SERVICE
DE GEODESIE
ET NIVELLEMENT

CENTRE NATIONAL D'ÉTUDES SPATIALES

J-C. Poyard

Rattachement ITRF à Rikitea

Lien terrestre DORIS - GNSS (REGINA)

DORIS - GNSS (REGINA) terrestrial local tie

Rikitea ITRF co-location survey

July 2011

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ITRF; DORIS; REGINA; GNSS; Rikitea; Gambier; Polynésie Française

Résumé

L'ITRF2008, dernière réalisation de l'International Terrestrial Reference System, menée par le Laboratoire de Recherche en Géodésie (LAREG) de l'IGN, est le résultat de la combinaison des référentiels terrestres issus des quatre techniques de géodésie spatiale (c'est à dire GNSS, SLR, DORIS et VLBI). Un moyen d'améliorer les réalisations consiste à ajouter dans la combinaison les résultats de rattachement sur des sites co-localisés. Avec l'avènement du réseau REGINA, la co-localisation GNSS/DORIS est maintenue à Rikitea (Polynésie Française). Le présent rapport décrit le rattachement de précision réalisé lors de la mission d'installation de la station GNSS du réseau REGINA.

Matériel

Système d'exploitation	**Logiciel**
Mac OS X	Word 2008 pour Mac version 12.2.3

Validation

	Fonction	**Nom**	**Visa**
Commanditaire	Chef de l'unité RSI	Bruno Garayt	23/01/2012 – signé
Rédacteur principal	Responsable de production	Jean-Claude Poyard	27/10/2011 – signé
Correcteur	Responsable opérations REGINA	Charles Velut	15/11/2011 – signé
Approbateur	Chef de service	Alain Harmel	02/04/2012 – signé
Vérificateur	Responsable qualité	Thierry Person	03/04/2012 – signé

Diffusion

Organisme, service	**Nom**	**Numérique**	**Papier**
IGN / DG	Alain Perret	oui	-
IGN / MODSP	François Becirspahic	oui	-
IGN / SG / SDOG / CDOC	Richard Grimm	oui	-
IGN / DT / SR / LAREG	Olivier Jamet	oui	-
IGN / ENSG / DPTS	Serge Botton	oui	-
IGN / DPR / SGN	Alain Harmel	oui	-
IGN / DPR / SGN	Responsable qualité / Thierry Person	oui	-
IGN / DPR / SGN / PMC	Responsable documentation / Xavier della Chiesa	non	3
IGN / DPR / SGN / PMT	Responsable produits / François L'Ecu	oui	-
IGN / DPR / SGN	Chefs de départements	oui	-
IGN / DPR / SGN	Bruno Garayt	non	1
IGN / DPR / SGN	Jérôme Saunier	oui	-
IGN / DPR / SGN	Charles Velut	oui	-
IGN / DPR / SGN	Jean-Claude Poyard	non	1
IGN / DT / SR / LAREG	Zuheir Altamimi	non	1
IGN / DT / SR / LAREG	Xavier Collilieux	oui	-
CNES	REGINA operation	oui	-
CNES / DCT / ME / OT	François Boldo	oui	1
CNES / DCT / ME / OT	Cédric Tourain	oui	1
CNES / DCT / ME / OT	Thierry Guinle	oui	-

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INTRODUCTION

The International Terrestrial Reference Frame (ITRF) is the result of a combination of different terrestrial reference frames provided by the four space geodetic techniques (i.e. GNSS, SLR, DORIS and VLBI). To perform this combination between independent reference frames, it is necessary to have some co-location sites where the various techniques are operating, from which local tie vectors between their reference points have been surveyed in three dimensions.

In April 2000, the Geographical Survey Institute of Japan (GSI) installed a permanent GNSS station, in the premises of Meteo France at Rikitea. The purpose of this Trimble equipment was to collect data to study the tectonic around Japan. By lack of Internet connection GNSS data were monthly sent to GSI.
Mid-July 2010, Dr. Machida Morito informed the SIRS about their duty to leave Rikitea. With the advent of REGINA network, in the early July 2011 they gave IGN their agreement to use their pillar for the GNSS station allowing by this way the data time series continuity.
REGINA project (Reseau GNSS pour l'IGS et la Navigation), based on a cooperation between CNES and IGN, aims to increase the size of CNES GNSS stations network with the purpose to provide a provision of consolidated and real time data.
With the installation of this new REGINA station, in place of the GSI one, we took the opportunity to survey the reference points of both DORIS and REGINA. So these two different space geodetic techniques are tied by terrestrial observations providing a 3D vector.

This document presents the Rikitea local tie survey, which took place in August 2011, from the observations on site to the computation with as many details as necessary to fully analyze the resulting SINEX file.

ACKNOWLEDGEMENTS

We would like to acknowledge Meteo France agency based in Faa'a for his involvement for many years in DORIS project and now in REGINA one. I would also add a special thank to Olivier, Pierre and Sylvain, all members of MF team at Rikitea, for their warmly welcome, for the equipment management and for their precious help during the survey work or the REGINA and DORIS stations installation and renovation.

1 CO-LOCATION SITE

1.1 Site description

Rikitea site is located by 23°S & 135°W, more than 1600 km to the east-south-east of Tahiti, at the far eastern part of the Tuamotu Archipelago. This fourteen islands group with his own language and culture is for this reason often considered as a separate islands group called Gambier Archipelago.
The primary village is Rikitea located on the largest island of Mangareva. With the appearance of pearl culture the Gambier population rises quickly during the last decades to reach more than 1200 inhabitants.
The Gambier Archipelago, especially the primary island, Mangareva, is of volcanic origin. The highest points, Mt Duff and Mt Mokoto, are rising to more than 400 m. They're along the island's south coast and for our trouble just near the premises of the weather station where both DORIS and REGINA stations are setup.

At the "Vivier du roi" there's a tide gauge (GLOSS n°138) run by the University of Hawaii Sea Level Center. The marker has been tied with DORIS by IGN in 2007 and 2009 using GNSS observations *(see reports CR/G 230 SGN n° 28185 "Installation de la station DORIS de Rikitea H. Fagard/JC. Poyard – janvier 2008* and *CR/G 245 SGN n° 28243 "Rénovation de la station DORIS de Rikitea JC. Poyard – juin 2009).*

On a geodetic point of view, Rikitea site possesses reference points from two space geodetic techniques; indeed there are :

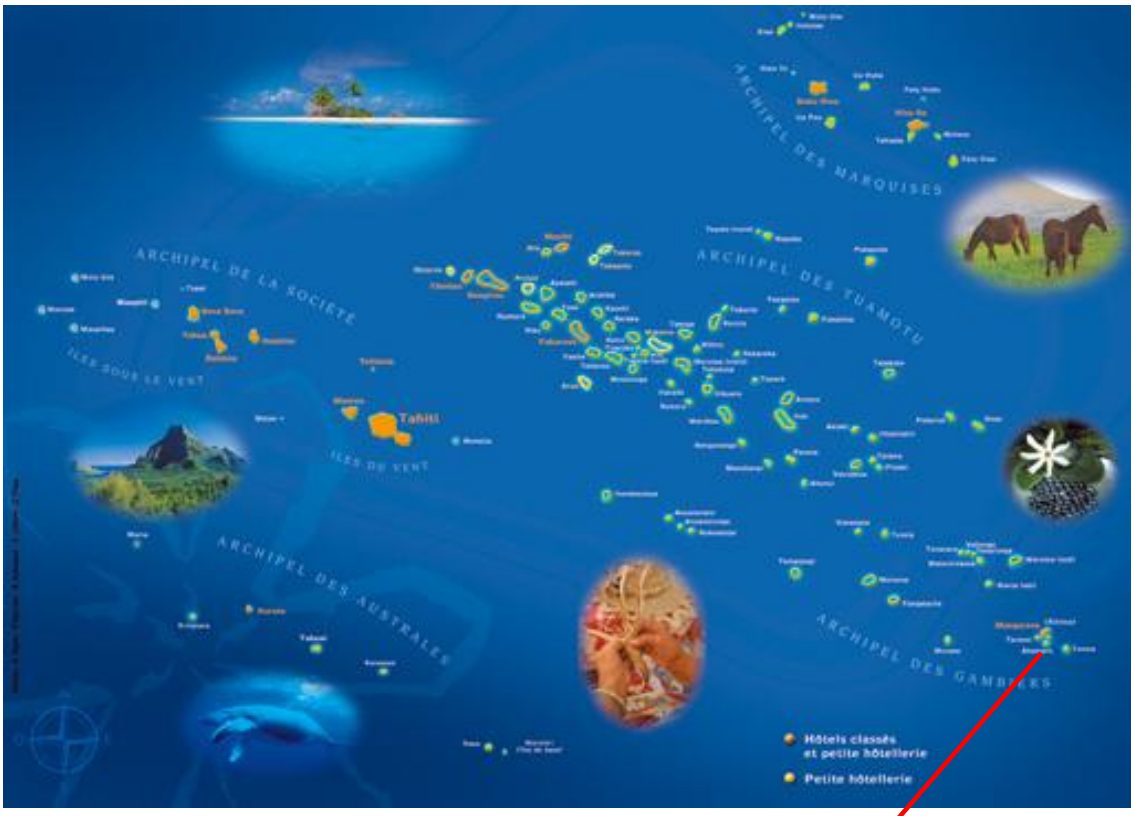
- a GNSS REGINA station
- a DORIS station

DORIS antenna

REGINA antenna

1.2 Site situation

General map of French Polynesia



Site location on Mangareva Island – Gambier Archipelago

2 CO-LOCATED POINTS

2.1 DORIS station

2.1.1 DORIS reference points

After an experiment in 1995, the first real DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) station "RIKB" was set up on September 23rd 2006. The DORIS antenna is on top of a very rigid 30 cm sided and 2 m height metal tower. Following a car bump on the tower, the antenna "RILB" was renovated on March 13th 2009. More recently, just before this survey work the station was upgraded and the DORIS antenna changed. The current reference point is "RIMB".

The different DORIS points have been associated with distinct acronym and DOMES number as summarized below :

Acronym	DOMES number	Antenna / Support	Period
RIKB	92301S002	Starec / very rigid 2 m height tower	from Sep. 2006 to Mar. 2009 (with car bump in Jun. 2008)
RILB	92301S003	Starec / very rigid 2 m height tower	from Mar. 2009 to Jul. 2011
RIMB	92301S004	Starec / very rigid 2 m height tower	from Aug. 2011 till now

NB: the antennas reference points were accurately surveyed (precise DORIS internal local ties between the different positions) with respect to the DORIS marker embedded in a concrete block (DOMES number : 92301M001). An extract of the site log is given in appendix 6.2.

Acronym : RIMB	DOMES number : 92301S004
	
General view	Close-up view (reference point)
Description : DORIS antenna reference point (Chelton F6175 type).	

2.1.2 DORIS marker

Point name : DORIS mark	DOMES number : 92301M001
	
General view	Close-up view (reference point)
Description : DORIS domed mark in concrete block.	

2.2 GNSS REGINA station (GAMB)

This GNSS station, part of the REGINA network, has been installed in Aug. 2011 on top of the GSI stainless pillar. Indeed with the departure of GSI from Riktea their pillar was free. In July 2011 they confirmed IGN the authorization for using their pillar. Our first idea was to call the REGINA station RIKG but on a request of our colleagues from GSI who treated the RINEX files from April 2000 to 2010 with the name GAMB we finally agreed to keep the name GAMB for the station (appendix 6.3).
Their agreement to use their pillar for the GNSS station allows a nice data time series continuity.

Acronym : GAMB	DOMES number : 92301M003
	
General view	Reference point
Description : Antenna height is **<u>0.000 m</u>**.	

Tie with the DORIS antenna has been surveyed in 2007 and 2009 using GNSS observations *(see reports CR/G 230 SGN n° 28185 "Installation de la station DORIS de Rikitea* and *CR/G 245 SGN n° 28243 "Rénovation de la station DORIS de Rikitea).*

2.3 Other points of interest

2.3.1 SHOM marker

In the south-east part of the meteo station premises there are three concrete blocks with a SHOM marker on each. They were set up during the Pacific Oceanographic Mission (MOP). This geodetic campaign aimed at establishing and realizing a geodetic reference frame for French Polynesia based on GPS and DORIS observations. We choose for our survey the marker in the block carved MOP 2000.

Point name : SHOM	no DOMES number
	
General view	Close-up view (reference point)
Description : mark carved SHOM embedded in a concrete block	

2.3.2 Other survey point

Most of the points are temporary markers but one of these points could be re-use later if needed. It's a bolt in a concrete block.

Point name : RM-1	no DOMES number
	
General view	Close-up view (reference point)
Description : bolt in a concrete block	

3 SURVEY DESCRIPTION

3.1 Organization

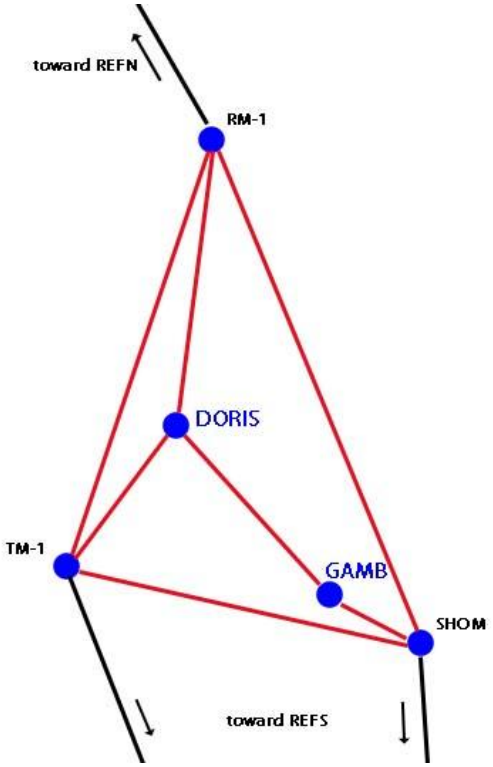
All the topometric survey instruments and equipments belong to IGN and were sent for the purpose of the survey that was carried out by JC. Poyard from July 30th to 31st, 2011.

3.2 Equipment (Instruments)

A Leica tacheometer (TC2002) was used for this work. This instrument, which is regularly calibrated by IGN equipment control unit, was associated with two Leica accurate prisms. It has a standard deviation of 0.15 mgon for horizontal and vertical angles and 1 mm + 1 ppm for distances. The GPS observations were performed with two Leica 1200 receivers and a Leica AX 1202 GG antenna or an Ashtech 701945-01 (Revision E) antenna.
All these instruments allowed the observations to be recorded electronically on memory cards or storage devices and were then downloaded to a laptop PC for checkings.

3.3 Rikitea observations polygon

All the survey was conducted in order to provide the highest accuracy in the determination of the 3D vectors between the observing reference points. Hereafter is the Rikitea observations polygon.



3.4 Survey method

All the visible lines of sight were observed with the tacheometer. Horizontal directions and zenith angles were observed in data sets, each set consisting in one reading in both direct and reverse theodolite positions. Distance measurements were observed at least once over each line. Meteorological data (atmospheric pressure and temperature) used to correct the distances, were recorded at the beginning of each station occupation.
Two stations were determined by GPS technique and used to get the polygon's bearing.

3.4.1 Verticality check and centring equation

Using a theodolite the verticality of the DORIS « theoretical » antenna reference point was measured with respect to the corresponding marker. The results of this eccentricity combined with the height above the marker forms the centring equations.
For the prism on GAMB, the height above the marker was 0,236 m and for DORIS the prism was 0,253 m above the DORIS plate.

3.4.2 GPS observations

GPS observations have been carried out on the two reference points "REFN" and "REFS with a Leica 1200 receiver associated with a Leica AX1202 GG antenna and for GAMB the receiver a Leica 1200 associated with an Ashtech 701945-01 Rev.E antenna.

The following table sums up the GPS observations.

Point	Start (UT)	End (UT)	Ant. Height (m)	Ant. Type
GAMB	DOY 218 09 : 46	DOY 219 08 : 47	0,000	ASH701945E_M
REFN	DOY 218 08 : 29	DOY 218 16 : 04	1,397	LEIAX1202GG
REFS	DOY 218 16 : 21	DOY 219 08 : 30	-0,050	LEIAX1202GG

All antenna heights are related to the antenna reference point. None of the antennas was equipped with a radome. On the two references, the antenna heights are measured but in fact we're mainly interested by the planimetric position!

4 COMPUTATIONS

4.1 On-site validation

The theodolite observations were checked on site in order to point out any problem.

4.2 GPS network

Back to the office, the short GPS baselines were processed with LEICA Geo Office v8.1 Software using the "absolute" GNSS antenna calibrations : igs08.atx.
The result allows us to determine the bearings from GAMB toward the two references REFS and REFN.

4.3 Global Adjustment

The final computation has been carried out by a 3D Least Squares Adjustment with the Microsearch GeoLab 2001 version 2001.9.20.0 software. The input file (see appendix 6.4) deals with :

- Theodolite observations : horizontal and zenith angles, distances
- Centring equations : relative position between points.
- Azimuths toward references issued from the GPS baselines process.
- RILB coordinates constrained at 1 mm to their ITRF2008 (epoch 2011:218) values.

The a priori standard deviations used for the different observations with tacheometers are :

- 0.8 mgon for horizontal angles
- 1.3 mgon for vertical angles
- 1mm for distances on prism

(These are the values used for most of the targets in our Microsearch GeoLab computation input file).
This adjustment output file (see appendix 6.5) provided coordinates and a covariance matrix of our survey work.

5 RESULTS

5.1 Station name translation table

The following list sums up the most interesting points used in the Microsearch GeoLab input file. In bold, the main points, description, used name or code and computation name (appendix 6.4).

Point Description	DOMES number	Computation name
DORIS station • **RIMB Antenna Reference Point** • **RILB Antenna Reference Point** • DORIS domed mark in concrete block	 **92301S004** **92301S003** 92301M001	 **RIMB** **RILB** DORm
GNSS REGINA station • **GAMB / axis and base of antenna**	 **92301M003**	 **GAMB**

5.2 Adjusted coordinates and confidence regions

The results of the adjustment are the coordinates of all points as well as their confidence ellipsoids in the ITRF2008 at the mean epoch of the observations (i.e. epoch 2011:218).
The table below provides the 3D coordinates and confidence region at 95% of the points of interest.

```
================================================================================
         RIKITEA METEO STATION (FRENCH POLYNESIA) - AUGUST 2011 SURVEY
Microsearch GeoLab, V2001.9.20.0             GRS80       UNITS: m,GRAD Page 0004
================================================================================
Adjusted XYZ Coordinates:
                            X-COORDINATE       Y-COORDINATE       Z-COORDINATE
 CODE FFF STATION                 STD DEV            STD DEV            STD DEV
 ---- --- ------------ ------------------ ------------------ ------------------
 XYZ      DORm              -4147136.2891      -4152217.5254      -2490022.8669 m       0
                                   0.0018             0.0018             0.0018
 XYZ      GAMB              -4147126.7862      -4152222.1601      -2490033.1198 m       0
                                   0.0020             0.0020             0.0019
 XYZ      RILB              -4147137.8620      -4152219.1040      -2490023.8360 m       0
                                   0.0012             0.0012             0.0012
 XYZ      RIMB              -4147137.8620      -4152219.1040      -2490023.8360 m       0
                                   0.0016             0.0016             0.0016
 XYZ      RM-1              -4147139.7890      -4152224.5591      -2490006.0527 m       0
                                   0.0018             0.0018             0.0018
 XYZ      SHOM              -4147120.6328      -4152224.0751      -2490035.2402 m       0
                                   0.0018             0.0018             0.0018

================================================================================
         RIKITEA METEO STATION (FRENCH POLYNESIA) - AUGUST 2011 SURVEY
Microsearch GeoLab, V2001.9.20.0             GRS80       UNITS: m,GRAD Page 0011
================================================================================
2-D and 1-D Station Confidence Regions (95.000 and 95.000 percent):
STATION           MAJOR SEMI-AXIS  AZ     MINOR SEMI-AXIS            VERTICAL
----------- -------------------- --- ------------------ --------------------
DORm                       0.0044 139             0.0044               0.0035
GAMB                       0.0046 122             0.0045               0.0042
RILB                       0.0028  90             0.0028               0.0023
RIMB                       0.0040  90             0.0040               0.0032
RM-1                       0.0046  83             0.0045               0.0035
SHOM                       0.0045 144             0.0044               0.0035
```

From the above coordinates, it's possible to calculate the following vectors :

Vector	dX (m)	dY (m)	dZ (m)
GAMB→ RIMB	-11.076	3.056	9.284
RIMB→DORIS_marker	1.573	1.579	0.969

The whole covariance matrix was computed and then it was possible to extract from it the covariance submatrix for the main points of interest. Finally, this covariance submatrix has been converted into the SINEX format using the « geotosnx » tool provided by Z. Altamimi. The resulting SINEX file (92301_IGN_2011-218.SNX) is presented in appendix 6.6.

6 APPENDIXES

6.1 Appendix 1 : site pictures

General view of the site with a GNSS station above RefN point in the foreground.

General view with from left to right points SHOM, GAMB and DORIS.

6.2 Appendix 2 : "RILB" DORIS station site log (extract)

Note : only the points most relevant to this survey were retained in the following extract.
The complete version of this site log is available at : http://ids-doris.org/network/sitelogs.html

```
RIKITEA DORIS site description form
0. Form

     Prepared by    : SIMB (DORIS installation and maintenance department)
     Date prepared : 04/02/2011
     Report type    : UPDATE

1. Site location information

     Site name              : RIKITEA
     Site DOMES number      : 92301
     Host agency            : Meteo-France
     City                   : Rikitea
     State or province      : Mangareva, Gambier Islands
     Country                : FRANCE (Polynesia)
     Tectonic plate         : PCFC
     Geological information :

     Geographical coordinates (ITRF) :
         North Latitude       :   -23 deg  7' 49''
         East Longitude       :  -134 deg 57' 54''
         Ellipsoid height     :    82 m
         Approximate altitude :    92 m

2. DORIS antenna and reference point information
2.1
     Four character ID        : RIKB
(…)
     IERS DOMES number        : 92301S002
(…)
     Date installed (dd/mm/yy): 23/09/2006
     Date removed (dd/mm/yy)  : 04/06/2008
(…)
     Height above ground mark : 2.428 m

2.2
     Four character ID        : RIKB
(…)
     IERS DOMES number        : 92301S002
(…)
     Date installed (dd/mm/yy): 04/06/2008
     Date removed (dd/mm/yy)  : 11/03/2009
(…)
     Height above ground mark : 2.428 m
(…)
     Notes                    : 2 GHz offset 54 mm south, 51 mm east, 2 mm up
                                following a car bump on the tower

2.3
     Four character ID        : RILB
     Antenna model            : Starec 52291 type
     Antenna serial number    : 139
     IERS DOMES number        : 92301S003
     CNES/IGN number          : 923012
     DORIS SSALTO number      : 287
     Date installed (dd/mm/yy): 13/03/2009
     Date removed (dd/mm/yy)  :
     Antenna support type     : 30 cm sided very rigid metal tower, 2 m high
     Installed on             : 60 cm sided concrete block extending 2 m deep
     Height above ground mark : 2.431 m
     Ground mark type         : Domed brass mark 12 mm diameter
     Ground mark DOMES number : 92301M001
     Notes                    : New antenna, 15 mm south, 2 mm west of the
                                initial RIKB position
```

```
3. DORIS beacons information
(…)

4. ITRF coordinates and velocities of the current DORIS ref. point (RILB)
    Solution         : ITRF2005
    Epoch            : 2000.0

    X = -4147137.218 m    Y = -4152219.575 m    Z = -2490024.180 m
    Sig X = 0.003 m    Sig Y = 0.003 m    Sig Z = 0.003 m

    VX = -0.05649 m/y    VY = 0.03853 m/y    VZ = 0.02982 m/y
    Sig VX = 0.001 m/y    Sig VY = 0.001 m/y    Sig VZ = 0.001 m/y

5. IERS colocation information

6. Tide Gauge colocation information

(…) site log fausse !

7. Local site ties
7.1
(…)
7.2
(…)
7.3
    Point description      : Domed  mark under DORIS antenna
    DOMES number           : 92301M001
    Differential components from the current DORIS ref. point (RILB)
    to the above point (in the ITRS) :
    dX (m)                 : 1.574
    dY (m)                 : 1.579
    dZ (m)                 : 0.968
    Accuracy (m)           : 0.002
    Date measured          : 14/03/2009
    Additional information : Survey by IGN-F 2009
7.4
(…)
7.5
    Point description      : Permanent GNSS station managed by GSI (Japan)
    DOMES number           : 92301S000
    Differential components from the current DORIS ref. point (RILB)
    to the above point (in the ITRS) :
    dX (m)                 : 11.075
    dY (m)                 : -3.059
    dZ (m)                 : -9.281
    Accuracy (m)           : 0.002
    Date measured          : 14/03/2009
    Additional information : Survey by IGN-F 2007 & 2009


8. Meteorological Instrumentation
 (…)

9. DORIS network contacts
 (…)
```

6.3 Appendix 3 : "GAMB" GNSS site log (extract)

```
GAMB Site Information Form
0.   Form
(…)

1.   Site Identification of the GNSS Monument
     Site Name                 : Rikitea
     Four Character ID         : GAMB
     Monument Inscription      :
     IERS DOMES Number         : 29301M003
     CDP Number                :
     Monument Description      : Stainless mast
       Height of the Monument  : 1.727
       Monument Foundation     : CONCRETE BLOCK
       Foundation Depth        : 1.4
     Marker Description        : none
     Date Installed            : 2000-03-27
(…)
     Additional Information   : The first GNSS station was installed by the Geographical Survey
Institute of Japan (GSI) on Apr. 2000. Recorded data were sent monthly. Mid-2010 GSI had to leave
Rikitea. On August 2011, CNES and IGS set up an antenna in place of the former one.

2.   Site Location Information
     City or Town              : Rikitea
     State or Province         : Gambier Archipelago
     Country                   : French Polynesia
     Tectonic Plate            : Pacific Plate
     Approximate Position (ITRF)
       X coordinate (m)        : -4147126.11
       Y coordinate (m)        : -4152222.61
       Z coordinate (m)        : -2490033.48
       Latitude (N is +)       : -230749.290
       Longitude (E is +)      : -1345753.336
       Elevation (m,ellips.)   : 80.65
     Additional Information    : ITRF2005 ep 2000.0 coordinates
                               : Located in the meteo station premises

3.   GNSS Receiver Information

3.1  Receiver Type             : TRIMBLE 4000SSI
(…)

3.2  Receiver Type             : TRIMBLE NETR9
     Satellite System          : GPS+GLONASS
     Serial Number             : 5025K68523
     Firmware Version          : 4.22
     Elevation Cutoff Setting  :
     Date Installed            : 2011-08-04T00:00Z
     Date Removed              : (CCYY-MM-DDThh:mmZ)
     Temperature Stabiliz.     :
     Additional Information    :

3.x  Receiver Type             : (A20, from rcvr_ant.tab; see instructions)
(…)

4.   GNSS Antenna Information

4.1  Antenna Type              : TRM33429.20+GP     DOME
(…)

4.2  Antenna Type              : TRM59800.00        NONE
     Serial Number             : 5037353973
     Antenna Reference Point   : BPA
     Marker->ARP Up Ecc. (m)   : 0.000
     Marker->ARP North Ecc(m)  : 0.000
     Marker->ARP East Ecc(m)   : 0.000
     Alignment from True N     : 0
     Antenna Radome Type       : NONE
     Radome Serial Number      :
     Antenna Cable Type        : Leica
     Antenna Cable Length      : 30m
     Date Installed            : 2011-08-04T00:00Z
     Date Removed              : (CCYY-MM-DDThh:mmZ)
     Additional Information    :

4.x  Antenna Type              : (A20, from rcvr_ant.tab; see instructions)
(…)

5.   Surveyed Local Ties
5.1  Tied Marker Name          : Tide gauge GLOSS n°138 Mark carved SHOM n°1 1969
(…)

5.2  Tied Marker Name          : SHOM (carved SHOM in a block inscribed MOP 2000)
```

```
(…)

5.3  Tied Marker Name          : DORIS MARKER
     Tied Marker Usage         : (SLR/VLBI/LOCAL CONTROL/FOOTPRINT/etc)
     Tied Marker CDP Number    : (A4)
     Tied Marker DOMES Number  : 92301M001
     Differential Components from GNSS Marker to the tied monument (ITRS)
       dx (m)                  : -9.503
       dy (m)                  : 4.635
       dz (m)                  : 10.253
     Accuracy (mm)             : 4
     Survey method             : TRILATERATION
     Date Measured             : 2011-07-31T00:00Z
     Additional Information    : Surveyed by IGN (France)

5.4  Tied Marker Name          : RILB
(…)

5.5  Tied Marker Name          : RIMB
     Tied Marker Usage         : (SLR/VLBI/LOCAL CONTROL/FOOTPRINT/etc)
     Tied Marker CDP Number    : (A4)
     Tied Marker DOMES Number  : 92301S004
     Differential Components from GNSS Marker to the tied monument (ITRS)
       dx (m)                  : -11.084
       dy (m)                  : 3.048
       dz (m)                  : 9.279
     Accuracy (mm)             : 4
     Survey method             : TRILATERATION
     Date Measured             : 2011-07-31T00:00Z
     Additional Information    : Surveyed by IGN (France)

5.x  Tied Marker Name          :
(…)
6.   Frequency Standard
(…)
7.   Collocation Information
7.1  Instrumentation Type      : DORIS
       Status                  : PERMANENT
       Effective Dates         : 2006-09-23
(…)
8.   Meteorological Instrumentation
(…)
9.  Local Ongoing Conditions Possibly Affecting Computed Position
(…)
10.  Local Episodic Effects Possibly Affecting Data Quality
(…)
11.   On-Site, Point of Contact Agency Information
     Agency                    : METEO STATION, RIKITEA
(…)

12.  Responsible Agency (if different from 11.)
     Agency                    : Centre National d"Etudes Spatiales
     Preferred Abbreviation    : CNES
     Mailing Address         : CNES DCT/OP/EM - 18, avenue Ed. Belin 31401 Toulouse Cedex09 France
     Primary Contact
       Contact Name            : Jean-Paul Cardaliaguet
       Telephone (primary)     : +33 5 61 27 31 98
       Fax                     : +33 5 61 28 15 36
       E-mail                  : jean-paul.cardaliaguet@cnes.fr
     Secondary Contact
       Contact Name            : Bruno Garayt
       Telephone (primary)     : +33 1 43 98 81 97
       E-mail                  : bruno.garayt@ign.fr

13.  More Information
(…)
```

6.4 Appendix 4 : adjustment input file

```
*RIKITEA METEO STATION GROUND CONTROL SURVEY PERFORMED IN AUGUST 2011

 TITL RIKITEA METEO STATION (FRENCH POLYNESIA) - AUGUST 2011 SURVEY
 COMP ADJ
 ELIP GRS80             6378137.0000  6356752.3141
 MAXI         30
 CONF YES YES YES YES NO
 PSOL NO  YES
 PMIS NO  NO
 PRES YES NO
 PADJ NO  NO  YES NO  YES NO
 VARF YES YES NO
 RTST TAU MAX
 LUNT m    1.000000000000
 CONV    0.00010
 CLEV     95.000
 ANGT GRD
 LDEC 4


*****************************************************************************************************
*   LIST OF POINTS for the SURVEY ADJUSTMENT, ITRF ACRONYMS, n° DOMES  and  POINTS DESCRIPTION     *
*****************************************************************************************************

* PERMANENT GPS
* GAMB: REGINA GNSS station mark (DOMES 92301M003)
* (= Top of stainless mast = antenna's axis and base at ARP)

* DORIS
**RIKB: former DORIS Starec antenna reference point (Sep. 2006 to Jun. 2008 = SOLN1) (DOMES
92301S002)
**RIKB_SOLN2 : former DORIS Starec antenna reference point (Jun. 2008 to Mar. 2009) (DOMES
92301S002)
* RILB : former DORIS Starec antenna reference point (Mar. 2009 to Jul. 2011) (DOMES 92301S003)
* RIMB : current DORIS Chelton antenna reference point (as of 2007-10-02) (DOMES 92301S004)
* DORm : IGN hexagonal domed mark below the DORIS antennas (DOMES 92301M001)

* PERMANENT MARKS
* SHOM: mark carved SHOM embedded in a concrete block inscribed "MOP 2000"

* TEMPORARY MARKS
* TM_1: temporary mark 1 = wood stick in the ground
* RM_1: It's not a marker but a "nail" that could be re-use later.
* RefN: temporary mark = wood stick in the ground
* RefS: temporary mark = wood stick in the ground
* GAMB_Prism  : Prism 0,236 m above GAMB
* DORIS_Prism : Prism 0,138 m below RIMB (or 0,253 m above DORIS plate)
* DORIS_th = DORIS_Prism 0,138 m below RIMB (or 0,253 m above DORIS plate)


**********************AZIMUT DEDUCTED FROM THE GPS DETERMINATION*****************************
 AZIM     GAMB_prism   RefN                      371 95    85.0      0.003
 AZIM     GAMB_prism   RefS                      191  6    35.0      0.004


************************FORCED ITRF2008 EPOCH 2011:218 COORDINATES**************************
 3DC
 XYZ  000 RILB               -4147137.862       -4152219.104       -2490023.836 m
 COV  CT DIAG                       1
 ELEM               0.000001               0.000001               0.000001


*****************************APPROXIMATE COORDINATES*****************************************
 PLH  000 DORm         S 23  7  48.92701 W134 57  53.71545      79.7925 m       0
 PLH  000 DORIS_prism  S 23  7  48.92751 W134 57  53.71538      82.0846 m       0
 PLH  000 DORIS_th     S 23  7  48.92755 W134 57  53.71535      82.0844 m       0
 PLH  000 GAMB         S 23  7  49.27738 W134 57  53.36402      80.6601 m       0
 PLH  000 GAMB_prism   S 23  7  49.27738 W134 57  53.36402      80.8961 m       0
*PLH  000 RIKB         S 23  7  48.92703 W134 57  53.71546      82.2205 m       0
*PLH  000 RIKB_SOLN2   S 23  7  48.92883 W134 57  53.71366      82.2225 m       0
*PLH  000 RILB         S 23  7  48.92753 W134 57  53.71536      82.2225 m       0
 PLH  000 RIMB         S 23  7  48.92753 W134 57  53.71536      82.2225 m       0
 PLH  000 RM-1         S 23  7  48.32924 W134 57  53.62779      80.1435 m       0
*PLH  000 Ref1         s 23  8 14.000000 w134 55  6.000000      20.0000 m  0
 PLH  000 RefN         S 23  7  46.27512 W134 57  54.89414      82.3240 m       0
 PLH  000 RefS         S 23  7  51.61587 W134 57  53.00673      72.4316 m       0
 PLH  000 SHOM         S 23  7  49.37899 W134 57  53.16343      78.6822 m       0
 PLH  000 TM-1         S 23  7  49.21038 W134 57  53.96180      81.3427 m       0
```

```
************************************CENTRING EQUATIONS*************************************
* DORIS antennas excentricities and height with respect to DORm    (MARKER)
 3DD
 PLH  000 RIMB         s 23  7 48.927000 w134 57 53.715800     82.43000
 PLH  000 RILB         s 23  7 48.927000 w134 57 53.715800     82.43000
 PLH  000 DORIS_th     s 23  7 48.927000 w134 57 53.715800     82.29200
 PLH  000 DORIS_prism  s 23  7 48.927000 w134 57 53.715800     82.29200
 PLH  000 DORm         s 23  7 48.926500 w134 57 53.715900     80.00000
 COV  LG DIAG
 ELEM               0.000001               0.000001               0.000001
 ELEM               0.000001               0.000001               0.000001
 ELEM               0.000001               0.000001               0.000001
 ELEM               0.000001               0.000001               0.000001

* GAMB_prism is centred and 0.236 m above GAMB
 3DD
 PLH  000 GAMB_prism   S 23  7  49.27700 W134 57  53.36400     81.236
 PLH  000 GAMB         S 23  7  49.27700 W134 57  53.36400     81.000
 COV  LG DIAG    0.00000    1.00000    0.00000    1.00000    0.00000
 ELEM              0.00000009             0.00000009               0.000001



*Tours d'horizon
 SIGM AH         8.0
*HIST NEW
 DSET AH
*DIR      SHOM         Ref1                      0  0     0.0
 DIR      SHOM         RefS                     85 98    35.1
 DIR      SHOM         GAMB_prism              222  0    18.9
 DIR      SHOM         DORm                    236 23    37.3
 DIR      SHOM         DORIS_prism             236 20    32.0
 DSET AH
*DIR      SHOM         Ref1                      0  0     0.0
 DIR      SHOM         TM-1                    204 39    22.1
 DIR      SHOM         RM-1                    265 37    79.9
 DSET AH
*DIR      TM-1         Ref1                      0  0     0.0
 DIR      TM-1         RefS                     67 67     4.1
 DIR      TM-1         DORIS_prism             333 24    88.4
 DIR      TM-1         DORm                    333 18    43.0
 DIR      TM-1         GAMB_prism              397 75    16.5
 DSET AH
*DIR      TM-1         Ref1                      0  0     0.0
 DIR      TM-1         SHOM                      4 37    23.5
 DIR      TM-1         RM-1                    311 54    51.7
 DSET AH
*DIR      RM-1         Ref2                      0  0     0.0
 DIR      RM-1         GAMB_prism               69 85    96.6          8
 DIR      RM-1         DORIS_prism              94 46    30.7
*DSET AH
*DIR      RM-1         Ref2                      0  0     0.0
 DIR      RM-1         SHOM                     61 17    21.6
 DIR      RM-1         TM-1                    107 36    12.5
 DIR      RM-1         RefN                    252 90    50.3
 DSET AH
 DIR      DORIS_th     RefS                      0  0     0.0
 DIR      DORIS_th     GAMB_prism              367 57    11.1
 DIR      DORIS_th     RefN                    190 39    62.2

*HIST GEN Tours d'horizon

*Instrument or Target/prism heights
 HI       SHOM              1.435 m
 HI       RM-1              1.544
 HT       SHOM              1.435
 HT       RM-1              1.544



 Zenithales
 SIGM ZA        13.0
*HIST NEW

*ZANG ZA  SHOM         Ref1                     101  3    29.9
 ZANG ZA  SHOM         RefS                     107 11    95.6
 ZANG ZA  SHOM         GAMB_prism                92 97    57.1
 ZANG ZA  SHOM         DORm                     101 16    15.0
 ZANG ZA  SHOM         DORIS_prism               94 21    89.8
*ZANG ZA  SHOM         Ref1                     101  3    30.7
 ZANG ZA  SHOM         TM-1                      96 80    90.1
 ZANG ZA  SHOM         RM-1                      97 43     9.2
*ZANG ZA  TM-1         Ref1                     101  4    50.8
 ZANG ZA  TM-1         RefS                     107 16    68.9
 ZANG ZA  TM-1         DORIS_prism               95 77    98.2
 ZANG ZA  TM-1         DORm                     108 76    75.4
```

```
 ZANG ZA  TM-1         GAMB_prism              101 65    96.2
*ZANG ZA  TM-1         Ref1                    101  4    52.3
 ZANG ZA  TM-1         SHOM                    103 18    50.7
 ZANG ZA  TM-1         RM-1                     99 46    68.3
*ZANG ZA  RM-1         Ref2                    101  7     6.2
 ZANG ZA  RM-1         GAMB_prism              101 45    10.5
 ZANG ZA  RM-1         DORIS_prism              98 27    95.0
*ZANG ZA  RM-1         Ref2                    101  7     8.7
 ZANG ZA  RM-1         SHOM                    102 56    40.3
 ZANG ZA  RM-1         TM-1                    100 52    91.0
 ZANG ZA  RM-1         RefN                     99 35    16.8
 ZANG ZA  DORIS_th     RefS                    107 18    80.8
 ZANG ZA  DORIS_th     GAMB_prism              105 13    92.3
 ZANG ZA  DORIS_th     RefN                     99 82    73.2

*HIST GEN Zénithales

 Distances
 SIGM DP   0.0010
*HIST NEW

 DIST DP  SHOM         GAMB_prism                6.54737
 DIST DP  SHOM         DORIS_prism              21.05202
 DIST DP  SHOM         TM-1                     23.32874
 DIST DP  SHOM         RM-1                     34.92076
 DIST DP  TM-1         DORIS_prism              11.19912
 DIST DP  TM-1         GAMB_prism               17.13708
 DIST DP  TM-1         SHOM                     23.32844
 DIST DP  TM-1         RM-1                     28.72550
 DIST DP  RM-1         GAMB_prism               30.12439
 DIST DP  RM-1         DORIS_prism              18.57928
 DIST DP  RM-1         SHOM                     34.92030
 DIST DP  RM-1         TM-1                     28.72505
 DIST DP  DORIS_th     GAMB_prism               14.73507

*HIST GEN Distances

 HIST ALL Toutes les observations
 END
```

6.5 Appendix 5 : adjustment output file

```
================================================================================
         RIKITEA METEO STATION (FRENCH POLYNESIA) - AUGUST 2011 SURVEY
Microsearch GeoLab, V2001.9.20.0             GRS80       UNITS: m,GRAD Page 0001
================================================================================
Wed Feb 22 14:31:56 2012

Input file:  X:\Ratt_tt\Ratt_tt.iob
Output file: X:\Ratt_tt\Ratt_tt.lst
Options file: C:\Program Files\Microsearch\GeoLab\default.gpj

 ------------------------------------------------------------------------------
|             PARAMETERS               |             OBSERVATIONS              |
|--------------------------------------------------------------------------------|
|   Description    |      Number       |   Description     |      Number       |
|--------------------------------------------------------------------------------|
| No. of Stations  |          12       | Directions        |          20       |
| Coord Parameters |          36       | Distances         |          13       |
| Free Latitudes   |          12       | Azimuths          |           2       |
| Free Longitudes  |          12       | Vertical Angles   |           0       |
| Free Heights     |          12       | Zenithal Angles   |          20       |
| Fixed Coordinates|           0       | Angles            |           0       |
| Astro. Latitudes |           0       | Heights           |           0       |
| Astro. Longitudes|           0       | Height Differences|           0       |
| Geoid Records    |           0       | Auxiliary Params. |           0       |
| All Aux. Pars.   |           6       | 2-D Coords.       |           0       |
| Direction Pars.  |           6       | 2-D Coord. Diffs. |           0       |
| Scale Parameters |           0       | 3-D Coords.       |           3       |
| Constant Pars.   |           0       | 3-D Coord. Diffs. |          15       |
| Rotation Pars.   |           0       |                   |                   |
| Translation Pars.|           0       |                   |                   |
|                  |                   |                   |                   |
|                  |    --------       |                   |    --------       |
| Total Parameters |          42       | Total Observations|          73       |
|--------------------------------------------------------------------------------|
|                      Degrees of Freedom =        31                            |
 --------------------------------------------------------------------------------

--------------------------------------------------------------------------------
                       SUMMARY OF SELECTED OPTIONS
--------------------------------------------------------------------------------
    OPTION                               |   SELECTION
--------------------------------------------------------------------------------
    Computation Mode                     |   Adjustment
    Maximum Iterations                   |   30
    Convergence Criterion                |   0.00010
    Residual Rejection Criterion         |   Tau Max
    Confidence Region Types              |   1D 2D 3D Station
    Variance Factor (VF) Known           |   Yes
    Scale Covariance Matrix With VF      |   Yes
    Scale Residual Variances With VF     |   No
    Force Convergence in Max Iters       |   No
    Distances Contribute To Heights      |   No
    Compute Full Inverse                 |   Yes
    Optimize Band Width                  |   Yes
================================================================================
         RIKITEA METEO STATION (FRENCH POLYNESIA) - AUGUST 2011 SURVEY
Microsearch GeoLab, V2001.9.20.0             GRS80       UNITS: m,GRAD Page 0002
================================================================================
    Generate Initial Coordinates         |   Yes
    Re-Transform Obs After 1st Pass      |   Yes
    Geoid Interpolation Method           |   Bi-Quadratic
--------------------------------------------------------------------------------


================================================================================
         RIKITEA METEO STATION (FRENCH POLYNESIA) - AUGUST 2011 SURVEY
Microsearch GeoLab, V2001.9.20.0             GRS80       UNITS: m,GRAD Page 0003
================================================================================
Adjusted PLH Coordinates:
                                    LATITUDE          LONGITUDE  ELIP-HEIGHT
 CODE FFF STATION                    STD DEV             STD DEV      STD DEV
 ---- --- ------------ ----------------- ----------------- ------------
 PLH  000 DORIS_prism  S 23  7 48.927515 W134 57 53.715385      82.0846 m       0
                                 0.0018            0.0018       0.0018
 PLH  000 DORIS_th     S 23  7 48.927555 W134 57 53.715351      82.0843 m       0
                                 0.0018            0.0018       0.0018
 PLH  000 DORm         S 23  7 48.927014 W134 57 53.715459      79.7925 m       0
                                 0.0018            0.0018       0.0018
 PLH  000 GAMB         S 23  7 49.277387 W134 57 53.364021      80.6601 m       0
                                 0.0018            0.0018       0.0021
```

```
 PLH  000 GAMB_prism   S 23  7 49.277387 W134 57 53.364021      80.8961 m       0
                                0.0018             0.0018       0.0018
 PLH  000 RILB         S 23  7 48.927528 W134 57 53.715365      82.2225 m       0
                                0.0012             0.0012       0.0012
 PLH  000 RIMB         S 23  7 48.927528 W134 57 53.715365      82.2225 m       0
                                0.0016             0.0016       0.0016
 PLH  000 RM-1         S 23  7 48.329251 W134 57 53.627793      80.0385 m       0
                                0.0018             0.0019       0.0018
 PLH  000 RefN         S 23  7 46.275143 W134 57 54.894132      82.3239 m       0
                                0.0259             0.0124       0.0022
 PLH  000 RefS         S 23  7 51.615904 W134 57 53.006730      72.4315 m       0
                                0.0105             0.0024       0.0021
 PLH  000 SHOM         S 23  7 49.378996 W134 57 53.163430      78.7402 m       0
                                0.0018             0.0018       0.0018
 PLH  000 TM-1         S 23  7 49.210384 W134 57 53.961801      81.3428 m       0
                                0.0018             0.0018       0.0018


================================================================================
         RIKITEA METEO STATION (FRENCH POLYNESIA) - AUGUST 2011 SURVEY
Microsearch GeoLab, V2001.9.20.0            GRS80       UNITS: m,GRAD Page 0004
================================================================================
Adjusted XYZ Coordinates:
                           X-COORDINATE       Y-COORDINATE       Z-COORDINATE
 CODE FFF STATION               STD DEV            STD DEV            STD DEV
 ---- --- ------------ ----------------- ----------------- -----------------
 XYZ      DORIS_prism       -4147137.7729      -4152219.0140      -2490023.7815 m       0
                                 0.0018             0.0018             0.0018
 XYZ      DORIS_th          -4147137.7717      -4152219.0142      -2490023.7825 m       0
                                 0.0018             0.0018             0.0018
 XYZ      DORm              -4147136.2891      -4152217.5254      -2490022.8669 m       0
                                 0.0018             0.0018             0.0018
 XYZ      GAMB              -4147126.7862      -4152222.1601      -2490033.1198 m       0
                                 0.0020             0.0020             0.0019
 XYZ      GAMB_prism        -4147126.9396      -4152222.3137      -2490033.2125 m       0
                                 0.0018             0.0018             0.0018
 XYZ      RILB              -4147137.8620      -4152219.1040      -2490023.8360 m       0
                                 0.0012             0.0012             0.0012
 XYZ      RIMB              -4147137.8620      -4152219.1040      -2490023.8360 m       0
                                 0.0016             0.0016             0.0016
 XYZ      RM-1              -4147139.7890      -4152224.5591      -2490006.0527 m       0
                                 0.0018             0.0018             0.0018
 XYZ      RefN              -4147184.3076      -4152218.1478      -2489948.8391 m       0
                                 0.0160             0.0025             0.0239
 XYZ      RefS              -4147094.2756      -4152203.9944      -2490096.0443 m       0
                                 0.0045             0.0026             0.0097
 XYZ      SHOM              -4147120.6328      -4152224.0751      -2490035.2402 m       0
                                 0.0018             0.0018             0.0018
 XYZ      TM-1              -4147139.8357      -4152211.1583      -2490031.4925 m       0
                                 0.0018             0.0018             0.0018


================================================================================
         RIKITEA METEO STATION (FRENCH POLYNESIA) - AUGUST 2011 SURVEY
Microsearch GeoLab, V2001.9.20.0            GRS80       UNITS: m,GRAD Page 0005
================================================================================
Residuals (critical value = 3.305):
NOTE: Observation values shown are reduced to mark-to-mark.
                                                    OBSERVATION RESIDUAL  STD RES
TYPE AT           FROM         TO                       STD DEV  STD DEV      PPM
---- ------------ ------------ ------------ ----------------- -------- --------
AZIM              GAMB_prism   RefN           371 95     85.0      0.0      0.0
                                                          0.0      0.0        *
AZIM              GAMB_prism   RefS           191  6     35.0     -0.0     -0.0
                                                          0.0      0.0        *
XCT  RILB                                   -4147137.86200   0.0000   0.0000
                                                     0.0010   0.0000        *
YCT  RILB                                   -4152219.10400  -0.0000  -0.0000
                                                     0.0010   0.0000        *
ZCT  RILB                                   -2490023.83600  -0.0000  -0.0000
                                                     0.0010   0.0000        *
ELAT              RIMB         RILB            0 00  0.000000   0.0000   0.0000
                                                     0.0010   0.0000        *
ELON              RIMB         RILB            0 00  0.000000  -0.0000  -0.0000
                                                     0.0010   0.0000        *
EHGT              RIMB         RILB                  0.00000  -0.0000  -0.0000
                                                     0.0010   0.0000        *
ELAT              RIMB         DORIS_th        0 00  0.000000  -0.0008  -1.2045
                                                     0.0010   0.0007  6069.83
ELON              RIMB         DORIS_th        0 00  0.000000   0.0004   0.5829
                                                     0.0010   0.0007  2831.20
EHGT              RIMB         DORIS_th             -0.13800  -0.0001  -0.1781
                                                     0.0010   0.0008  1008.57
ELAT              RIMB         DORIS_prism     0 00  0.000000   0.0004   0.5332
```

```
                                                      0.0010   0.0008  3002.19
ELON              RIMB          DORIS_prism     0 00  0.000000  -0.0006  -0.7291
                                                      0.0010   0.0008  4080.36
EHGT              RIMB          DORIS_prism           -0.13800   0.0001   0.1316
                                                      0.0010   0.0008   761.18
ELAT              RIMB          DORm            0 00  0.000500   0.0004   0.5511
                                                      0.0010   0.0008   174.69
ELON              RIMB          DORm            0 00  0.000100   0.0002   0.2222
                                                      0.0010   0.0008    70.60
EHGT              RIMB          DORm                  -2.43000   0.0000   0.0432
                                                      0.0010   0.0008    14.14
ELAT              GAMB_prism    GAMB            0 00  0.000000  -0.0000  -0.0000
                                                      0.0003   0.0000     0.00*
ELON              GAMB_prism    GAMB            0 00  0.000000  -0.0000  -0.0000
                                                      0.0003   0.0000     0.00*
EHGT              GAMB_prism    GAMB                  -0.23600   0.0000   0.0000
                                                      0.0010   0.0000     0.00*
DIR               SHOM          RefS             85 98     35.1      0.8      0.3
                                                        8.0      2.3
DIR               SHOM          GAMB_prism      222  0     18.9      3.3      2.4
                                                        8.0      1.4
DIR               SHOM          DORm            236 23     37.3     -0.9     -0.6
================================================================================
         RIKITEA METEO STATION (FRENCH POLYNESIA) - AUGUST 2011 SURVEY
Microsearch GeoLab, V2001.9.20.0             GRS80       UNITS: m,GRAD Page 0006
================================================================================
Residuals (critical value = 3.305):
NOTE: Observation values shown are reduced to mark-to-mark.
                                                    OBSERVATION RESIDUAL  STD RES
TYPE AT           FROM          TO                      STD DEV  STD DEV      PPM
---- ------------ ------------ ------------ ------------------ -------- --------
                                                        8.0      1.6
DIR               SHOM          DORIS_prism     236 20     32.0     -3.1     -1.0
                                                        8.0      3.2
DIR               SHOM          TM-1            204 39     22.1      3.9      1.0
                                                        8.0      3.9
DIR               SHOM          RM-1            265 37     79.9     -3.9     -1.0
                                                        8.0      3.9
DIR               TM-1          RefS             67 67      4.1      0.1      0.2
                                                        8.0      0.8
DIR               TM-1          DORIS_prism     333 24     88.4     -2.1     -0.8
                                                        8.0      2.6
DIR               TM-1          DORm            333 18     43.0      0.2      0.2
                                                        8.0      0.9
DIR               TM-1          GAMB_prism      397 75     16.5      1.8      0.6
                                                        8.0      2.8
DIR               TM-1          SHOM             4 37     23.5     -5.2     -1.3
                                                        8.0      4.1
DIR               TM-1          RM-1            311 54     51.7      5.2      1.3
                                                        8.0      4.1
DIR               RM-1          GAMB_prism       69 85     96.6     25.6      3.1
                                                       11.3      8.3
DIR               RM-1          DORIS_prism      94 46     30.7     -4.4     -1.0
                                                        8.0      4.5
DIR               RM-1          SHOM             61 17     21.6     -2.9     -0.6
                                                        8.0      5.3
DIR               RM-1          TM-1            107 36     12.5     -5.1     -0.9
                                                        8.0      5.4
DIR               RM-1          RefN            252 90     50.3     -0.4     -0.3
                                                        8.0      1.3
DIR               DORIS_th      RefS              0  0      0.0      0.4      0.1
                                                        8.0      3.2
DIR               DORIS_th      GAMB_prism      367 57     11.1      0.2      0.2
                                                        8.0      1.4
DIR               DORIS_th      RefN            190 39     62.2     -0.7     -0.3
                                                        8.0      2.4
ZANG              SHOM          RefS            105 80     84.4      1.3      0.1
                                                       13.0      9.9
ZANG              SHOM          GAMB_prism       79 63     22.9     -0.8     -0.2
                                                       13.0      4.9
ZANG              SHOM          DORm             96 80     91.8      1.1      0.1
                                                       13.0     10.6
ZANG              SHOM          DORIS_prism      89 93      3.1     10.4      0.9
                                                       13.0     11.0
ZANG              SHOM          TM-1             92 91     48.0    -35.0     -2.9
                                                       13.0     11.9
================================================================================
         RIKITEA METEO STATION (FRENCH POLYNESIA) - AUGUST 2011 SURVEY
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================================================================================
Residuals (critical value = 3.305):
NOTE: Observation values shown are reduced to mark-to-mark.
                                                    OBSERVATION RESIDUAL  STD RES
TYPE AT           FROM          TO                      STD DEV  STD DEV      PPM
---- ------------ ------------ ------------ ------------------ -------- --------
ZANG              SHOM          RM-1             97 62     95.0    -28.7     -2.4
```
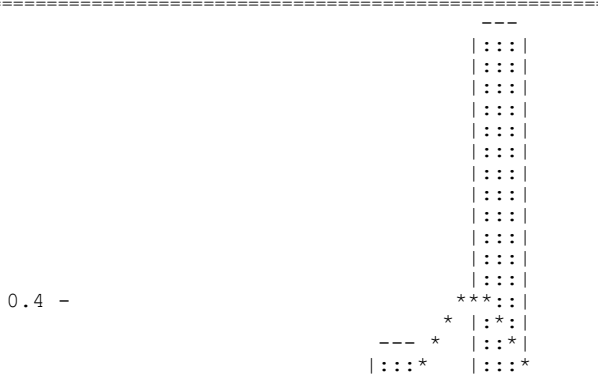
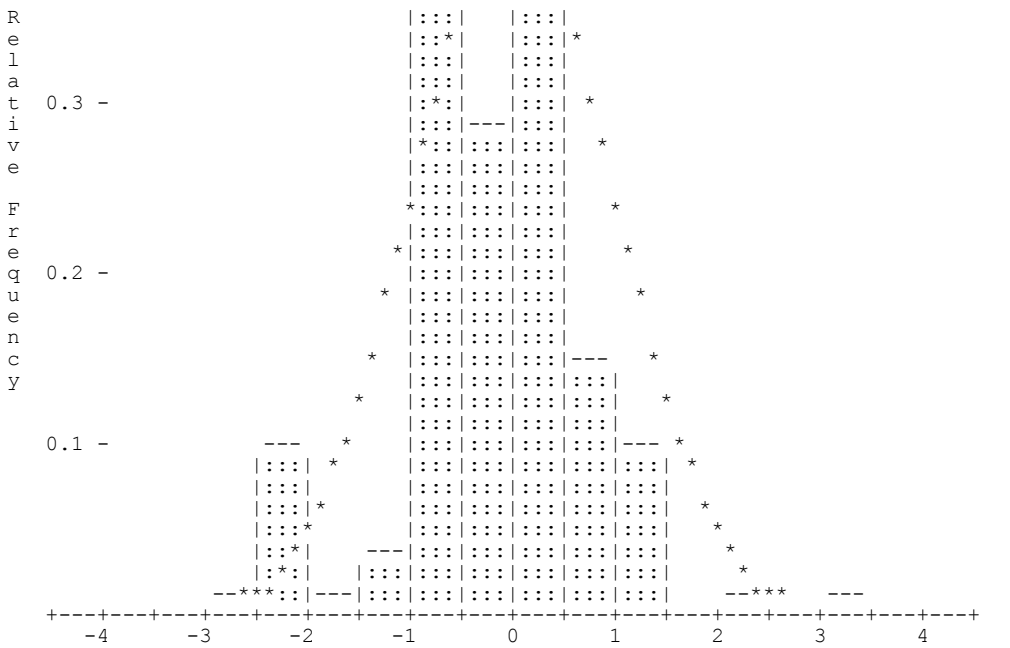

					13.0	12.1	
ZANG	TM-1	RefS	107	16	68.9	5.2	0.5
					13.0	10.7	
ZANG	TM-1	DORIS_prism	95	77	98.2	-5.2	-0.7
					13.0	7.1	
ZANG	TM-1	DORm	108	76	75.4	-0.7	-0.1
					13.0	6.0	
ZANG	TM-1	GAMB_prism	101	65	96.2	-0.3	-0.0
					13.0	10.5	
ZANG	TM-1	SHOM	107	7	92.8	-26.6	-2.2
					13.0	11.9	
ZANG	TM-1	RM-1	102	88	68.6	-20.0	-1.7
					13.0	11.8	
ZANG	RM-1	GAMB_prism	98	18	81.2	1.6	0.1
					13.0	11.7	
ZANG	RM-1	DORIS_prism	93	1	47.7	-0.9	-0.1
					13.0	9.6	
ZANG	RM-1	SHOM	102	36	54.5	-25.3	-2.1
					13.0	12.1	
ZANG	RM-1	TM-1	97	10	90.7	-23.6	-2.0
					13.0	11.8	
ZANG	RM-1	RefN	98	0	10.2	1.8	0.2
					13.0	8.2	
ZANG	DORIS_th	RefS	107	18	80.8	-7.3	-0.7
					13.0	11.0	
ZANG	DORIS_th	GAMB_prism	105	13	92.3	1.1	0.3
					13.0	3.8	
ZANG	DORIS_th	RefN	99	82	73.2	-2.1	-0.2
					13.0	9.9	
DIST	SHOM	GAMB_prism			6.85533	-0.0004	-0.5131
					0.0010	0.0009	65.04
DIST	SHOM	DORIS_prism			21.23031	-0.0006	-0.6423
					0.0010	0.0009	27.64
DIST	SHOM	TM-1			23.44437	0.0000	0.0334
					0.0010	0.0009	1.32
DIST	SHOM	RM-1			34.91647	-0.0008	-0.9063
					0.0010	0.0009	23.41
DIST	TM-1	DORIS_prism			11.19910	0.0003	0.3485
					0.0010	0.0009	27.47
DIST	TM-1	GAMB_prism			17.13700	0.0010	1.0927
					0.0010	0.0009	55.90
DIST	TM-1	SHOM			23.44407	0.0003	0.3575
					0.0010	0.0009	14.11
DIST	TM-1	RM-1			28.75409	-0.0006	-0.6222

Residuals (critical value = 3.305):
NOTE: Observation values shown are reduced to mark-to-mark.

TYPE	AT	FROM	TO	OBSERVATION STD DEV	RESIDUAL STD DEV	STD RES PPM
				0.0010	0.0009	19.72
DIST		RM-1	GAMB_prism	30.12868	0.0011	1.3024
				0.0010	0.0009	37.70
DIST		RM-1	DORIS_prism	18.68478	0.0000	0.0022
				0.0010	0.0009	0.10
DIST		RM-1	SHOM	34.91607	-0.0004	-0.4628
				0.0010	0.0009	11.95
DIST		RM-1	TM-1	28.75359	-0.0001	-0.0735
				0.0010	0.0009	2.33
DIST		DORIS_th	GAMB_prism	14.73500	0.0009	1.4462
				0.0010	0.0006	63.45





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S T A T I S T I C S S U M M A R Y

Residual Critical Value Type	Tau Max
Residual Critical Value	3.3048
Number of Flagged Residuals	0
Convergence Criterion	0.0001
Final Iteration Counter Value	5
Confidence Level Used	95.0000
Estimated Variance Factor	1.3372
Number of Degrees of Freedom	31

Chi-Square Test on the Variance Factor:

8.5943e-01 < 1.0000 < 2.3634e+00 ?

THE TEST PASSES

NOTE: All confidence regions were computed using the following factors:

Variance factor used	=	1.3372
1-D expansion factor	=	1.9600
2-D expansion factor	=	2.4477
3-D expansion factor	=	2.7955

Note that, for relative confidence regions, precisions are computed from the ratio of the major semi-axis and the spatial distance between the two stations.

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2-D and 1-D Station Confidence Regions (95.000 and 95.000 percent):

STATION	MAJOR SEMI-AXIS	AZ	MINOR SEMI-AXIS	VERTICAL
DORIS_prism	0.0044	128	0.0044	0.0035
DORIS_th	0.0046	130	0.0044	0.0035
DORm	0.0044	139	0.0044	0.0035
GAMB	0.0046	122	0.0045	0.0042
GAMB_prism	0.0045	122	0.0044	0.0035
RILB	0.0028	90	0.0028	0.0023
RIMB	0.0040	90	0.0040	0.0032

```
RM-1                        0.0046  83             0.0045               0.0035
RefN                        0.0703 155             0.0044               0.0043
RefS                        0.0259 171             0.0044               0.0040
SHOM                        0.0045 144             0.0044               0.0035
TM-1                        0.0045   9             0.0044               0.0035
================================================================================
         RIKITEA METEO STATION (FRENCH POLYNESIA) - AUGUST 2011 SURVEY
Microsearch GeoLab, V2001.9.20.0            GRS80       UNITS: m,GRAD Page 0012
================================================================================
3D Station Confidence Regions (95.000 percent):
STATION         MAJ-SEMI (AZ,VANG)    MED-SEMI (AZ,VANG)    MIN-SEMI (AZ,VANG)
------------ -------------------- -------------------- --------------------
DORIS_prism       0.0050 (128,  0)      0.0050 ( 38,  0)      0.0050 (307, 90)
DORIS_th          0.0052 (310,  0)      0.0050 ( 40,  0)      0.0050 (171, 90)
DORm              0.0050 (139,  0)      0.0050 (229,  0)      0.0050 (345, 90)
GAMB              0.0059 (118, 90)      0.0052 (302,  0)      0.0051 (212,  0)
GAMB_prism        0.0051 (122,  0)      0.0050 (212,  0)      0.0050 (319, 90)
RILB              0.0032 (304,  0)      0.0032 (205, 90)      0.0032 ( 34,  0)
RIMB              0.0046 (304,  0)      0.0046 (200, 90)      0.0046 ( 34,  0)
RM-1              0.0053 ( 83,  0)      0.0052 (173,  0)      0.0050 (294, 90)
RefN              0.0802 (335,  0)      0.0062 ( 69, 90)      0.0050 (245,  0)
RefS              0.0296 (171,  0)      0.0058 ( 60, 90)      0.0050 (261,  0)
SHOM              0.0052 (144,  0)      0.0050 ( 54,  0)      0.0050 (244, 90)
TM-1              0.0052 (  9,  0)      0.0050 ( 99,  0)      0.0050 (271, 90)
Wed Feb 22 14:31:58 2012
```

6.6 Appendix 6 : Rikitea SINEX File

```
%=SNX 1.00 IGN 12:053:00000 IGN 11:218:00000 11:218:00000 C 00012
*-------------------------------------------------------------------------------
+FILE/COMMENT
* File created by geotosnx software (Z.Altamimi)
* Original input file: ratt_tt.cov
* Matrix Scalling Factor used:         1.0000000000
-FILE/COMMENT
*-------------------------------------------------------------------------------
+SITE/ID
*CODE PT __DOMES__ T _STATION DESCRIPTION__ APPROX_LON_ APPROX_LAT_ _APP_H_
 RILB  A 92301S003   92301S003              225 02 06.2 -23 07 48.9    82.2
 DORm  A 92301M001   92301M001              225 02 06.2 -23 07 48.9    79.8
 GAMB  A 92301M003   92301M003              225 02 06.6 -23 07 49.2    80.7
 RIMB  A 92301S004   92301S004              225 02 06.2 -23 07 48.9    82.2
-SITE/ID
*-------------------------------------------------------------------------------
+SOLUTION/EPOCHS
*Code PT SOLN T Data_start__ Data_end____ Mean_epoch__
-SOLUTION/EPOCHS
*-------------------------------------------------------------------------------
+SOLUTION/ESTIMATE
*INDEX TYPE__ CODE PT SOLN _REF_EPOCH__ UNIT S __ESTIMATED VALUE____ _STD_DEV___
     1 STAX   RILB  A    1 11:218:00000 m    2 -.4147137862000000E+07 0.11564E-02
     2 STAY   RILB  A    1 11:218:00000 m    2 -.4152219104000000E+07 0.11564E-02
     3 STAZ   RILB  A    1 11:218:00000 m    2 -.2490023836000000E+07 0.11564E-02
     4 STAX   DORm  A    1 11:218:00000 m    2 -.4147136289100000E+07 0.17806E-02
     5 STAY   DORm  A    1 11:218:00000 m    2 -.4152217525400000E+07 0.17977E-02
     6 STAZ   DORm  A    1 11:218:00000 m    2 -.2490022866900000E+07 0.17875E-02
     7 STAX   GAMB  A    1 11:218:00000 m    2 -.4147126786200000E+07 0.20777E-02
     8 STAY   GAMB  A    1 11:218:00000 m    2 -.4152222160100000E+07 0.18584E-02
     9 STAZ   GAMB  A    1 11:218:00000 m    2 -.2490033119800000E+07 0.18698E-02
    10 STAX   RIMB  A    1 11:218:00000 m    2 -.4147137862000000E+07 0.16353E-02
    11 STAY   RIMB  A    1 11:218:00000 m    2 -.4152219104000000E+07 0.16353E-02
    12 STAZ   RIMB  A    1 11:218:00000 m    2 -.2490023836000000E+07 0.16353E-02
-SOLUTION/ESTIMATE
*-------------------------------------------------------------------------------
+SOLUTION/MATRIX_ESTIMATE L COVA
*PARA1 PARA2 ___PARA2+0___________ ____PARA2+1__________ ____PARA2+2__________
     1     1 0.133715662419719E-05
     2     1 0.268611831920353E-15 0.133715662643789E-05
     3     1 -.447177170512686E-15 0.628830442832753E-15 0.133715662334135E-05
     4     1 0.133715636609571E-05 0.116901132424014E-14 0.110031130954878E-12
     4     4 0.317057305170658E-05
     5     1 -.161976253437470E-13 0.133715659432542E-05 -.404705579296078E-13
     5     4 -.753320354971392E-09 0.323169153712728E-05
     6     1 0.108593098470600E-12 0.572390518754688E-14 0.133715657522779E-05
     6     4 0.128776276006448E-07 -.176355063113520E-08 0.319521924590655E-05
     7     1 0.133715654478823E-05 -.368686958596645E-12 0.260421284158886E-13
     7     4 0.311133020201044E-05 -.368500659390951E-08 -.128835567377938E-07
     7     7 0.431667258408324E-05
     8     1 0.387811136105869E-12 0.133715655411727E-05 0.905594379899010E-12
     8     4 -.136581482394816E-07 0.316273907476323E-05 -.319742423814263E-07
     8     7 0.134780291669781E-07 0.345362567738025E-05
     9     1 0.248376014786802E-13 -.860403271994856E-12 0.133715659352086E-05
     9     4 -.128835572048038E-07 -.862673870148541E-08 0.308667265934530E-05
     9     7 -.428703926872609E-06 0.315525778939037E-07 0.349618602447001E-05
    10     1 0.133715662400609E-05 0.537223607096017E-15 -.894354144621676E-15
    10     4 0.267431273219142E-05 0.233802274249422E-14 0.220062261851025E-12
    10     7 0.267431308957646E-05 -.737373917099277E-12 0.520842567728405E-13
    10    10 0.267431324801217E-05
    11     1 0.537223595262264E-15 0.133715662848748E-05 0.125766040993290E-14
    11     4 -.323952506125824E-13 0.267431318865084E-05 -.809411160088320E-13
    11     7 0.775622272361459E-12 0.267431310823454E-05 0.181118875964840E-11
    11    10 0.107444734024422E-14 0.267431325697497E-05
    12     1 -.894354167110649E-15 0.125766038180315E-14 0.133715662229440E-05
    12     4 0.217186196872441E-12 0.114478103349347E-13 0.267431315045557E-05
    12     7 0.496752029574638E-13 -.172080654402987E-11 0.267431318704173E-05
    12    10 -.178870833422130E-14 0.251532071235822E-14 0.267431324458880E-05
-SOLUTION/MATRIX_ESTIMATE L COVA
%ENDSNX
```