .971568084042687E-06 | -.647061214298981E-06 |
| 20 | 4 | -.864656633017267E-08 | .525727936889298E-07 | -.323890657352015E-07 |
| 20 | 7 | -.108710634826358E-06 | .105604361992354E-05 | -.635561733800245E-06 |
| 20 | 10 | -.864676362146940E-08 | .527030826745019E-07 | -.323879927835408E-07 |
| 20 | 13 | -.940034516443555E-07 | .919113399473517E-06 | -.656469899549192E-06 |
| 20 | 16 | -.864663641976182E-08 | .528329103068561E-07 | -.323876928928241E-07 |
| 20 | 19 | -.633966666291032E-07 | .223441414981916E-05 | |
| 21 | 1 | .152250239949836E-06 | -.659018534122933E-06 | .762123223264226E-06 |
| 21 | 4 | .867037128849919E-08 | -.342691874114821E-07 | .458728740977419E-07 |
| 21 | 7 | .155063448096067E-06 | -.626811924896319E-06 | .828197705033729E-06 |
| 21 | 10 | .867023369945012E-08 | -.342691410507295E-07 | .460039129196952E-07 |
| 21 | 13 | .155503236345388E-06 | -.682817035884504E-06 | .717348519422349E-06 |
| 21 | 16 | .866981039892762E-08 | -.342685634541973E-07 | .461356366526707E-07 |
| 21 | 19 | -.224372096689881E-07 | -.164886260589808E-06 | .180692704400701E-05 |
| 22 | 1 | .157169423356815E-07 | -.894259510596844E-08 | .874586881798111E-08 |
| 22 | 4 | .140681294050520E-08 | -.815216364542433E-09 | .783107250502123E-09 |
| 22 | 7 | .201715312421969E-07 | -.805216912209794E-08 | .881807427701101E-08 |
| 22 | 10 | .141458439109970E-08 | -.815218900493033E-09 | .783099439188189E-09 |
| 22 | 13 | .135585490259809E-07 | -.954269464843543E-08 | .892543436307251E-08 |
| 22 | 16 | .142234705906530E-08 | -.815211832934370E-09 | .783111735525907E-09 |
| 22 | 19 | .183563449958596E-07 | -.864631898210292E-08 | .866886932501856E-08 |
| 22 | 22 | .143787362689215E-08 | | |
| 23 | 1 | -.940582292868666E-08 | .506207005067424E-07 | -.343326951477147E-07 |
| 23 | 4 | -.815234953399386E-09 | .445483020375192E-08 | -.302983904074788E-08 |
| 23 | 7 | -.105304992987150E-07 | .548430370054176E-07 | -.339561386786658E-07 |
| 23 | 10 | -.815254642216114E-09 | .446260773262421E-08 | -.302981344167186E-08 |
| 23 | 13 | -.897715671859589E-08 | .481606098108236E-07 | -.347114760628029E-07 |
| 23 | 16 | -.815246880916305E-09 | .447034138609520E-08 | -.302985940141796E-08 |
| 23 | 19 | -.962133574442320E-08 | .530934112971428E-07 | -.342683505225832E-07 |
| 23 | 22 | -.815221586545958E-09 | .448588746860929E-08 | |
| 24 | 1 | .905418657853765E-08 | -.336765041992967E-07 | .437796457136603E-07 |
| 24 | 4 | .783123922946637E-09 | -.302984209274085E-08 | .391065090551492E-08 |
| 24 | 7 | .947769996630330E-08 | -.313244988525373E-07 | .475852325967141E-07 |
| 24 | 10 | .783141245213979E-09 | -.302985747667696E-08 | .391839267372256E-08 |
| 24 | 13 | .916042696165395E-08 | -.356114363839979E-07 | .410008540126823E-07 |
| 24 | 16 | .783133988320713E-09 | -.302982505686009E-08 | .392619488094326E-08 |
| 24 | 19 | .881808785867601E-08 | -.323859223281967E-07 | .463980896458257E-07 |
| 24 | 22 | .783109799839332E-09 | -.302984419845434E-08 | .394171153307314E-08 |
| 25 | 1 | .205236790216571E-06 | -.247118990115517E-06 | .220000327968499E-06 |
| 25 | 4 | .143540530509958E-07 | -.889101109252036E-08 | .865879487342832E-08 |
| 25 | 7 | .250937319436679E-06 | -.237031358736578E-06 | .222195883663565E-06 |
| 25 | 10 | .143540928951806E-07 | -.889103403726355E-08 | .865871790925392E-08 |
| 25 | 13 | .182119640807929E-06 | -.252895395359328E-06 | .221252682977428E-06 |
| 25 | 16 | .143540045894240E-07 | -.889095706297100E-08 | .865884549825850E-08 |
| 25 | 19 | .225461903080647E-06 | -.243995159109810E-06 | .219626794098427E-06 |
| 25 | 22 | .143538923330453E-07 | -.889105937605803E-08 | .865881040404516E-08 |
| 25 | 25 | .527944619044075E-06 | | |
| 26 | 1 | -.195610850983823E-07 | .748368810477448E-06 | -.511172859887893E-06 |
| 26 | 4 | -.950191965497477E-08 | .504509528445222E-07 | -.349404503303732E-07 |
| 26 | 7 | -.350270239564814E-07 | .794939019362509E-06 | -.507574906689904E-06 |
| 26 | 10 | -.950215010334005E-08 | .504510547980744E-07 | -.349401583174590E-07 |

+SOLUTION/MATRIX_ESTIMATE L COVA (cont.)

| *PARA1 | PARA2 | ____PARA2+0_____ | ____PARA2+1_____ | ____PARA2+2_____ |
|---|---|---|---|---|
| 26 | 13 | -.139958118057662E-07 | .718994957258890E-06 | -.514810499477564E-06 |
| 26 | 16 | -.950205768854084E-08 | .504506440446383E-07 | -.349406703339660E-07 |
| 26 | 19 | -.244751567109460E-07 | .769547656134325E-06 | -.510063625208311E-06 |
| 26 | 22 | -.950177694200628E-08 | .504507454045062E-07 | -.349404909923356E-07 |
| 26 | 25 | -.153897853427100E-06 | .114108026782715E-05 | |
| 27 | 1 | .151172103743533E-06 | -.632216822618826E-06 | .692873208291583E-06 |
| 27 | 4 | .925337307593235E-08 | -.348889027941589E-07 | .428961146404375E-07 |
| 27 | 7 | .158330483469872E-06 | -.608754735748951E-06 | .731912676026269E-06 |
| 27 | 10 | .925356807844771E-08 | -.348890674063489E-07 | .428958081267299E-07 |
| 27 | 13 | .152693961241359E-06 | -.649421445976222E-06 | .662281215147411E-06 |
| 27 | 16 | .925349017373805E-08 | -.348887018357155E-07 | .428961888372419E-07 |
| 27 | 19 | .149227140765385E-06 | -.620044367720140E-06 | .714061041986957E-06 |
| 27 | 22 | .925322056143853E-08 | -.348889069265016E-07 | .428959553745490E-07 |
| 27 | 25 | .267334030670525E-06 | -.588392073645151E-06 | .977987421171784E-06 |
| 28 | 1 | .150836242816109E-07 | -.904762316012595E-08 | .876761537458994E-08 |
| 28 | 4 | .135168432017892E-08 | -.825941091976405E-09 | .786032663264631E-09 |
| 28 | 7 | .190082887738934E-07 | -.815434689472539E-08 | .884911732007017E-08 |
| 28 | 10 | .135168734748473E-08 | -.825943699470900E-09 | .786024808049281E-09 |
| 28 | 13 | .129159396647770E-07 | -.964079278573879E-08 | .894246880352153E-08 |
| 28 | 16 | .135168188271767E-08 | -.825936595379677E-09 | .786037175994723E-09 |
| 28 | 19 | .171044211296989E-07 | -.875364652307599E-08 | .869720564601068E-08 |
| 28 | 22 | .135167163667591E-08 | -.825946182984708E-09 | .786035236024255E-09 |
| 28 | 25 | .146978080317961E-07 | -.963151638086639E-08 | .929755486787141E-08 |
| 28 | 28 | .138432990295196E-08 | | |
| 29 | 1 | -.932214300496595E-08 | .501001971783616E-07 | -.342103750987662E-07 |
| 29 | 4 | -.807571087890405E-09 | .440901513923929E-08 | -.301669392484082E-08 |
| 29 | 7 | -.104567149832808E-07 | .538732228339796E-07 | -.339091424244408E-07 |
| 29 | 10 | -.807590645611340E-09 | .440902436693964E-08 | -.301666863983047E-08 |
| 29 | 13 | -.888465729893295E-08 | .476452332943500E-07 | -.345524308316087E-07 |
| 29 | 16 | -.807582853173490E-09 | .440899014349574E-08 | -.301671450242598E-08 |
| 29 | 19 | -.953890467304442E-08 | .519691062536467E-07 | -.341747360015541E-07 |
| 29 | 22 | -.807557691424703E-09 | .440899976399877E-08 | -.301669965714979E-08 |
| 29 | 25 | -.882196069012601E-08 | .509338961065863E-07 | -.347834808981910E-07 |
| 29 | 28 | -.818268528616095E-09 | .445090438401679E-08 | |
| 30 | 1 | .904663964069070E-08 | -.338306777188100E-07 | .433839620767172E-07 |
| 30 | 4 | .781851097538094E-09 | -.304279520928032E-08 | .387731892597905E-08 |
| 30 | 7 | .946944562115804E-08 | -.316022999911416E-07 | .467240885305572E-07 |
| 30 | 10 | .781868379175137E-09 | -.304281072421440E-08 | .387729302659495E-08 |
| 30 | 13 | .914445949838239E-08 | -.356993480941098E-07 | .406394791162239E-07 |
| 30 | 16 | .781861235823564E-09 | -.304277854632464E-08 | .387732761663613E-08 |
| 30 | 19 | .881909373756650E-08 | -.325909143710244E-07 | .453748050493316E-07 |
| 30 | 22 | .781837075314013E-09 | -.304279796702755E-08 | .387730899394833E-08 |
| 30 | 25 | .867332003992506E-08 | -.351027427727497E-07 | .434871328356320E-07 |
| 30 | 28 | .784672898681686E-09 | -.302975229991071E-08 | .393023332498107E-08 |
| 31 | 1 | .203028221163304E-06 | -.245690962478632E-06 | .218262637133094E-06 |
| 31 | 4 | .141585441008094E-07 | -.876467525637109E-08 | .850143527809970E-08 |
| 31 | 7 | .247852257701592E-06 | -.234965046030293E-06 | .219980365326113E-06 |
| 31 | 10 | .141585836270523E-07 | -.876469868602054E-08 | .850136006870470E-08 |
| 31 | 13 | .180126959216436E-06 | -.251708380470373E-06 | .219796495823627E-06 |
| 31 | 16 | .141584967384845E-07 | -.876462410283812E-08 | .850148810078193E-08 |
| 31 | 19 | .222988866929713E-06 | -.242371228449151E-06 | .217692332848576E-06 |
| 31 | 22 | .141583860398818E-07 | -.876472726582773E-08 | .850145583592026E-08 |

+SOLUTION/MATRIX_ESTIMATE L COVA (cont.)

| *PARA1 | PARA2 | ____PARA2+0_____ | ____PARA2+1_____ | ____PARA2+2_____ |
|---|---|---|---|---|
| 31 | 25 | .511832404057029E-06 | -.131785896738755E-06 | .249714349127525E-06 |
| 31 | 28 | .144902967799441E-07 | -.868763071733716E-08 | .850516735127809E-08 |
| 31 | 31 | .511393125591161E-06 | | |
| 32 | 1 | -.148764741843984E-07 | .739994408577949E-06 | -.502863704326600E-06 |
| 32 | 4 | -.907413900205471E-08 | .497019837926377E-07 | -.341794124197492E-07 |
| 32 | 7 | -.291345389717418E-07 | .783244515233335E-06 | -.497137115246669E-06 |
| 32 | 10 | -.907436646683830E-08 | .497020876219983E-07 | -.341791290510458E-07 |
| 32 | 13 | -.945169714161076E-08 | .711975468791266E-06 | -.507758836462767E-06 |
| 32 | 16 | -.907427677120068E-08 | .497016889759273E-07 | -.341796420543230E-07 |
| 32 | 19 | -.194330644728439E-07 | .760111845275145E-06 | -.500862214582584E-06 |
| 32 | 22 | -.907400042023584E-08 | .497017963404763E-07 | -.341794757828235E-07 |
| 32 | 25 | -.128984313065617E-06 | .103058826285068E-05 | -.508685074747895E-06 |
| 32 | 28 | -.919389460393713E-08 | .501387915857634E-07 | -.342933575948302E-07 |
| 32 | 31 | -.129881836015149E-06 | .103330004711931E-05 | |
| 33 | 1 | .147732568444725E-06 | -.627036761483243E-06 | .685769738146516E-06 |
| 33 | 4 | .893695194203065E-08 | -.344212155720115E-07 | .422553017142392E-07 |
| 33 | 7 | .153966863813056E-06 | -.601732729358085E-06 | .722433788681970E-06 |
| 33 | 10 | .893714477612400E-08 | -.344213812720662E-07 | .422550025364682E-07 |
| 33 | 13 | .149350341589168E-06 | -.644935442381415E-06 | .656539448744779E-06 |
| 33 | 16 | .893706921992461E-08 | -.344210241696373E-07 | .422553854733112E-07 |
| 33 | 19 | .145534448720320E-06 | -.614306931322837E-06 | .705972538769393E-06 |
| 33 | 22 | .893680280091576E-08 | -.344212329663640E-07 | .422551640179693E-07 |
| 33 | 25 | .248377961363621E-06 | -.511778209743296E-06 | .904171726726204E-06 |
| 33 | 28 | .897352598199131E-08 | -.342887549507573E-07 | .427945021801498E-07 |
| 33 | 31 | .248384512447420E-06 | -.510957792678270E-06 | .904104295741770E-06 |
| 34 | 1 | .150836264336594E-07 | -.904762276659837E-08 | .876761534472480E-08 |
| 34 | 4 | .135168449350699E-08 | -.825941067246415E-09 | .786032666903196E-09 |
| 34 | 7 | .190082919326107E-07 | -.815434653198069E-08 | .884911732288799E-08 |
| 34 | 10 | .135168752081237E-08 | -.825943674740567E-09 | .786024811687544E-09 |
| 34 | 13 | .129159415212131E-07 | -.964079240490077E-08 | .894246876196692E-08 |
| 34 | 16 | .135168205604396E-08 | -.825936570649178E-09 | .786037179632445E-09 |
| 34 | 19 | .171044235894835E-07 | -.875364612488900E-08 | .869720560769747E-08 |
| 34 | 22 | .135167181000109E-08 | -.825946158254375E-09 | .786035239661174E-09 |
| 34 | 25 | .146914727125746E-07 | -.963151693940582E-08 | .929755517339798E-08 |
| 34 | 28 | .138390629579059E-08 | -.818268504060519E-09 | .784672903211841E-09 |
| 34 | 31 | .144902975915755E-07 | -.919389420567830E-08 | .897352587895630E-08 |
| 34 | 34 | .138390647496787E-08 | | |
| 35 | 1 | -.932214308349758E-08 | .501001984628875E-07 | -.342103753426018E-07 |
| 35 | 4 | -.807571100450637E-09 | .440901525852761E-08 | -.301669395865678E-08 |
| 35 | 7 | -.104567149960289E-07 | .538732247261802E-07 | -.339091424755177E-07 |
| 35 | 10 | -.807590658172023E-09 | .440902448622750E-08 | -.301666867364548E-08 |
| 35 | 13 | -.888465740806033E-08 | .476452343045038E-07 | -.345524311716356E-07 |
| 35 | 16 | -.807582865734377E-09 | .440899026278205E-08 | -.301671453624115E-08 |
| 35 | 19 | -.953890475798004E-08 | .519691077504324E-07 | -.341747361325123E-07 |
| 35 | 22 | -.807557703985449E-09 | .440899988328374E-08 | -.301669969096376E-08 |
| 35 | 25 | -.882196000666318E-08 | .509275540957045E-07 | -.347834790772035E-07 |
| 35 | 28 | -.818268540747179E-09 | .445048072059819E-08 | -.302975233241880E-08 |
| 35 | 31 | -.868763089234212E-08 | .501387919883204E-07 | -.342887552235888E-07 |
| 35 | 34 | -.818268516455036E-09 | .445048084460647E-08 | |
| 36 | 1 | .904663962761704E-08 | -.338306771603065E-07 | .433839629474749E-07 |
| 36 | 4 | .781851100837084E-09 | -.304279516917835E-08 | .387731900359683E-08 |
| 36 | 7 | .946944561966816E-08 | -.316022990967998E-07 | .467240900248624E-07 |

+SOLUTION/MATRIX_ESTIMATE L COVA (cont.)

| *PARA1 | PARA2 | ____PARA2+0_____ | ____PARA2+1_____ | ____PARA2+2_____ |
|---|---|---|---|---|
| 36 | 10 | .781868382474093E-09 | -.304281068411295E-08 | .387729310421283E-08 |
| 36 | 13 | .914445950169561E-08 | -.356993477032378E-07 | .406394796413744E-07 |
| 36 | 16 | .781861239122160E-09 | -.304277850622350E-08 | .387732769425388E-08 |
| 36 | 19 | .881909368664045E-08 | -.325909136819691E-07 | .453748062409545E-07 |
| 36 | 22 | .781837078612382E-09 | -.304279792692739E-08 | .387730907156607E-08 |
| 36 | 25 | .867331875540464E-08 | -.351027385655006E-07 | .434807900827601E-07 |
| 36 | 28 | .784672902062614E-09 | -.302975225870516E-08 | .392980962409259E-08 |
| 36 | 31 | .850516733124003E-08 | -.342933571810442E-07 | .427945022873193E-07 |
| 36 | 34 | .784672906751975E-09 | -.302975229197241E-08 | .392980971025266E-08 |
| 37 | 1 | .202770988667733E-06 | -.243676700439092E-06 | .216688636290352E-06 |
| 37 | 4 | .141490630121878E-07 | -.863074217801613E-08 | .839918077484284E-08 |
| 37 | 7 | .247708144408502E-06 | -.233007082329867E-06 | .218472362256328E-06 |
| 37 | 10 | .141491017870570E-07 | -.863076502895488E-08 | .839910625843793E-08 |
| 37 | 13 | .179841422057490E-06 | -.249678564619053E-06 | .218183896868154E-06 |
| 37 | 16 | .141490150096521E-07 | -.863069150612881E-08 | .839923254960472E-08 |
| 37 | 19 | .222766708827511E-06 | -.240374991419608E-06 | .216146469895945E-06 |
| 37 | 22 | .141489050316503E-07 | -.863079397753567E-08 | .839920043503996E-08 |
| 37 | 25 | .511781136786575E-06 | -.129843504162537E-06 | .248347581771010E-06 |
| 37 | 28 | .144815829821909E-07 | -.855457953173261E-08 | .840431344277691E-08 |
| 37 | 31 | .510143225095127E-06 | -.126291297224794E-06 | .245756287390301E-06 |
| 37 | 34 | .144815835707927E-07 | -.855457971304812E-08 | .840431342114016E-08 |
| 37 | 37 | .510780564156479E-06 | | |
| 38 | 1 | -.157539765930031E-07 | .742244357164841E-06 | -.504908002352628E-06 |
| 38 | 4 | -.914633552259323E-08 | .498823682640087E-07 | -.343461584113064E-07 |
| 38 | 7 | -.301567150073962E-07 | .785886186023688E-06 | -.499438199203867E-06 |
| 38 | 10 | -.914656382997462E-08 | .498824722092186E-07 | -.343458734351126E-07 |
| 38 | 13 | -.103098045789924E-07 | .714071415884402E-06 | -.509656203609887E-06 |
| 38 | 16 | -.914647363311078E-08 | .498820712984023E-07 | -.343463873650501E-07 |
| 38 | 19 | -.203521367564886E-07 | .762489180690494E-06 | -.503015035793942E-06 |
| 38 | 22 | -.914619618358886E-08 | .498821783480696E-07 | -.343462192097656E-07 |
| 38 | 25 | -.130063317145524E-06 | .103447617634525E-05 | -.511766756194624E-06 |
| 38 | 28 | -.926723731322690E-08 | .503240587196696E-07 | -.344660861167357E-07 |
| 38 | 31 | -.129303509667101E-06 | .102956485623203E-05 | -.508796340971447E-06 |
| 38 | 34 | -.926723686809006E-08 | .503240589527911E-07 | -.344660856817960E-07 |
| 38 | 37 | -.128513457395822E-06 | .103923705516519E-05 | |
| 39 | 1 | .147919683674540E-06 | -.626544018458307E-06 | .685767727173777E-06 |
| 39 | 4 | .896027023707383E-08 | -.344051626804225E-07 | .422776328322819E-07 |
| 39 | 7 | .154273898975842E-06 | -.601440396080946E-06 | .722744944829025E-06 |
| 39 | 10 | .896046295644127E-08 | -.344053280054178E-07 | .422773331505768E-07 |
| 39 | 13 | .149520941395263E-06 | -.644375272024399E-06 | .656362979466946E-06 |
| 39 | 16 | .896038724398415E-08 | -.344049705136316E-07 | .422777149640855E-07 |
| 39 | 19 | .145753607673566E-06 | -.613875581434289E-06 | .706101474207646E-06 |
| 39 | 22 | .896012086393135E-08 | -.344051785861598E-07 | .422774921951375E-07 |
| 39 | 25 | .248692760615815E-06 | -.512217038899840E-06 | .905151659639888E-06 |
| 39 | 28 | .899780584901887E-08 | -.342760133921314E-07 | .428228204303025E-07 |
| 39 | 31 | .247431597250364E-06 | -.506160566588522E-06 | .900119704589879E-06 |
| 39 | 34 | .899780570563213E-08 | -.342760136279129E-07 | .428228204053704E-07 |
| 39 | 37 | .246905615101991E-06 | -.513194760025559E-06 | .904663329497973E-06 |
| 40 | 1 | .150472728735311E-07 | -.890029808930235E-08 | .864545588438416E-08 |
| 40 | 4 | .134853979735633E-08 | -.813079865294950E-09 | .775355002430484E-09 |
| 40 | 7 | .189710772074605E-07 | -.800623507428537E-08 | .872699086514652E-08 |
| 40 | 10 | .134854275594179E-08 | -.813082426943180E-09 | .775347226549149E-09 |

+SOLUTION/MATRIX_ESTIMATE L COVA (cont.)

| *PARA1 | PARA2 | ____PARA2+0_____ | ____PARA2+1_____ | ____PARA2+2_____ |
|---|---|---|---|---|
| 40 | 13 | .128796795652043E-07 | -.949370577196132E-08 | .882033025325688E-08 |
| 40 | 16 | .134853731872662E-08 | -.813075439389697E-09 | .775359448081665E-09 |
| 40 | 19 | .170679017005078E-07 | -.860617064381335E-08 | .857511587824265E-08 |
| 40 | 22 | .134852715333219E-08 | -.813084972483141E-09 | .775357552598161E-09 |
| 40 | 25 | .146552177970765E-07 | -.948216143875860E-08 | .917522077773790E-08 |
| 40 | 28 | .138075874464056E-08 | -.805402523973347E-09 | .773992492297952E-09 |
| 40 | 31 | .144558483091745E-07 | -.904450799580123E-08 | .885117759460375E-08 |
| 40 | 34 | .138075892353206E-08 | -.805402536365063E-09 | .773992495926936E-09 |
| 40 | 37 | .144512449573436E-07 | -.911753795468518E-08 | .887579636758056E-08 |
| 40 | 40 | .137808411667420E-08 | | |
| 41 | 1 | -.934376698645542E-08 | .501918333940874E-07 | -.342869979407302E-07 |
| 41 | 4 | -.809441506165563E-09 | .441701669972474E-08 | -.302338729331183E-08 |
| 41 | 7 | -.104783806443715E-07 | .539647565330908E-07 | -.339859356711350E-07 |
| 41 | 10 | -.809461107060673E-09 | .441702595667722E-08 | -.302336195860408E-08 |
| 41 | 13 | -.890636261237334E-08 | .477369830719962E-07 | -.346289472526600E-07 |
| 41 | 16 | -.809453297900125E-09 | .441699166113873E-08 | -.302340791280731E-08 |
| 41 | 19 | -.956047470037708E-08 | .520606363137488E-07 | -.342513879157942E-07 |
| 41 | 22 | -.809428086237500E-09 | .441700131662733E-08 | -.302339303951106E-08 |
| 41 | 25 | -.884289734234912E-08 | .510195765024212E-07 | -.348602778580476E-07 |
| 41 | 28 | -.820137683044043E-09 | .445848036489912E-08 | -.303644733333576E-08 |
| 41 | 31 | -.870852655819083E-08 | .502324054179796E-07 | -.343654726362062E-07 |
| 41 | 34 | -.820137658771811E-09 | .445848048875910E-08 | -.303644729304785E-08 |
| 41 | 37 | -.857509842162909E-08 | .504213825693257E-07 | -.343525603392315E-07 |
| 41 | 40 | -.807239973224631E-09 | .446692334136255E-08 | |
| 42 | 1 | .903013119611858E-08 | -.337608076691051E-07 | .433248343633506E-07 |
| 42 | 4 | .780420458781646E-09 | -.303669354978328E-08 | .387215346185861E-08 |
| 42 | 7 | .945292547438640E-08 | -.315323761985940E-07 | .466643473847280E-07 |
| 42 | 10 | .780437707405495E-09 | -.303670904267006E-08 | .387212760129258E-08 |
| 42 | 13 | .912785447004906E-08 | -.356294302211758E-07 | .405807055906748E-07 |
| 42 | 16 | .780430576889504E-09 | -.303667692039064E-08 | .387216212268450E-08 |
| 42 | 19 | .880263919993661E-08 | -.325210910889724E-07 | .453154584647415E-07 |
| 42 | 22 | .780406454374551E-09 | -.303669631511069E-08 | .387214352337352E-08 |
| 42 | 25 | .865740611640970E-08 | -.350319305995208E-07 | .434206128248598E-07 |
| 42 | 28 | .783242979134273E-09 | -.302364880183074E-08 | .392463483736656E-08 |
| 42 | 31 | .848922727947683E-08 | -.342223785009340E-07 | .427358912889228E-07 |
| 42 | 34 | .783242983870442E-09 | -.302364883527415E-08 | .392463492328902E-08 |
| 42 | 37 | .838867190505972E-08 | -.343949874046424E-07 | .427678584199750E-07 |
| 42 | 40 | .772586887938163E-09 | -.303032931385947E-08 | .391989435426744E-08 |
| 43 | 1 | .283437403610238E-06 | -.214295598552899E-06 | .210491797678914E-06 |
| 43 | 4 | .136818368905192E-07 | -.994603700844821E-08 | .950786119561460E-08 |
| 43 | 7 | .317955685970411E-06 | -.204874883881304E-06 | .213576851414453E-06 |
| 43 | 10 | .136818912015137E-07 | -.994605334173256E-08 | .950777532100400E-08 |
| 43 | 13 | .268255920675107E-06 | -.218896667886113E-06 | .210879804657628E-06 |
| 43 | 16 | .136818082989237E-07 | -.994597814029945E-08 | .950792648369188E-08 |
| 43 | 19 | .299883009284566E-06 | -.210908961319838E-06 | .209684239458673E-06 |
| 43 | 22 | .136817077944260E-07 | -.994608312688894E-08 | .950789149976926E-08 |
| 43 | 25 | .377923966195014E-06 | -.144717475654121E-06 | .246517431472090E-06 |
| 43 | 28 | .139583958637901E-07 | -.987495611415012E-08 | .949968966157708E-08 |
| 43 | 31 | .378319398613528E-06 | -.144183215334839E-06 | .246192098037640E-06 |
| 43 | 34 | .139583953922277E-07 | -.987495631108605E-08 | .949968967526526E-08 |
| 43 | 37 | .377797099740590E-06 | -.144525332243380E-06 | .245995556481487E-06 |
| 43 | 40 | .139215149641014E-07 | -.989845256186272E-08 | .948176976906393E-08 |

+SOLUTION/MATRIX_ESTIMATE L COVA (cont.)

| *PARA1 | PARA2 | ____PARA2+0_____ | ____PARA2+1_____ | ____PARA2+2_____ |
|---|---|---|---|---|
| 43 | 43 | .170418007828418E-04 | | |
| 44 | 1 | .461069832990536E-07 | .599837316455380E-06 | -.389276017688437E-06 |
| 44 | 4 | -.661781496316281E-08 | .411925008748602E-07 | -.276867756673270E-07 |
| 44 | 7 | .326707036867833E-07 | .636882467883233E-06 | -.390124406664188E-06 |
| 44 | 10 | -.661800061669100E-08 | .411925783704067E-07 | -.276865473862355E-07 |
| 44 | 13 | .494951503082904E-07 | .573679517412287E-06 | -.392426157022215E-06 |
| 44 | 16 | -.661791384343280E-08 | .411922657015207E-07 | -.276869762224323E-07 |
| 44 | 19 | .423055821202946E-07 | .616230162218156E-06 | -.385978094861511E-06 |
| 44 | 22 | -.661768369287366E-08 | .411923560213849E-07 | -.276868422825568E-07 |
| 44 | 25 | -.112308070010866E-06 | .673836075208694E-06 | -.321882428315948E-06 |
| 44 | 28 | -.671445292776976E-08 | .415862533327224E-07 | -.277660218263526E-07 |
| 44 | 31 | -.114564333578200E-06 | .683918622440526E-06 | -.329152263676273E-06 |
| 44 | 34 | -.671445240789178E-08 | .415862523714521E-07 | -.277660215699187E-07 |
| 44 | 37 | -.112760892270138E-06 | .683698265863696E-06 | -.327522490331076E-06 |
| 44 | 40 | -.659258659358251E-08 | .416641497386090E-07 | -.277080144429347E-07 |
| 44 | 43 | -.316276216766921E-04 | .147839124909943E-03 | |
| 45 | 1 | .130300148472198E-06 | -.559215186298230E-06 | .629623093507129E-06 |
| 45 | 4 | .759630819125607E-08 | -.311954520730870E-07 | .397151167354390E-07 |
| 45 | 7 | .134149535752427E-06 | -.535769304833230E-06 | .667489760006402E-06 |
| 45 | 10 | .759648176725590E-08 | -.311956113607527E-07 | .397148524535027E-07 |
| 45 | 13 | .134212199000864E-06 | -.575195455871727E-06 | .601002727926590E-06 |
| 45 | 16 | .759641515667066E-08 | -.311952812413028E-07 | .397152145074415E-07 |
| 45 | 19 | .127462157933469E-06 | -.545979800661071E-06 | .645882103407039E-06 |
| 45 | 22 | .759616388544539E-08 | -.311954804383334E-07 | .397150367498811E-07 |
| 45 | 25 | .231818519039742E-06 | -.356763026805963E-06 | .723110775141528E-06 |
| 45 | 28 | .760767163693063E-08 | -.310612795182802E-07 | .401796728148275E-07 |
| 45 | 31 | .232801905462428E-06 | -.360894251195086E-06 | .727640179269055E-06 |
| 45 | 34 | .760767144098915E-08 | -.310612798403061E-07 | .401796716032656E-07 |
| 45 | 37 | .231203419282693E-06 | -.361285554044157E-06 | .726336410832755E-06 |
| 45 | 40 | .749401688525873E-08 | -.311325427663343E-07 | .401266727208227E-07 |
| 45 | 43 | .260468471081205E-04 | -.115908200843487E-03 | .109632661209053E-03 |
| 46 | 1 | .155100499601547E-07 | -.102170190755726E-07 | .984670126132282E-08 |
| 46 | 4 | .132497952555604E-08 | -.873910059026273E-09 | .825521624974119E-09 |
| 46 | 7 | .190082848384902E-07 | -.923386133578172E-08 | .997095258844447E-08 |
| 46 | 10 | .132498319752714E-08 | -.873912316275713E-09 | .825513369339224E-09 |
| 46 | 13 | .135389982828622E-07 | -.108002203469981E-07 | .100192973472167E-07 |
| 46 | 16 | .132497751037132E-08 | -.873905442832905E-09 | .825526933368078E-09 |
| 46 | 19 | .173673172521648E-07 | -.987445455390733E-08 | .974179697263069E-08 |
| 46 | 22 | .132496759954491E-08 | -.873915563318389E-09 | .825525028823808E-09 |
| 46 | 25 | .139585081985621E-07 | -.101875613831465E-07 | .981761536572829E-08 |
| 46 | 28 | .135402635369139E-08 | -.865361686391522E-09 | .822584464549976E-09 |
| 46 | 31 | .139926587220243E-07 | -.100844348393036E-07 | .974302863385921E-08 |
| 46 | 34 | .135402625277112E-08 | -.865361712718549E-09 | .822584470128397E-09 |
| 46 | 37 | .139478636115946E-07 | -.101212269398573E-07 | .973231177909905E-08 |
| 46 | 40 | .135077025285080E-08 | -.867437917926746E-09 | .820991750302030E-09 |
| 46 | 43 | .967326916978199E-06 | -.183554407934167E-05 | .150132410032031E-05 |
| 46 | 46 | .582594394296625E-07 | | |
| 47 | 1 | -.849364560932173E-08 | .473806271435213E-07 | -.320608672355241E-07 |
| 47 | 4 | -.607290739107144E-09 | .372688745023465E-08 | -.245368165320475E-08 |
| 47 | 7 | -.941396850314059E-08 | .506318432850892E-07 | -.319969654146237E-07 |
| 47 | 10 | -.607307070945706E-09 | .372689445517555E-08 | -.245366095074483E-08 |
| 47 | 13 | -.819770831560953E-08 | .450025096825604E-07 | -.324198454254777E-07 |

+SOLUTION/MATRIX_ESTIMATE L COVA (cont.)

| *PARA1 | PARA2 | ____PARA2+0_____ | ____PARA2+1_____ | ____PARA2+2_____ |
|---|---|---|---|---|
| 47 | 16 | -.607299944853449E-09 | .372686761306973E-08 | -.245370047739182E-08 |
| 47 | 19 | -.863089179217439E-08 | .489833321550595E-07 | -.318912840312558E-07 |
| 47 | 22 | -.607279021187037E-09 | .372687582701217E-08 | -.245368866103297E-08 |
| 47 | 25 | -.817218822332341E-08 | .430934538355679E-07 | -.300619497318679E-07 |
| 47 | 28 | -.615679528559400E-09 | .376318181501965E-08 | -.246110524238896E-08 |
| 47 | 31 | -.837976858522269E-08 | .440252011941246E-07 | -.307337535675470E-07 |
| 47 | 34 | -.615679480506443E-09 | .376318171906282E-08 | -.246110522454333E-08 |
| 47 | 37 | -.822340688907804E-08 | .439972193440607E-07 | -.305887413224590E-07 |
| 47 | 40 | -.604945975736201E-09 | .377004534490776E-08 | -.245599847488191E-08 |
| 47 | 43 | -.183701514773597E-05 | .860385375510323E-05 | -.672708325569815E-05 |
| 47 | 46 | -.109028286779545E-06 | .512545381576762E-06 | |
| 48 | 1 | .892750851352292E-08 | -.349417386714903E-07 | .441939407280503E-07 |
| 48 | 4 | .670594862774889E-09 | -.278373252105338E-08 | .366929781452995E-08 |
| 48 | 7 | .918303148453195E-08 | -.328477261006389E-07 | .473005033346152E-07 |
| 48 | 10 | .670610709270315E-09 | -.278374770997922E-08 | .366927513553046E-08 |
| 48 | 13 | .914874636008858E-08 | -.367128267003854E-07 | .415551372375083E-07 |
| 48 | 16 | .670604446200688E-09 | -.278371790575496E-08 | .366930870675827E-08 |
| 48 | 19 | .866643938853257E-08 | -.336807017593436E-07 | .458225008138612E-07 |
| 48 | 22 | .670581643069957E-09 | -.278373687325978E-08 | .366929451038209E-08 |
| 48 | 25 | .865721973599513E-08 | -.325894704806770E-07 | .418454943199130E-07 |
| 48 | 28 | .671665859891783E-09 | -.276886772752335E-08 | .371334614934117E-08 |
| 48 | 31 | .874118273428911E-08 | -.329362259656807E-07 | .422439137948334E-07 |
| 48 | 34 | .671665837795731E-09 | -.276886776995938E-08 | .371334602478292E-08 |
| 48 | 37 | .860810169068252E-08 | -.329691746970363E-07 | .421326471167967E-07 |
| 48 | 40 | .661610222283829E-09 | -.277516599538359E-08 | .370866382670333E-08 |
| 48 | 43 | .150193971637445E-05 | -.672343206692633E-05 | .632787392961243E-05 |
| 48 | 46 | .888458549069270E-07 | -.397682868204909E-06 | .373777762663218E-06 |
| 49 | 1 | .281004673108819E-06 | -.207664223161207E-06 | .204743971733435E-06 |
| 49 | 4 | .137911284708569E-07 | -.102314078626107E-07 | .974004284012077E-08 |
| 49 | 7 | .315078299740488E-06 | -.198136916010297E-06 | .206341819597632E-06 |
| 49 | 10 | .137911848006603E-07 | -.102314263346875E-07 | .973995695035492E-08 |
| 49 | 13 | .265676401909341E-06 | -.212806212383644E-06 | .205488471898888E-06 |
| 49 | 16 | .137911020509048E-07 | -.102313485658739E-07 | .974011381236575E-08 |
| 49 | 19 | .297500531793584E-06 | -.204342980211161E-06 | .203916389957011E-06 |
| 49 | 22 | .137910002222947E-07 | -.102314566049304E-07 | .974008211719490E-08 |
| 49 | 25 | .376611728326971E-06 | -.145086126293077E-06 | .244734843040087E-06 |
| 49 | 28 | .140681746534800E-07 | -.101530911776431E-07 | .972593116409482E-08 |
| 49 | 31 | .376958260965092E-06 | -.144311790109488E-06 | .244223353929564E-06 |
| 49 | 34 | .140681741867645E-07 | -.101530913958422E-07 | .972593119812058E-08 |
| 49 | 37 | .376447785329647E-06 | -.144682415570395E-06 | .244054866217272E-06 |
| 49 | 40 | .140301573829870E-07 | -.101772861478797E-07 | .970745640733100E-08 |
| 49 | 43 | .756722314435239E-05 | -.129018700724236E-04 | .106782505294686E-04 |
| 49 | 46 | .423982953141914E-06 | -.764337091372701E-06 | .624014752947401E-06 |
| 49 | 49 | .147918556219056E-04 | | |
| 50 | 1 | .544994902663121E-07 | .564598261828048E-06 | -.359014958095350E-06 |
| 50 | 4 | -.714454579563204E-08 | .424181295449879E-07 | -.286100888683452E-07 |
| 50 | 7 | .405456779720188E-07 | .599896267371208E-06 | -.354029537921702E-06 |
| 50 | 10 | -.714473860232527E-08 | .424182161692228E-07 | -.286098563787618E-07 |
| 50 | 13 | .595333534685858E-07 | .541118276535982E-06 | -.364043366635988E-06 |
| 50 | 16 | -.714465218845035E-08 | .424178933122354E-07 | -.286103061024110E-07 |
| 50 | 19 | .505399445790352E-07 | .581237100211063E-06 | -.355834678109688E-06 |
| 50 | 22 | -.714441426399263E-08 | .424179964939570E-07 | -.286101788434157E-07 |

+SOLUTION/MATRIX_ESTIMATE L COVA (cont.)

| *PARA1 | PARA2 | ____PARA2+0_____ | ____PARA2+1_____ | ____PARA2+2_____ |
|---|---|---|---|---|
| 50 | 25 | -.102384711191754E-06 | .673448334609642E-06 | -.309634019214046E-06 |
| 50 | 28 | -.724806112735056E-08 | .427768984256147E-07 | -.286634560454541E-07 |
| 50 | 31 | -.104422318705796E-06 | .682422723859696E-06 | -.316047449043774E-06 |
| 50 | 34 | -.724806062762186E-08 | .427768975674929E-07 | -.286634558757479E-07 |
| 50 | 37 | -.102676005302594E-06 | .682332587705174E-06 | -.314549075638787E-06 |
| 50 | 40 | -.712144764241508E-08 | .428577085169004E-07 | -.286031233800686E-07 |
| 50 | 43 | -.128282463704021E-04 | .603708106431923E-04 | -.467401884021603E-04 |
| 50 | 46 | -.759220402908904E-06 | .358449761315646E-05 | -.277074367844906E-05 |
| 50 | 49 | -.264701586650437E-04 | .136368520310246E-03 | |
| 51 | 1 | .123859882104012E-06 | -.529580689056885E-06 | .602922881229270E-06 |
| 51 | 4 | .808813934562526E-08 | -.322204027165576E-07 | .403756705814664E-07 |
| 51 | 7 | .127708193122772E-06 | -.504530535885089E-06 | .635695061288489E-06 |
| 51 | 10 | .808831848439640E-08 | -.322205690005821E-07 | .403754019440685E-07 |
| 51 | 13 | .126227906943106E-06 | -.547639433967118E-06 | .576114511825563E-06 |
| 51 | 16 | .808825325608641E-08 | -.322202307749089E-07 | .403757807086187E-07 |
| 51 | 19 | .121192355659643E-06 | -.516543278120711E-06 | .619294532028622E-06 |
| 51 | 22 | .808799591354649E-08 | -.322204396729749E-07 | .403756075128615E-07 |
| 51 | 25 | .224142434756829E-06 | -.355183858264014E-06 | .712809621596231E-06 |
| 51 | 28 | .810464703083422E-08 | -.320570977460358E-07 | .408192828504682E-07 |
| 51 | 31 | .224944682038977E-06 | -.358400280458516E-06 | .716633157449451E-06 |
| 51 | 34 | .810464685338636E-08 | -.320570981528975E-07 | .408192817124753E-07 |
| 51 | 37 | .223396674022700E-06 | -.358897304415686E-06 | .715439405735758E-06 |
| 51 | 40 | .798714679784038E-08 | -.321307185353327E-07 | .407644002436100E-07 |
| 51 | 43 | .106936577822633E-04 | -.470671696022785E-04 | .449898161627036E-04 |
| 51 | 46 | .624413629104873E-06 | -.279085376985322E-05 | .264140205773328E-05 |
| 51 | 49 | .194954086820740E-04 | -.920866259003301E-04 | .800181013426298E-04 |
| 52 | 1 | .155100497833771E-07 | -.102170191584331E-07 | .984670129641943E-08 |
| 52 | 4 | .132497950865963E-08 | -.873910059041963E-09 | .825521622805111E-09 |
| 52 | 7 | .190082847004012E-07 | -.923386143336187E-08 | .997095261610136E-08 |
| 52 | 10 | .132498318063067E-08 | -.873912316291526E-09 | .825513367170320E-09 |
| 52 | 13 | .135389980939946E-07 | -.108002204246046E-07 | .100192973809717E-07 |
| 52 | 16 | .132497749347490E-08 | -.873905442848635E-09 | .825526931199058E-09 |
| 52 | 19 | .173673170936268E-07 | -.987445464271354E-08 | .974179700139845E-08 |
| 52 | 22 | .132496758264841E-08 | -.873915563333984E-09 | .825525026654790E-09 |
| 52 | 25 | .139585081101516E-07 | -.101875614900551E-07 | .981761540408019E-08 |
| 52 | 28 | .135402633706196E-08 | -.865361686532972E-09 | .822584462436664E-09 |
| 52 | 31 | .139926586349914E-07 | -.100844349501834E-07 | .974302867531045E-08 |
| 52 | 34 | .135402623614169E-08 | -.865361712860000E-09 | .822584468015087E-09 |
| 52 | 37 | .139478635241942E-07 | -.101212270504134E-07 | .973231182008790E-08 |
| 52 | 40 | .135077023624488E-08 | -.867437918054139E-09 | .820991748199686E-09 |
| 52 | 43 | .967326858145842E-06 | -.183554406367409E-05 | .150132408630973E-05 |
| 52 | 46 | .582594358952038E-07 | -.109028285863569E-06 | .888458540713055E-07 |
| 52 | 49 | .423991444462760E-06 | -.759220287886176E-06 | .624413583890648E-06 |
| 52 | 52 | .582606131218558E-07 | | |
| 53 | 1 | -.849364565079624E-08 | .473806271019432E-07 | -.320608673536354E-07 |
| 53 | 4 | -.607290741356978E-09 | .372688744538371E-08 | -.245368166702130E-08 |
| 53 | 7 | -.941396853050373E-08 | .506318432648028E-07 | -.319969655055851E-07 |
| 53 | 10 | -.607307073195586E-09 | .372689445032468E-08 | -.245366096456152E-08 |
| 53 | 13 | -.819770836428945E-08 | .450025096413662E-07 | -.324198455435163E-07 |
| 53 | 16 | -.607299947103271E-09 | .372686760821871E-08 | -.245370049120860E-08 |
| 53 | 19 | -.863089183489150E-08 | .489833321249568E-07 | -.318912841242302E-07 |
| 53 | 22 | -.607279023436850E-09 | .372687582216127E-08 | -.245368867485002E-08 |

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+SOLUTION/MATRIX_ESTIMATE L COVA (cont.)
*PARA1 PARA2 ____PARA2+0__________ ____PARA2+1__________ ____PARA2+2__________
    53    25 -.817218822171663E-08  .430934537936189E-07 -.300619498314824E-07
    53    28 -.615679530760964E-09  .376318181014603E-08 -.246110525591255E-08
    53    31 -.837976858249724E-08  .440252011477916E-07 -.307337536631747E-07
    53    34 -.615679482708007E-09  .376318171418918E-08 -.246110523806692E-08
    53    37 -.822340688623941E-08  .439972192983851E-07 -.305887414184756E-07
    53    40 -.604945977914180E-09  .377004534004884E-08 -.245599848839366E-08
    53    43 -.183701515847509E-05  .860385374922961E-05 -.672708329712663E-05
    53    46 -.109028287408144E-06  .512545381111962E-06 -.397682870622323E-06
    53    49 -.764337037853310E-06  .358450595475272E-05 -.279085361144988E-05
    53    52 -.109028286492190E-06  .512546561408339E-06
    54     1  .892750850856895E-08 -.349417386608704E-07  .441939405499166E-07
    54     4  .670594865635938E-09 -.278373252762818E-08  .366929779977898E-08
    54     7  .918303148426182E-08 -.328477260590878E-07  .473005031845904E-07
    54    10  .670610712131336E-09 -.278374771655392E-08  .366927512077928E-08
    54    13  .914874634807269E-08 -.367128266930663E-07  .415551370616359E-07
    54    16  .670604449061763E-09 -.278371791232983E-08  .366930869200705E-08
    54    19  .866643937693597E-08 -.336807017337372E-07  .458225006669193E-07
    54    22  .670581645931059E-09 -.278373687983459E-08  .366929449563055E-08
    54    25  .865721975523426E-08 -.325894704947657E-07  .418454941807443E-07
    54    28  .671665862735724E-09 -.276886773405542E-08  .371334613489085E-08
    54    31  .874118275421476E-08 -.329362259826790E-07  .422439136585836E-07
    54    34  .671665840639673E-09 -.276886777649144E-08  .371334601033261E-08
    54    37  .860810171091655E-08 -.329691747134795E-07  .421326469803610E-07
    54    40  .661610225144540E-09 -.277516600190497E-08  .370866381226173E-08
    54    43  .150193970258909E-05 -.672343201129585E-05  .632787381898590E-05
    54    46  .888458541172131E-07 -.397682865066272E-06  .373777756185183E-06
    54    49  .624014740936901E-06 -.277074351673431E-05  .264141049673769E-05
    54    52  .888458532815966E-07 -.397682867483731E-06  .373778930468292E-06
-SOLUTION/MATRIX_ESTIMATE L COVA
%ENDSNX
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