Thomas Donal

Arequipa ITRF co-location survey

January 2013

DIFFUSION OUVERTE

IGN	Thomas DONAL	RT/G 186
Service		v 1
de Géodésie	**Arequipa ITRF co-location survey**	
et Nivellement		page 2/78

Mots-clé

Rattachement ; ITRF ; SLR ; DORIS ; GNSS ; REGINA ; Arequipa ; Pérou

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. Le site d'Arequipa (Pérou) dispose d'une station SLR, d'une station DORIS et de deux stations GNSS permanentes, intégrées dans le réseau de l'IGS. Le présent rapport décrit le rattachement de précision réalisé en janvier 2013 sur ce site suite à l'installation d'une station GNSS REGINA

Matériel

Système d'exploitation	Logiciel
Windows	LibreOffice Writer 4.1.4.2

Validation

	Fonction	Nom	Visa
Commanditaire	Chef de département RSI	Bruno Garayt	29/08/2014 – signé
Rédacteur	Technicien d'études	Thomas Donal	11/07/2014 – signé
Lecteur	Responsable SIRS DORIS	Jérôme Saunier	21/07/2014 – signé
Approbateur	Chef de service	Thierry Person	07/09/2014 – signé
Vérificateur	Responsable qualité	Thierry Person	18/01/2015 – signé

Diffusion

Organisme / Service	Fonction / Nom	Numérique	Papier
IGN / DPR	Directeur / Philippe Gerbe	oui	-
IGN / DPR	Directeur adjoint / Didier Moisset	oui	-
IGN / DPC / SP / CKP	Chargé MO géodésie / François Becirspahic	oui	-
IGN / DRE/ SMGI / CDOS	Chef du CDoS / Anne Berry	oui	-
IGN / DRE / SRIG / LAREG	Chef de laboratoire / Olivier Jamet	oui	-
IGN / DRE / DE / DPTS	Chef de département / Serge Botton	oui	-
IGN / DPR / SGN	Chef de service / 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 / PMM	Thomas Donal	oui	1
IGN / DPR / SGN / PMM	Bruno Garayt	oui	1
IGN / DPR / SGN / PMM	Jérôme Saunier	oui	-
IGN / DPR / SGN / PMM	Charles Velut	oui	-
IGN / DPR / SGN / PMM	Jean-Claude Poyard	oui	-
IGN / DRE / SRIG / LAREG	Zuheir Altamimi	oui	1
IGN / DRE / SRIG / LAREG	Xavier Collilieux	oui	-
CNES / DCT / ME / NC	Alain Brissaud	oui	-
CNES / DCT / ME / OT	Thierry Guinle	oui	-
CNES / DCT / ME / OT	Cédric Tourain	oui	1
CNES / DCT / ME / OT	François Boldo	oui	1
NASA	David McCormick	oui	-
NASA	James Long	oui	-
UNSA	Pablo Raul Yanyachi	oui	-
IGN / DPR / SGN / PMM	Archives DORIS	oui	1
CNES	regina.operation@cnes.fr	oui	-
IGN	projet-regina@ign.fr	oui	-
IGN	doris@ign.fr	oui	-
IGN	itrf.ign.fr	oui	-

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   4/78

_____

Table of contents

_____

1. Introduction

1.1. Subject

The International Terrestrial Reference Frame (ITRF) is the result of a combination of different terrestrial reference frames provided by the four space geodetic techniques:
-Very Long Baseline Interferometry (VLBI)
-Satellite Laser Ranging (SLR)
-Global Navigation Satellite System (GNSS)
-Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS)

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 tie vectors between their reference points have been surveyed in three dimensions.

The local ties survey accuracy as stated by GGOS should reach 1 mm.

As far as a REGINA or DORIS site is co-located, a local tie is carried out by IGN with the triple purpose:
→ assign coordinates to new instruments reference points;
→ provide tie vectors between instruments reference points (i.e. DORIS, GNSS, SLR, VLBI, tide gauge);
→ produce a local tie SINEX file to LAREG

This document presents the local tie survey at Arequipa (Peru), which took place in January 2013 within the framework of the REGINA station installation.

1.2. Glossary

CDP : Crustal Dynamics Project
CNES : Centre National d'Études Spatiales (France)
DOMES : Directory of MERIT Sites
DORIS : Détermination d'Orbite et Radio positionnement Intégré par Satellite
GNSS : Global Navigation Satellite System
IDS : International DORIS Service
ILRS : International Laser Ranging Service
IGN : Institut National de l'Information Géographique et Forestière (France)
IGS : International GNSS Service
NASA : National Aeronautics and Space Administration (USA)
REGINA : REseau Gnss pour l'IGS et la NAvigation
SLR : Satellite Laser Ranging
SINEX : Solution INdependent EXchange
UNSA : Universidad Nacional de San Agustin (Peru)

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 6/78

Acknowledgements

On behalf of CNES and IGN, we would like to acknowledge the president of UNSA, Dr. Valdemar Medina Hoyos, and the vice-president Dra. Elisa Castañeda Huaman for their welcome given to us. In particular, we would like to acknowledge all the team of the Characato observatory for its memorable hospitality and its important logistical support. Our special thanks to the chief of the observatory, Mr Pablo Raul Yanyachi, who has done everything possible to ensure the success of the mission.

From left to right :Pablo Raul Yanyachi, Thomas Donal, the logistic team and Gregory Bonnes.

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 7/78

2. Co-location site description

2.1. Site description

The local ties survey was performed at the Characato Observatory about ten kilometers south-east of the Arequipa city center (Peru).

IGN	Thomas DONAL	RT/G 186
Service		v 1
de Géodésie	**Arequipa ITRF co-location survey**	
et Nivellement		page 8/78
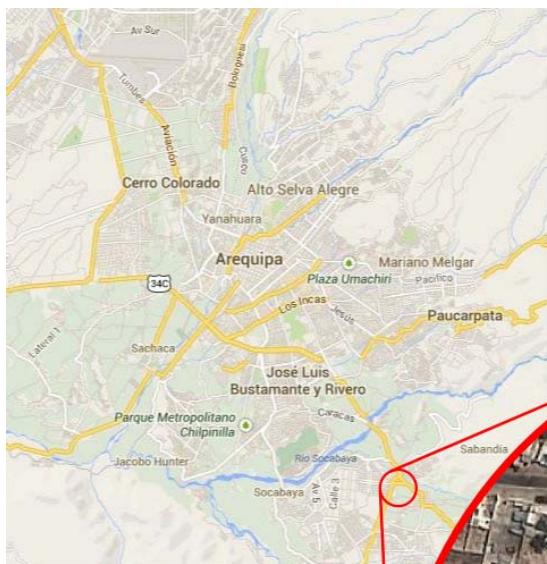
The Characato Observaty depends on the Universidad Nacional de San Agustin (UNSA).

▪Address
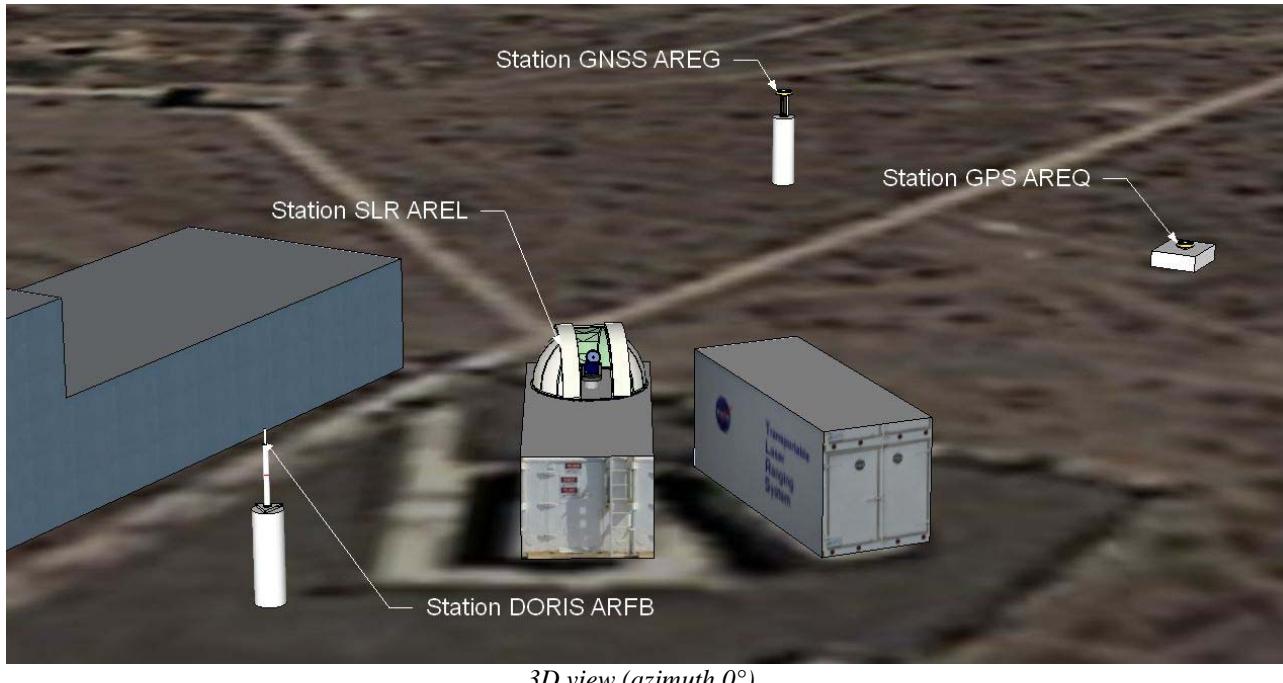
Observatorio de Characato
TLRS-3 Nasa Laser Tracking Stations
Universidad Nacional de San Agustin
Cerro San Franciscos/n Characato
AREQUIPA – PERU
Tel : +51-54-448211
Fax : +51-54-448418

Observatory
of Characato
16°27'55"S
71°29'37"W

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   9/78

From a geodetic point of view, the site is equiped with several scientific instruments :

→ a GPS station
→ a GNSS station
→ a DORIS station
→ a SLR telescope

3D view (azimuth 0°)

In addition to that, few geodetic benchmarks are implanted around these instruments.

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 10/78
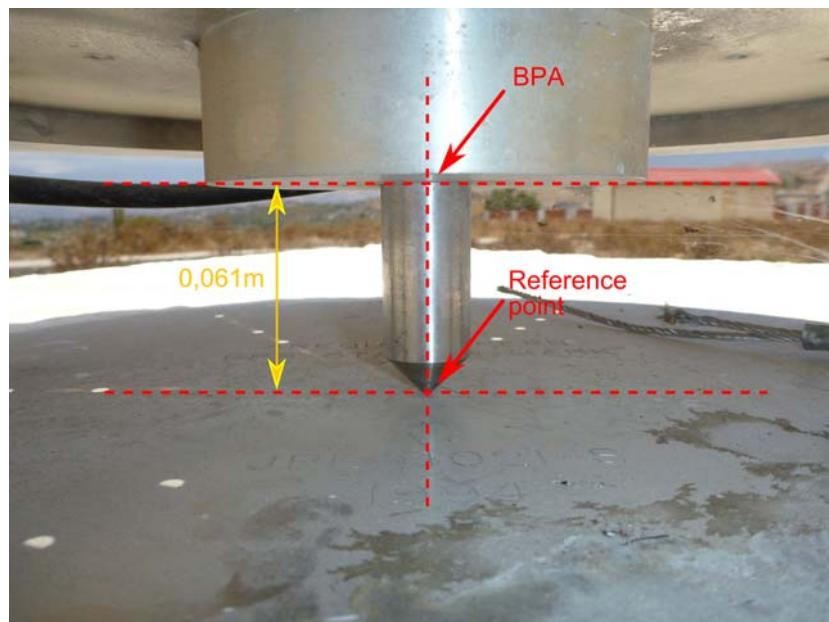
2.2. Co-located points

2.2.1. GPS station – AREQ

A permanent GPS station called AREQ was installed in 1993. This station is part of the IGS network. The antenna is an AOAD/M_T type with radome JPLA type. The reference point is a mark in steel plate on top of a concrete block.

Acronym : **AREQ**	DOMES number : **42202M005**
General view	Close-up view (reference point)

Description : antenna monument and reference point.
Antenna height is **0,061 m**.

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   11/78

2.2.2.   GNSS station – AREG

A permanent GNSS station called AREG was installed during the campaign. This station is dedicated to the GNSS real time Network for IGS and Navigation (REGINA) project. The antenna is a Trimble TRM 59800.00 type without radome. This antenna is mounted on top of a 40 cm high stainless steel rigidstructure. The reference point is a brass mark embedded on top of the concrete pillar vertically down the BPA (Bottom of the Pre-Amp).

Acronym : **AREG**	DOMES number : **42202M008**
General view	Close-up view (reference point)

Description : antenna monument and reference point.
Antenna height is **0,429 m**.

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   12/78

2.2.3.   DORIS station – ARFB

The DORIS station was initially set up on December 1988. After two renovations, the current antenna is installed on a 1,5 meter high, 40 cm diameter and 2 m deep concrete pillar, and bears the acronym « ARFB ». A domed brass marker is embedded on the concrete pillar vertically down the antenna.

Acronym : **ARFB**	DOMES number : **42202S007**
General view	Close-up view (reference point)
Description : DORIS antenna and reference point.	

Acronym : **DORIS mark**	DOMES number : **42202M007**
General view	Close-up view
Description : domed brass marker	

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 13/78

2.2.4. SLR telescope – AREL

The Transportable Laser Ranging Station 3 (TLRS-3) has replaced SAO-2 system as tracking station since 1992.

The SLR measurements refer to a point in the telescope where the two rotation axes intersect. This Ranging System Reference Point (SRP) can't be materialized.

The TLRS-3 SLR system has a removable plate at the top, which is intended to be used as a mount for a survey instrument or survey target. The survey mount is approximately 1 mm offset from the vertical rotation axis. When performing distance measurements to the SLR mount, we observe the measurements with the SLR telescope in one position, then rotate the SLR mount 180 degrees in azimuth and then repeat the measurements, to account for the offset. The removable plate is 0,174 m above the SRP.

The reference station mark is a standard NASA-GSFC brass disk set flush near the center of a 1,2 x 1,2 m isolated concrete pad that set in the north end of a 8,2 x 7,6 m concrete pad. The disk is stamped « 7403 89 ». The pad is located inside a 19,8 x 24,4 m fenced area.

The TLRS-3 mount is installed over the 7403 survey mark.
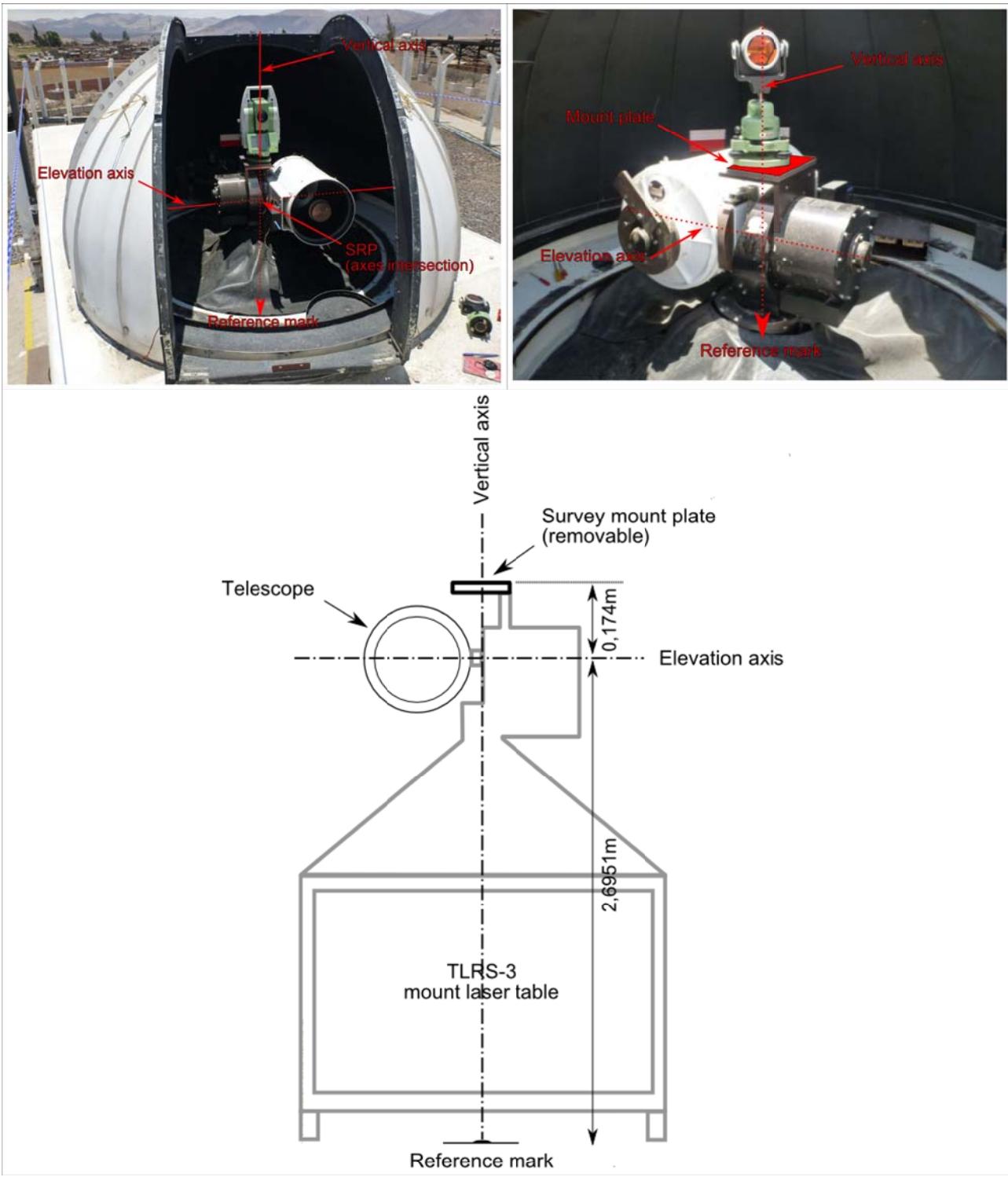
The eccentricities from reference station mark to SRP are :
        North   [m]: 0.0112 +- 0.002
        East   [m]:-0.0046 +- 0.002
        Up   [m]: 2.6951 +- 0.002
        (see sitelog, appendix 6.4))

To access to the reference mark, the TLRS-3 needs to be put out of order and moved. This decommission was not possible during the surveying operation. So, the reference mark was unreachable. The survey includes only the survey mount and not the link to the reference mark.

Acronym : **AREL**	DOMES number : **42202M003**
General view	Reference mark

Description : brass disk under TLRS-3 mount
CDP pad identity: 7403

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 14/78

The vertical offset from SRP to the mount plate is 0,174 m.

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   15/78

2.2.5.   Geodetic benchmarks

Five geodetic benchmarks have been included in the local tie survey.

Survey control point « BM. CHR-5 »	DOMES number : **42202M001**
General view	Close-up view

The survey control point is a standard « Geodesico Inter-Americano » brass disk.
The disk stamped « BM. CHR-5 1961 » is located just South of the doorway entrance from the North end of the administration building.

Survey control point « EST-SATELITE 1961 »	DOMES number : **42202M002**
General view	Close-up view

The survey control point is a standard « Geodesico Inter-Americano » brass disk.
The disk stamped « EST-SATELITE 1961 » is located on the terrasse roof of the administration building.

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 16/78

Survey control point «EST-SATELITE 1961 REF 1»	DOMES number : **42202M004**
General view	Close-up view

The survey control point is a standard « Geodesico Inter-Americano » brass disk.
The disk stamped « EST-SATELITE 1961 MAR. REF. 1 » is located on the terrasse roof of the SAO-2 laser building.

Survey control point «7403 RM2 89»	DOMES number : **42202M009**
General view	Close-up view

The survey control point is a standard « NASA-GSFC » brass disk.
The disk stamped « 7403 RM2 89 » is embedded center of a 0.40x0.30 m concrete monument.
This monument projects over a 0.6m diameter concrete mass that is flush with the ground.

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   17/78

Survey control point «AUX. SATELLITE 1958»	DOMES number : **42202M010**
General view	Close-up view

The survey control point is a standard « Geodesico Inter-Americano » brass disk.
The disk stamped « AUX. SATELLITE 1958» is set flush with the concrete path in the North from administration building.

2.2.6.   Calibration piers

Four laser system calibration piers were set up for station 7403 in April 1989.
Three of them have been included in the local tie. Due to the continuing build-up of residences around the fourth pier (pier « C »), this pier was not observed.
A 0.025m diameter stainless steel insert is embedded into the top of each calibration pier. The exact center of these inserts represent the plumb point of the control station and the lip of the inserts represent the elevation point.

7403 calibration pier A	
General view	Close-up view

7403 calibration pier A is a 0.35 x 0.33 m concrete monolith that extends 1.89 m above the ground. Prism « A » stamped LTN 91-R was placed on the stainless steel insert.

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   18/78

7403 calibration pier B

| General view | Close-up view |

7403 calibration pier B is a 0.34 x 0.34 m concrete monolith that extends 2,23 m above the ground. A permanent prism « B » stamped 86-5 is placed on the stainless steel insert.

7403 calibration pier D

| General view | Close-up view |

7403 calibration pier D is a 0.33 x 0.33 m concrete monolith that extends 1,85 m above the ground. Prism « D» stamped 86-1 was placed on the stainless steel insert.

Adjusted coordinates from calibration piers published in this document correspond to the prisms center.

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   19/78

2.3. Site sketch
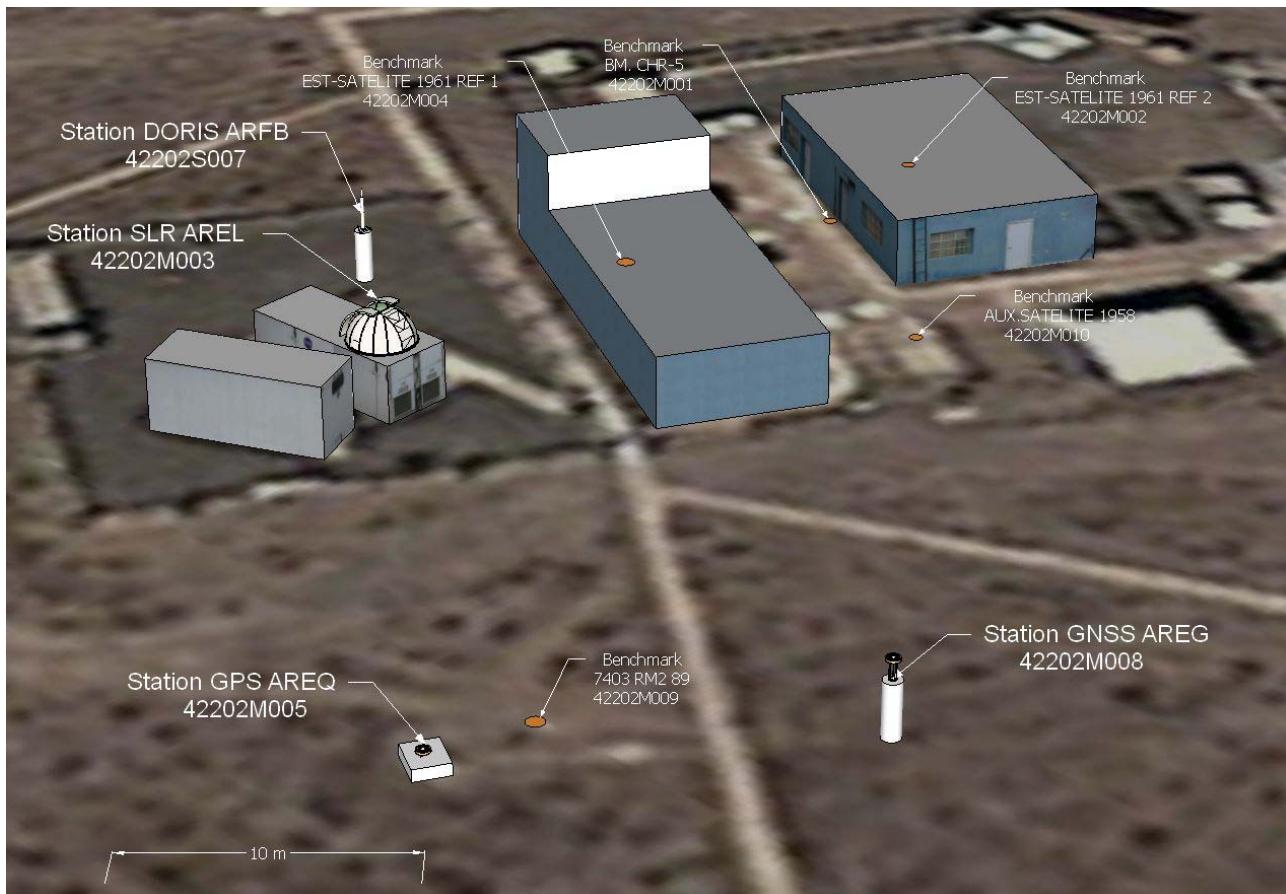
Illustration azimuth : 40°

Illustration azimuth : 340°

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   20/78
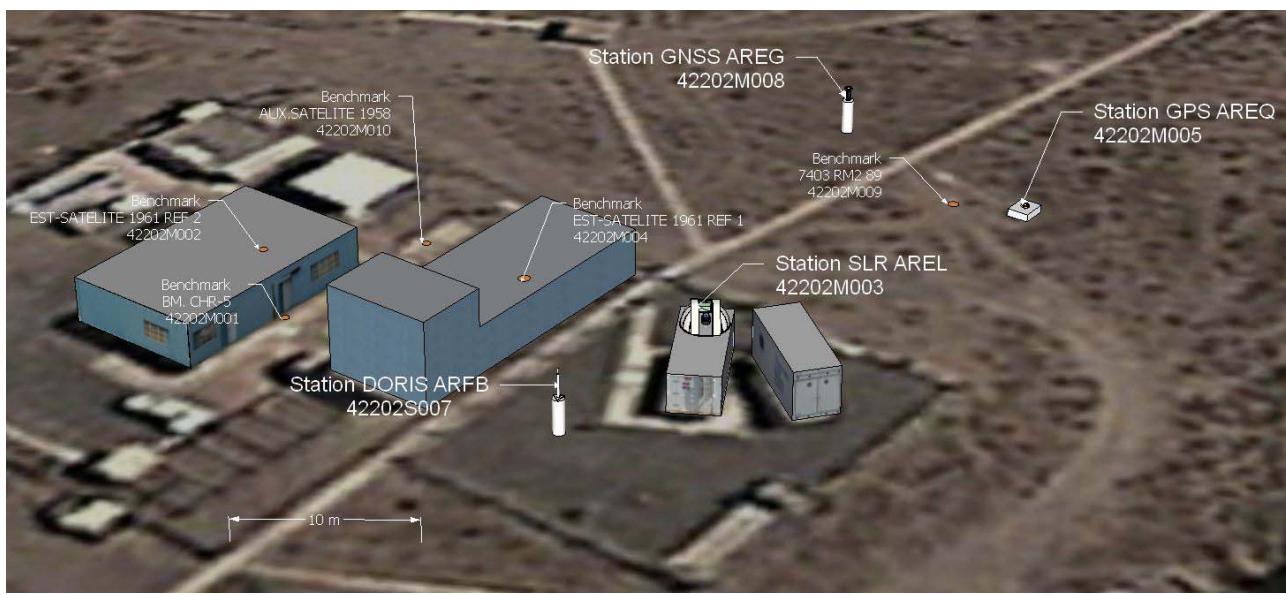
The Characato Observatory : co-located points

IGN	Thomas DONAL	RT/G 186
Service		v 1
de Géodésie	**Arequipa ITRF co-location survey**	
et Nivellement		page 21/78

3.   Survey description

3.1. Organization

The local ties survey was conducted during the AREG GNSS station installation, part of the REGINA network, on which the two following french agencies participated :
- Centre National d'Etudes Spatiales – CNES, France ;
- Institut National de l'Information Géographique et Forestière – IGN, France ;

The survey took place from January 11th to January 14th, 2013 and was operated by Thomas Donal (IGN) and Gregory Bonnes (mandated by CNES).

3.2. Equipment

All the survey instruments used for this project belong to IGN.

3.2.1.   GNSS REGINA permanent station

Type	Model	Quantity
GNSS antenna	Trimble chokering TRM 59800.00	1
GNSS receiver	Trimble NetR9	1

3.2.2.   Survey instruments

The Leica total station used for the survey, is yearly calibrated at IGN's calibration unit. It has a standard deviation of 0.3 mgon for angles and 1mm + 1.5 ppm for distances.

Type	Model	Quantity
GNSS receiver	Leica GX1230GG	2
GNSS antenna	Leica AX1202GG	2
Total station	Leica TCRA 1201+	1

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   22/78

3.2.3.   Survey accessories

Four Leica accurate reflectors calibrated with the total station were used to determine distances.

Type	Model	Quantity
Reflector	Leica GPH1P	4
Mini reflector	Leica GMP101	1
Carrier with optical plummet	Leica GZR3	2
Carrier with laser plummet	Leica SNLL121	2
Tripod	Leica wooden tripod	5
Meteo station	Kestrel 4500	1
Reflector pole	Leica GLS14	1
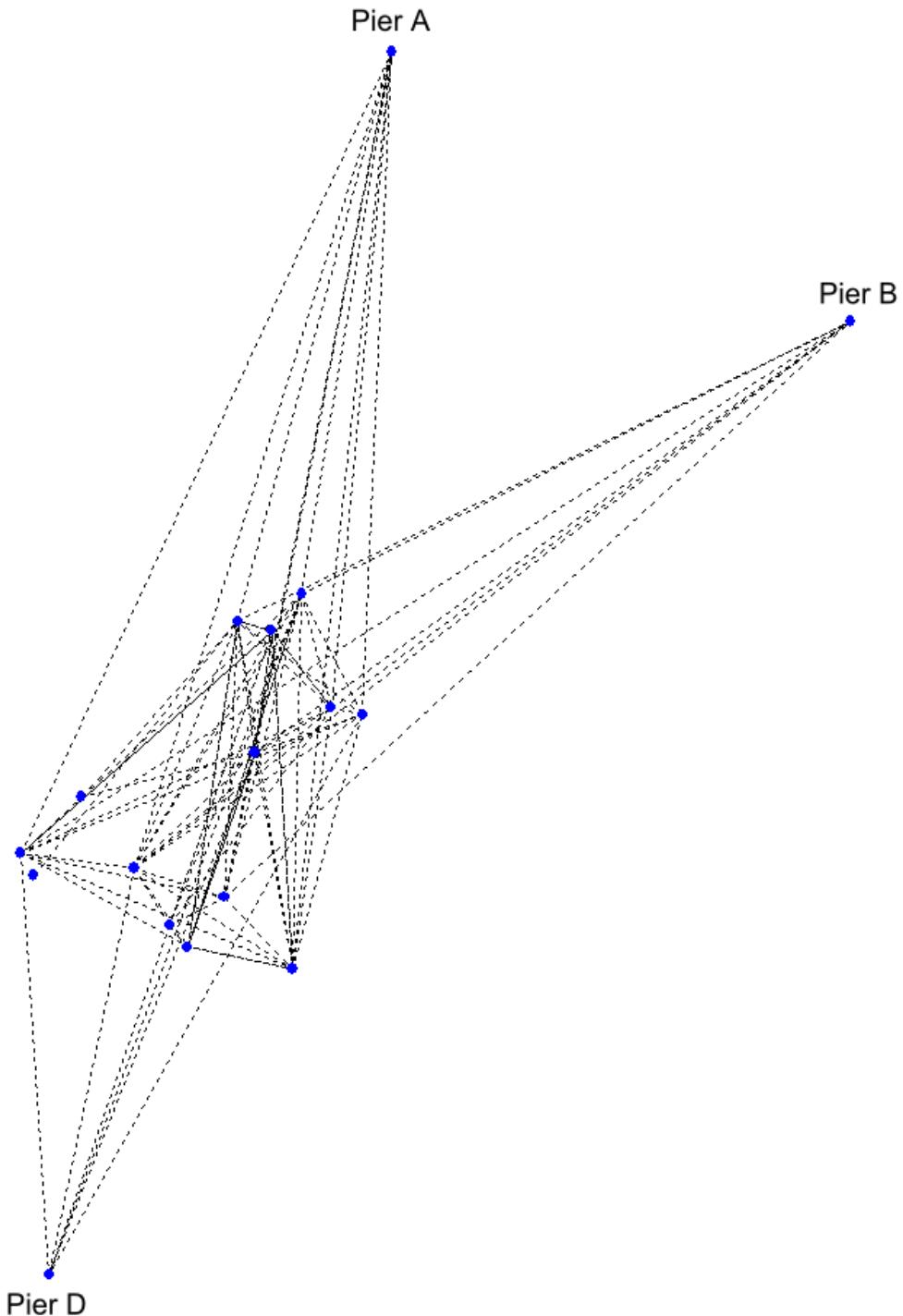
Survey operation

Survey operation

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   23/78
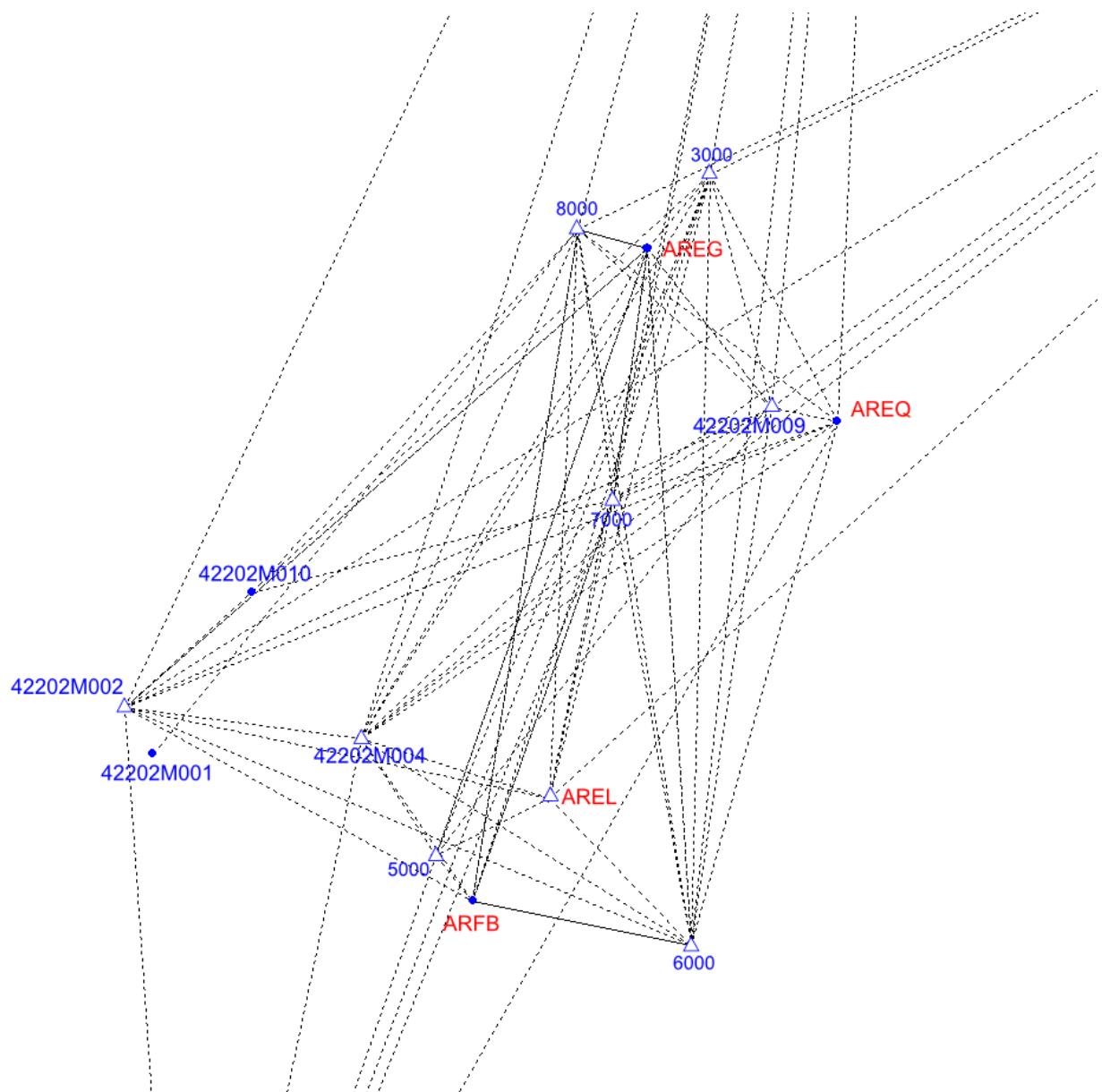
3.3. Polygon network

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

General polygon network sketch

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 24/78

Polygon network sketch, close-up

Observations were done by total station from five temporary stations (3000, 5000, 6000, 7000 and 8000), from three geodetic points (42202M002, 42202M004 and 42202M009) and from the TLRS-3 SLR mount.

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   25/78

3.4. Survey method

All the visible lines of sight have been observed with the total station . 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 twice over each line. Meteorological data (atmospheric pressure and temperature) used to correct the distances, were recorded during the operation.
The set up strategy mixes GNSS and conventional observations. The GNSS observations are used to get the polygon bearing.
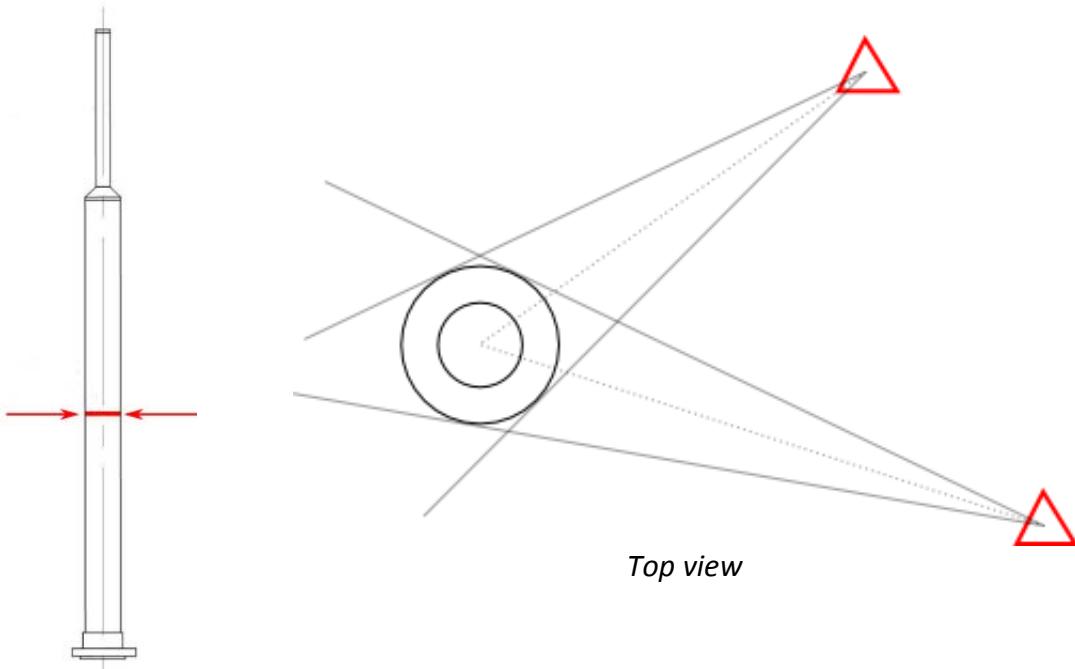
3.4.1.   Permanent stations reference point

As we can not remove permanent GNSS antennas, DORIS antenna and TLRS-3 SLR, their reference points had to be determined indirectly.
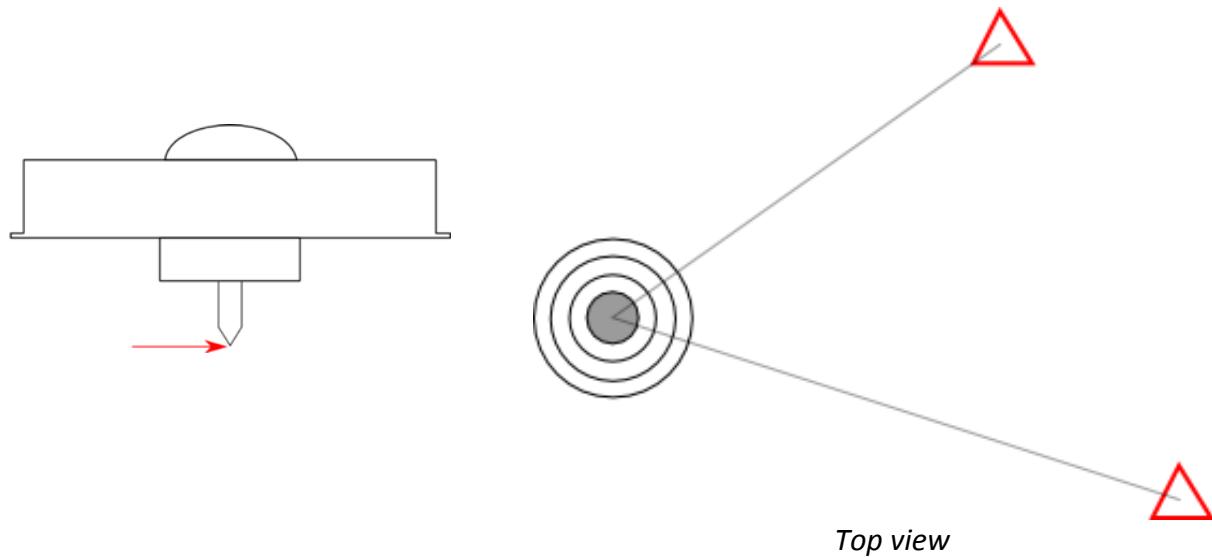
ARFB reference point :

From each survey station aiming at the antenna, the right and the left sides of the DORIS antenna centred on red circle were observed. In the adjustment, horizontal and zenithal angle observations were simply averaged to get its planimetric and altimetric positions.

Top view

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 26/78
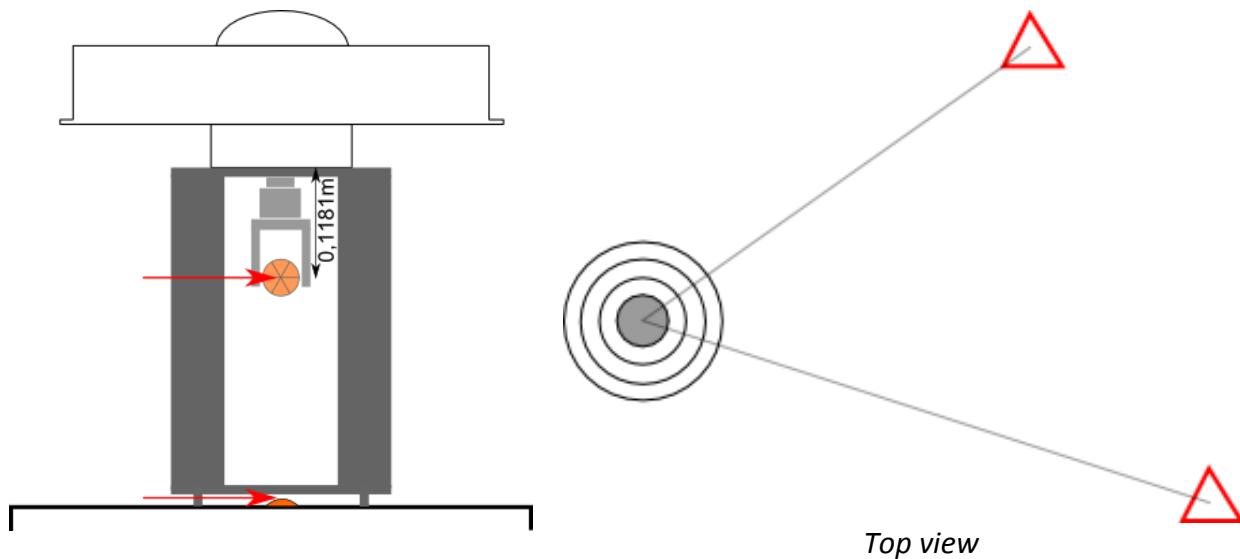
AREQ reference point :

From each survey station aiming at the antenna, the reference point was directly observed.

Top view

AREG reference point :
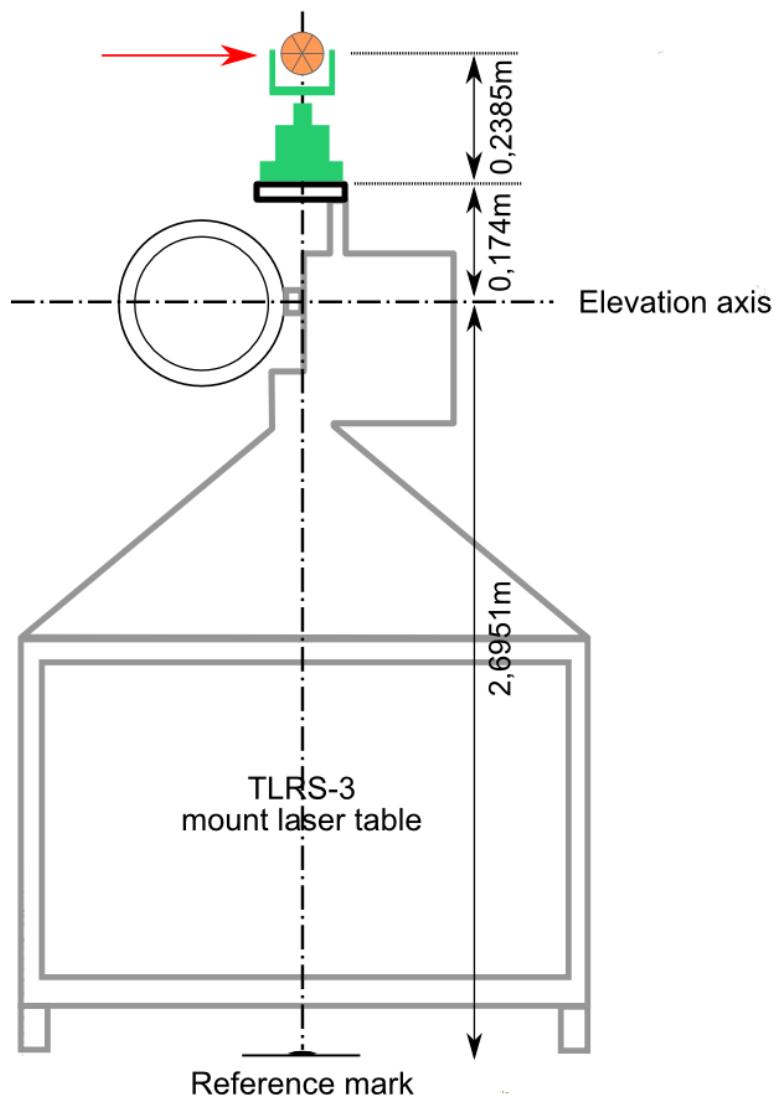
From each survey station aiming at the antenna, the reference point was directly observed. To determine the eccentricities from station reference point to antenna reference point (ARP), a prism directly set up on the vertical of ARP was observed. Vertical offset from prism to ARP is accurately known.

Top view

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   27/78

AREL reference point :

From each survey station aiming at the SLR, the prism installed on the survey mount was observed in one position, then rotate the SLR mount 180 degrees in azimuth and then repeat the measurements. In the adjustment, horizontal and zenithal angle observations were simply averaged to get its planimetric and altimetric positions.

The vertical offset from SRP (rotation axis) to prism, as well as the eccentricities from reference station mark to SRP are accurately known from previous measurements.

3.4.2.   GNSS observations

GNSS observations are carried out in order to determine the orientation of the survey network. Orientations are ensured by the baselines from AREQ to Pier A and D. Due to the permanent prism installed on Pier B, GNSS onservations are not possible on this point.

IGN	Thomas DONAL	RT/G 186
Service		v 1
de Géodésie	**Arequipa ITRF co-location survey**	
et Nivellement		page 28/78

4. Computation

4.1. GNSS network

Back to the office, the GNSS baselines were processed with Leica Geo Office V8.1 software using IGS08 precise ephemeris and the original set of « absolute » GNSS antenna calibrations (igs08.atx). AREQ coordinates come from the station in IGS08 at epoch 2013:03 of the corresponding IGS RF weekly solution (i.e. file igs13P1722.ssc)

The corresponding LGO report file is given in appendix 6.5.

4.2. Global adjustment

The final computation has been carried out by a Least Squares 3D Adjustment with the Microsearch Geolab version 2001.9.20.0 software. The input file (see appendix 6.6) comes from :
→ Total station observations : horizontal and zenith angles, distances,
→ Centring equations : relative position between points,
→ Azimuths issued from the GNSS baselines process,
→ AREQ coordinates have been constrained at 1 mm to its IGS08 (epoch 2013:03) values.
The a priori standard deviations used for the different observations with total station are :
→ 0.8 mgon for horizontal and vertical angles,
→ 1 mm for distances on prism,
These are the values used for most of the targets in our Microsearch Geolab computation input file.
This adjustment provided coordinates and a covariance matrix of our survey work (appendix 6.7).

Arequipa is bordered by mountains. Geoid slope is significant. The undulation of the geoid model EGM08 has been taken into account in the process.

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   29/78

5.   Results

5.1. Station name translation table

The following list sums up the most interesting points used in the Microsearch Geolab input file.

Point description	Used name or code	Computation name
DORIS stations → DORIS antenna reference point → DORIS pillar/domed mark	 42202S007 42202M007	 ARFB ARFB_marker
GNSS permanent station → AREQ reference point	 42202M005	 AREQ
GNSS permanent station → AREG reference point → AREG antenna ARP	 42202M008 -	 AREG AREG_ARP
TLRS-3 SLR → TLRS-3 survey mount → Ranging system reference point → Reference station mark	 - - 42202M003	 TLRS-3_mount TLRS-3_SRP 7403
Geodetic points → «BM. CHR-5» → «EST-SATELITE 1961» → «EST-SATELITE 1961 REF 1» → «7403 RM2 89» → «AUX. SATELLITE 1958»	 42202M001 42202M002 42202M004 42202M009 42202M010	 42202M001 42202M002 42202M004 42202M009 42202M010
Calibration piers → Pier A → Pier B → Pier D	 - - -	 PierA PierB PierD

5.2. Adjusted coordinates and confidence regions

The results of the adjustment are the coordinates of all points and their confidence ellipsoids in the ITRF2008 at the mean epoch of the observations (i.e. epoch 2013 :03).
The table below provides the 3D coordinates and confidence region at 95 % of the points of interest.

```
================================================================================
      AREG (AREQUIPA) REGINA-DORIS-AREQ-SLR TIES - JANUARY 2013 SURVEY
Microsearch GeoLab, V2001.9.20.0              GRS 80      UNITS: m,GRAD
================================================================================
Adjusted XYZ Coordinates:
                        X-COORDINATE       Y-COORDINATE       Z-COORDINATE
  CODE FFF STATION            STD DEV            STD DEV            STD DEV
  ---- --- -----------  ------------------ ------------------ ------------------
  XYZ     42202M001      1942785.0322       -5804077.8842      -1796913.0713 m      0
                              0.0025             0.0017             0.0026
  XYZ     42202M002      1942784.5359       -5804081.6974      -1796911.2333 m      0
                              0.0015             0.0014             0.0015
  XYZ     42202M004      1942797.9661       -5804076.7189      -1796913.0034 m      0
                              0.0016             0.0018             0.0016
  XYZ     42202M009      1942822.3955       -5804071.4272      -1796893.2395 m      0
                              0.0011             0.0011             0.0011
  XYZ     42202M010      1942791.6315       -5804078.6736      -1796903.8810 m      0
                              0.0024             0.0016             0.0024
  XYZ     7403           1942807.6082       -5804069.7829      -1796915.6836 m      0
                              0.0032             0.0031             0.0032
  XYZ     AREG           1942816.3642       -5804077.1455      -1796884.4274 m      0
                              0.0011             0.0011             0.0011
  XYZ     AREG_ARP       1942816.4942       -5804077.5359      -1796884.5491 m      0
                              0.0011             0.0011             0.0011
  XYZ     AREQ           1942826.2250       -5804070.3420      -1796894.1910 m      0
                              0.0011             0.0011             0.0011
  XYZ     ARFB           1942803.3526       -5804071.5748      -1796922.1421 m      0
                              0.0011             0.0011             0.0011
  XYZ     ARFB_marker    1942803.1586       -5804070.9977      -1796921.9615 m      0
                              0.0011             0.0011             0.0011
  XYZ     PierA          1942836.6959       -5804090.1053      -1796815.9438 m      0
                              0.0013             0.0012             0.0011
  XYZ     PierB          1942888.9051       -5804064.0584      -1796848.0381 m      0
                              0.0014             0.0012             0.0014
  XYZ     PierD          1942782.5293       -5804064.3253      -1796960.1331 m      0
                              0.0013             0.0012             0.0013
  XYZ     TLRS-3_SRP     1942808.4252       -5804072.2382      -1796916.4368 m      0
                              0.0019             0.0017             0.0019
  XYZ     TLRS-3_mount   1942808.4782       -5804072.3965      -1796916.4862 m      0
                              0.0015             0.0014             0.0015
```

IGN	Thomas DONAL	RT/G 186
Service		v 1
de Géodésie	**Arequipa ITRF co-location survey**	
et Nivellement		page 31/78

```
===============================================================================
        AREG (AREQUIPA) REGINA-DORIS-AREQ-SLR TIES - JANUARY 2013 SURVEY
Microsearch GeoLab, V2001.9.20.0            GRS 80     UNITS: m,GRAD
===============================================================================
2-D and 1-D Station Confidence Regions (95.000 and 95.000 percent):
STATION             MAJOR SEMI-AXIS  AZ    MINOR SEMI-AXIS          VERTICAL
------------ --------------------- --- ------------------ --------------------
42202M001                  0.0065  33             0.0063               0.0029
42202M002                  0.0038 147             0.0036               0.0026
42202M004                  0.0039 141             0.0038               0.0037
42202M009                  0.0027 100             0.0027               0.0021
42202M010                  0.0062  67             0.0060               0.0027
7403                       0.0080 119             0.0080               0.0061
AREG                       0.0027  89             0.0027               0.0021
AREG_ARP                   0.0027  84             0.0027               0.0021
AREQ                       0.0026  90             0.0026               0.0021
ARFB                       0.0029 129             0.0027               0.0021
ARFB_marker                0.0029 130             0.0027               0.0021
PierA                      0.0033  93             0.0028               0.0022
PierB                      0.0035 130             0.0032               0.0023
PierD                      0.0033 130             0.0031               0.0022
TLRS-3_SRP                 0.0047 119             0.0046               0.0031
TLRS-3_mount               0.0038 119             0.0038               0.0027
```

The whole covariance matrix was computed, then it was possible to extract from it the covariance submatrix for the 4 main points of interest i.e. AREQ, AREG, ARFB and 7403 for the ITRF2013 computation. Finally, this covariance submatrix has been converted into the SINEX format using the « geotosnx » tool provided by Z. Altamimi. The resulting SINEX file (42202_IGN_2013-012_V10.SNX) is presented in appendix 6.8.

6. Appendixes

6.1. « ARFB » DORIS station site log

```
AREQUIPA DORIS site description form


0. Form

    Prepared by   : SIMB (DORIS installation and maintenance department)
    Date prepared : 30/01/2013
    Report type   : UPDATE


1. Site location information

    Site name           : AREQUIPA
    Site DOMES number   : 42202
    Host agency         : UNIVERSIDAD NACIONAL DE SAN AGUSTIN
    City                : Arequipa
    State or province   :
    Country             : PERU
    Tectonic plate      : SOAM
    Geological information :

    Geographical coordinates (ITRF) :
        North Latitude    :   -16 deg 27' 57''
        East Longitude    :   -71 deg 29' 35''
        Ellipsoid height  :  2490 m
        Approximate altitude :  2446 m


2. DORIS antenna and reference point information

2.1
    Four character ID       : AREA
    Antenna model           : Alcatel
    Antenna serial number   : 44
    IERS DOMES number       : 42202S005
    CNES/IGN number         : 422021
    DORIS SSALTO number     : 46
    Date installed (dd/mm/yy): 16/12/1988
    Date removed (dd/mm/yy) : 20/11/2001
    Antenna support type    : Guyed 2 metre tower
    Installed on            : Top of a load-bearing wall of a one storied
                              building with terrace roof.
    Height above ground mark : 2.198 m
    Ground mark type        : Brass mark 12 mm diam.
    Ground mark DOMES number : 42202M006
    Notes                   :

2.2
    Four character ID       : AREB
    Antenna model           : Starec 52291 type
    Antenna serial number   : 82
    IERS DOMES number       : 42202S006
    CNES/IGN number         : 422022
    DORIS SSALTO number     : 221
    Date installed (dd/mm/yy): 21/11/2001
    Date removed (dd/mm/yy) : 01/08/2006
    Antenna support type    : 40 cm diameter, 1.5 m high and 2m deep concrete
                              pillar
    Installed on            : 2 m sided, 0.5 m thick concrete footing at 2 m
                              depth
    Height above ground mark : 0.487 m
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 33/78

```
    Ground mark type         : Domed brass mark 12 mm diameter on pillar
    Ground mark DOMES number : 42202M007
    Notes                    :
```

2.3
```
    Four character ID        : ARFB
    Antenna model            : Starec 52291 type
    Antenna serial number    : 82
    IERS DOMES number        : 42202S007
    CNES/IGN number          : 422023
    DORIS SSALTO number      : 274
    Date installed (dd/mm/yy): 02/08/2006
    Date removed (dd/mm/yy)  :
    Antenna support type     : 40 cm diameter, 1.5 m high and 2m deep concrete
                               pillar
    Installed on             : 2 m sided, 0.5 m thick concrete footing at 2 m
                               depth
    Height above ground mark : 0.637 m
    Ground mark type         : Domed brass mark 12 mm diameter on pillar
    Ground mark DOMES number : 42202M007
    Notes                    :
```

3. DORIS beacons information

3.1
```
    Beacon serial number     : 8633046
    Beacon model             : 1.0
    USO serial number        : 1.400
    4 Char. ID of the REF point : AREA
    Date installed (dd/mm/yy)   : 16/12/1988
    Date removed (dd/mm/yy)     : 01/12/1992
```

3.2
```
    Beacon serial number     : 8627016
    Beacon model             : 1.0
    USO serial number        : 1.403
    4 Char. ID of the REF point : AREA
    Date installed (dd/mm/yy)   : 02/03/1993
    Date removed (dd/mm/yy)     : 20/11/2001
```

3.3
```
    Beacon serial number     : 8627016
    Beacon model             : 1.0
    USO serial number        : 1.403
    4 Char. ID of the REF point : AREB
    Date installed (dd/mm/yy)   : 21/11/2001
    Date removed (dd/mm/yy)     : 31/07/2006
```

3.4
```
    Beacon serial number     : 2819010
    Beacon model             : 3.0
    USO serial number        : 3.226
    4 Char. ID of the REF point : ARFB
    Date installed (dd/mm/yy)   : 01/08/2006
    Date removed (dd/mm/yy)     : 14/09/2011
```

3.5
```
    Beacon serial number     : 2819035
    Beacon model             : 3.0
    USO serial number        : 3.223
    4 Char. ID of the REF point : ARFB
    Date installed (dd/mm/yy)   : 14/09/2011
    Date removed (dd/mm/yy)     :
```

4. ITRF coordinates and velocities of the current DORIS ref. point (ARFB)

```
    Solution        : DPOD2008
    Epoch           : 2005.0

    X = 1942803.313 m    Y = -5804071.540 m    Z = -1796922.189 m
    Sig X = 0.003 m    Sig Y = 0.001 m    Sig Z = 0.001 m

    VX = -0.0011 m/y    VY = -0.0059 m/y    VZ = 0.0106 m/y
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 34/78

```
    Sig VX =  m/y   Sig VY =  m/y   Sig VZ =  m/y
```

5. IERS colocation information

5.1
```
    Instrument type      : GNSS
    Status               : Permanent
    DOMES number of the
    instrument ref. point : 42202M005
    Notes                :
```

5.2
```
    Instrument type      : SLR
    Status               : Permanent
    DOMES number of the
    instrument ref. point : 42202S001
    Notes                :
```

6. Tide Gauge colocation information

7. Local site ties

7.1
```
    Point description     : DORIS Alcatel antenna reference point (AREA)
    DOMES number          : 42202S005
    Differential components from the current DORIS ref. point (ARFB)
    to the above point (in the ITRS) :
    dX (m)                : -7.107
    dY (m)                : -6.233
    dZ (m)                : 2.814
    Accuracy (m)          : 0.002
    Date measured         : 01/11/2001
    Additional information : Survey by IGN-F
```

7.2
```
    Point description     : GPS Mark 4021-S (IGS station AREQ)
    DOMES number          : 42202M005
    Differential components from the current DORIS ref. point (ARFB)
    to the above point (in the ITRS) :
    dX (m)                : 22.873
    dY (m)                : 1.232
    dZ (m)                : 27.950
    Accuracy (m)          : 0.001
    Date measured         : 01/11/2001
    Additional information : Survey by IGN-F
```

7.3
```
    Point description     : DORIS Starec antenna reference point (AREB)
    DOMES number          : 42202S006
    Differential components from the current DORIS ref. point (ARFB)
    to the above point (in the ITRS) :
    dX (m)                : -0.046
    dY (m)                : 0.136
    dZ (m)                : 0.043
    Accuracy (m)          : 0.001
    Date measured         : 01/08/2006
    Additional information : Survey by IGN-F
```

7.4
```
    Point description     : Mark on concrete pillar, under the DORIS antenna
    DOMES number          : 42202M007
    Differential components from the current DORIS ref. point (ARFB)
    to the above point (in the ITRS) :
    dX (m)                : -0.194
    dY (m)                : 0.579
    dZ (m)                : 0.181
    Accuracy (m)          : 0.001
    Date measured         : 01/08/2006
    Additional information : Survey by IGN-F
```

8. Meteorological Instrumentation

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 35/78

```
8.1 Humidity sensor
    Model      : HMP45D
    Manufacturer : VAISALA
    Accuracy   : +/- 3 percents
    Notes      :

8.2 Pressure sensor
    Model      : PTU200 class B
    Manufacturer : VAISALA
    Accuracy   : +/- 0.25 hPa
    Height     : 1.7 m above the current DORIS ref. point (ARFB)
    Notes      : long term stability = +/- 0.1 hPa/year

8.3 Temperature sensor
    Model      : HMP45D
    Manufacturer : VAISALA
    Accuracy   : +/- 0.5 deg C
    Notes      :


9. DORIS network contacts

    Primary contact:

    Name            : Jerome SAUNIER
    Agency          : Institut Geographique National
    Mailing address : Service de Geodesie et Nivellement
                    : 73 avenue de Paris
                    : 94165 SAINT-MANDE Cedex    FRANCE
    Telephone       : + 33 1 43 98 83 63
    Fax             : + 33 1 43 98 84 50
    E-mail          : jerome (.) saunier (@) ign.fr

    Secondary contact:

    Name            : Francois BOLDO
    Agency          : Institut Geographique National
    Mailing address : CNES (DCT/ME/OC)
                    : 18 Avenue Edouard Belin
                    : 31401 TOULOUSE Cedex    FRANCE
    Telephone       : + 33 5 61 27 40 72
    Fax             : + 33 5 61 28 25 95
    E-mail          : simb (.) doris (@) cnes.fr
```

IGN	Thomas DONAL	RT/G 186
Service		v 1
de Géodésie	**Arequipa ITRF co-location survey**	
et Nivellement		page 36/78

6.2. « AREQ » GNSS station site log (extract)

Note : only the most relevant points to this survey were retained in the following extract. The complete version of this site log is available at : **http://www.igs.org/network/network_by_site.php?site=areq**

```
AREQ Site Information Form (site log)
    International GNSS Service
    See Instructions at:
      ftp://igscb.jpl.nasa.gov/pub/station/general/sitelog_instr.txt

0.   Form

     Prepared by (full name)  : David Maggert
     Date Prepared            : 2013-01-31
     Report Type              : UPDATE
     If Update:
      Previous Site Log        : areq_20120217.log
      Modified/Added Sections  : 10.5


1.   Site Identification of the GNSS Monument

     Site Name                : Arequipa Laser Station
     Four Character ID        : AREQ
     Monument Inscription     : 4021-S
     IERS DOMES Number        : 42202M005
     CDP Number               : None
     Monument Description     : CONCRETE PILLAR
       Height of the Monument : 0.7
       Monument Foundation    : CONCRETE BLOCK
       Foundation Depth       :
     Marker Description       : DIVOT IN STEEL PLATE
     Date Installed           : 1993-01-01
     Geologic Characteristic  :
       Bedrock Type           :
       Bedrock Condition      :
       Fracture Spacing       :
       Fault zones nearby     :
         Distance/activity    :
     Additional Information   : Eugeosynclinal belt of Mesozoic Age
                              : Quaternary alluvium overlying granodioritic
                              : upper Cretaceous lower Tertiary coastal
                              : batholith. This batholith contains faulted
                              : inliers of Precambrian gneiss.
                              : The monument is  ~50 m north of
                              : TLRS-3 Laser station
                              : Geological information from "NASA Space Geodesy
                              : Program Memorandum 4482" p10.


2.   Site Location Information

     City or Town             : Arequipa
     State or Province        :
     Country                  : Peru
     Tectonic Plate           : SOUTH AMERICAN
     Approximate Position (ITRF)
       X coordinate (m)       : 1942826.1920
       Y coordinate (m)       : -5804070.3310
       Z coordinate (m)       : -1796894.2670
       Latitude (N is +)      : -162755.8612
       Longitude (E is +)     : -0712934.0680
       Elevation (m,ellips.)  : 2488.9226
     Additional Information   : The site is located in western South America in
                              : southern Peru at the Smithsonian Astronomical
                              : Observatory.
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 37/78

```
3.    GNSS Receiver Information

3.1   Receiver Type            : ROGUE SNR-8000
      (...)

3.2   Receiver Type            : ROGUE SNR-8000
      (...)

3.3   Receiver Type            : ROGUE SNR-8000
      (...)

3.4   Receiver Type            : ROGUE SNR-8000
      (...)

3.5   Receiver Type            : AOA SNR-8000 ACT
      (...)

3.6   Receiver Type            : ASHTECH UZ-12
      (...)

3.7   Receiver Type            : ASHTECH UZ-12
      Satellite System         : GPS
      Serial Number            : ZR220010401
      Firmware Version         : CQ00
      Elevation Cutoff Setting : 4
      Date Installed           : 2006-05-21T00:00Z
      Date Removed             : CCYY-MM-DDThh:mmZ
      Temperature Stabiliz.    : none
      Additional Information   :

3.x   Receiver Type            : (A20, from rcvr_ant.tab; see instructions)
      Satellite System         : (GPS+GLO+GAL+BDS+QZSS+SBAS)
      Serial Number            : (A20, but note the first A5 is used in SINEX)
      Firmware Version         : (A11)
      Elevation Cutoff Setting : (deg)
      Date Installed           : (CCYY-MM-DDThh:mmZ)
      Date Removed             : (CCYY-MM-DDThh:mmZ)
      Temperature Stabiliz.    : (none or tolerance in degrees C)
      Additional Information   : (multiple lines)


4.    GNSS Antenna Information

4.1   Antenna Type             : AOAD/M_T        JPLA
      (...)

4.2   Antenna Type             : AOAD/M_T        JPLA
      (...)

4.3   Antenna Type             : AOAD/M_T        JPLA
      (...)

4.4   Antenna Type             : AOAD/M_T        NONE
      (...)

4.5   Antenna Type             : AOAD/M_T        JPLA
      Serial Number            : 294
      Antenna Reference Point  : BPA
      Marker->ARP Up Ecc. (m)  : 0.061
      Marker->ARP North Ecc(m) : 0.000
      Marker->ARP East Ecc(m)  : 0.000
      Alignment from True N     :
      Antenna Radome Type      : JPLA
      Radome Serial Number      :
      Antenna Cable Type       : Hutton LMR400
      Antenna Cable Length     : 45 m
      Date Installed           : 2012-02-03T00:00Z
      Date Removed             : CCYY-MM-DDThh:mmZ
      Additional Information   : JPLA radome re-installed

4.x   Antenna Type             : (A20, from rcvr_ant.tab; see instructions)
      Serial Number            : (A*, but note the first A5 is used in SINEX)
      Antenna Reference Point  : (BPA/BCR/XXX from "antenna.gra"; see instr.)
      Marker->ARP Up Ecc. (m)  : (F8.4)
      Marker->ARP North Ecc(m) : (F8.4)
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 38/78

```
      Marker->ARP East Ecc(m)  : (F8.4)
      Alignment from True N    : (deg; + is clockwise/east)
      Antenna Radome Type      : (A4 from rcvr_ant.tab; see instructions)
      Radome Serial Number     :
      Antenna Cable Type       : (vendor & type number)
      Antenna Cable Length     : (m)
      Date Installed           : (CCYY-MM-DDThh:mmZ)
      Date Removed             : (CCYY-MM-DDThh:mmZ)
      Additional Information   : (multiple lines)


  5.    Surveyed Local Ties

  5.1  Tied Marker Name        : CDP Station-7403
       Tied Marker Usage       : SLR
       Tied Marker CDP Number  : 7403
       Tied Marker DOMES Number : 42202M003
       Differential Components from GNSS Marker to the tied monument (ITRS)
         dx (m)                : -18.6152
         dy (m)                : 0.5478
         dz (m)                : -21.4987
       Accuracy (mm)           :
       Survey method           :
       Date Measured           : 1994-03-07
       Additional Information   : Mark SLR
                                : Site Ref Domes Number and information from
                                : "IERS Tech Note 20, Results and Analysis of the
                                : ITRF94" March 1996, Tables T2 pT24 and T4 pT56.

  5.2  Tied Marker Name        : EST SATELITE (East Satellite mark Ref. 1)
       Tied Marker Usage       :
       Tied Marker CDP Number  : none
       Tied Marker DOMES Number : 42202M004
       Differential Components from GNSS Marker to the tied monument (ITRS)
         dx (m)                : -41.6902
         dy (m)                : -11.3518
         dz (m)                : -17.0411
       Accuracy (mm)           :
       Survey method           :
       Date Measured           : 1994-03-07
       Additional Information   : No CDP number listed in, and Monument Name in
                                : parentheses from
                                : and Analysis of the ITRF94" March 1996, Table T2
                                : pT24.

  5.3  Tied Marker Name        : DORIS Ref Pt
       Tied Marker Usage       :
       Tied Marker CDP Number  : none
       Tied Marker DOMES Number : 42202S005
       Differential Components from GNSS Marker to the tied monument (ITRS)
         dx (m)                : -29.9827
         dy (m)                : -07.4719
         dz (m)                : -25.1257
       Accuracy (mm)           :
       Survey method           :
       Date Measured           : 1994-03-07
       Additional Information   : No CDP number listed in Table T2 pT24, and Site
                                : Ref Domes from Tables T2 pT24 and T4 pT56
                                : Tech Note 20, Results and Analysis of the
                                : ITRF94" March 1996.

  5.x  Tied Marker Name        :
       Tied Marker Usage       : (SLR/VLBI/LOCAL CONTROL/FOOTPRINT/etc)
       Tied Marker CDP Number  : (A4)
       Tied Marker DOMES Number : (A9)
       Differential Components from GNSS Marker to the tied monument (ITRS)
         dx (m)                : (m)
         dy (m)                : (m)
         dz (m)                : (m)
       Accuracy (mm)           : (mm)
       Survey method           : (GPS CAMPAIGN/TRILATERATION/TRIANGULATION/etc)
       Date Measured           : (CCYY-MM-DDThh:mmZ)
       Additional Information   : (multiple lines)
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 39/78

```
6.    Frequency Standard

(...)


7.    Collocation Information

7.1   Instrumentation Type    : DORIS/SLR
        Status               : (PERMANENT/MOBILE)
        Effective Dates      : (CCYY-MM-DD/CCYY-MM-DD)
        Notes                :

7.x   Instrumentation Type    : (GPS/GLONASS/DORIS/PRARE/SLR/VLBI/TIME/etc)
        Status               : (PERMANENT/MOBILE)
        Effective Dates      : (CCYY-MM-DD/CCYY-MM-DD)
        Notes                : (multiple lines)


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               : Jet Propulsion Laboratory
        Preferred Abbreviation : JPL
        Mailing Address      : 4800 Oak Grove Drive
                             : Pasadena, CA
                             : USA    91109
        Primary Contact
          Contact Name       : David A. Stowers
          Telephone (primary) : 818-354-7055
          Telephone (secondary) :
          Fax                : 818-393-4965
          E-mail             : dstowers@jpl.nasa.gov
        Secondary Contact
          Contact Name       : UNAVCO Network Engineer
          Telephone (primary) : 303-381-7500
          Telephone (secondary) :
          Fax                : 303-381-7451
          E-mail             : ggn-ops@ls.unavco.org
        Additional Information :


12.   Responsible Agency (if different from 11.)

        Agency               :
        Preferred Abbreviation :
        Mailing Address      :
        Primary Contact
          Contact Name       :
          Telephone (primary) :
          Telephone (secondary) :
          Fax                :
          E-mail             :
        Secondary Contact
          Contact Name       :
          Telephone (primary) :
          Telephone (secondary) :
          Fax                :
          E-mail             :
        Additional Information :

13.   More Information

        Primary Data Center  : JPL (ODC-Operational Data Center)
```
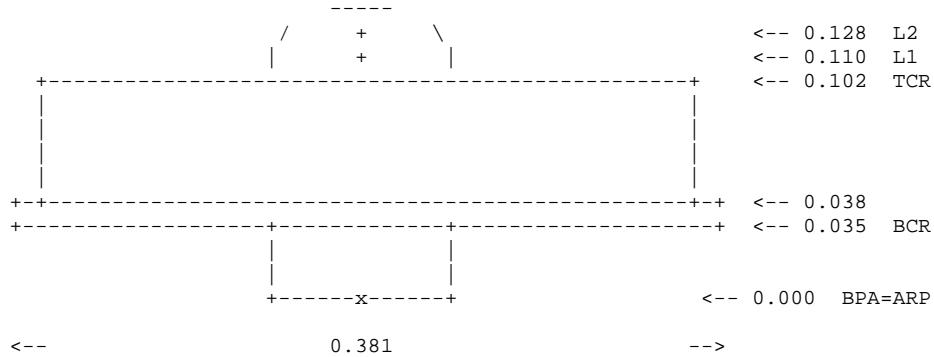
IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 40/78

```
    Secondary Data Center   : CDDIS (GDC-Global Data Center)
    URL for More Information :
    Hardcopy on File
      Site Map            :
      Site Diagram        :
      Horizon Mask        :
      Monument Description  :
      Site Pictures       : Y
    Additional Information   :
    Antenna Graphics with Dimensions


 AOAD/M_T


                          -----
                       /     +     \                      <-- 0.128  L2
                       |     +     |                      <-- 0.110  L1
      +----------------------------------------------+    <-- 0.102  TCR
      |                                              |
      |                                              |
      |                                              |
      |                                              |
    +-+----------------------------------------------+-+  <-- 0.038
    +------------------+-----------+------------------+    <-- 0.035  BCR
                       |           |
                       |           |
                       +------x------+                    <-- 0.000  BPA=ARP

    <--                    0.381                    -->

     ARP: Antenna Reference Point
     L1 : L1 Phase Center              L2 : L2 Phase Center
     TCR: Top of Chokering             BCR: Bottom of Chokering
     TGP: Top of Ground Plane          BGP: Bottom of Ground Plane
     TPA: Top of Preamplifier          BPA: Bottom of Preamplifier
     TOP: Top of Pole

 All dimensions are in meters.
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   41/78

6.3. « AREG » GNSS station site log

```
AREG Site Information Form
    International GNSS Service
    See Instructions at:
      ftp://igscb.jpl.nasa.gov/pub/station/general/sitelog_instr.txt

0.    Form

      Prepared by (full name)  : Thomas DONAL
      Date Prepared            : 2013-05-07
      Report Type              : update
      If Update:
       Previous Site Log       : areg_20130403.log
       Modified/Added Sections : 1

1.    Site Identification of the GNSS Monument

      Site Name                : Arequipa
      Four Character ID         : AREG
      Monument Inscription      : None
      IERS DOMES Number         : 42202M008
      CDP Number                : (A4)
      Monument Description      : concrete pillar and 40 cm steel antenna mount
        Height of the Monument : 1.6 m
        Monument Foundation     : concrete block
        Foundation Depth        : 1 m
      Marker Description        : brass hemispheric mark top of pillar
      Date Installed            : 2013-01-11
      Geologic Characteristic   : (BEDROCK/CLAY/CONGLOMERATE/GRAVEL/SAND/etc)
        Bedrock Type            : (IGNEOUS/METAMORPHIC/SEDIMENTARY)
        Bedrock Condition       : (FRESH/JOINTED/WEATHERED)
        Fracture Spacing        : (1-10 cm/10-50 cm/50-200 cm/over 200 cm)
        Fault zones nearby      : (YES/NO/Name of the zone)
          Distance/activity     : (multiple lines)
      Additional Information    : Eugeosynclinal belt of Mesozoic Age
                                : Quaternary alluvium overlying granodioritic
                                : upper Cretaceous lower Tertiary coastal
                                : batholith. This batholith contains faulted
                                : inliers of Precambrian gneiss.
                                : Geological information from "NASA Space Geodesy
                                : Program Memorandum 4482" p10.

2.    Site Location Information

      City or Town             : Arequipa
      State or Province         :
      Country                   : Peru
      Tectonic Plate            : SOUTH AMERICAN
      Approximate Position (ITRF)
        X coordinate (m)        : 1942816.3600
        Y coordinate (m)        : -5804077.1439
        Z coordinate (m)        : -1796884.4370
        Latitude (N is +)       : -162755.52356
        Longitude (E is +)      : -0712934.45497
        Elevation (m,ellips.)   : 2489.3392
      Additional Information    : IGS08 EPOCH 2012.0
                                : The site is located in western South America in
                                : southern Peru at Characato Observatory.

3.    GNSS Receiver Information

3.1   Receiver Type            : TRIMBLE NETR9
      Satellite System          : GPS+GLO+GAL+SBAS
      Serial Number             : 77739
      Firmware Version          : 4.62
      Elevation Cutoff Setting : 3 deg
      Date Installed            : 2013-01-11T00:00Z
      Date Removed              : 2013-04-03T13:30Z
      Temperature Stabiliz.     : 25 C +/- 5 C
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 42/78

```
           Additional Information    : (multiple lines)

     3.2   Receiver Type             : TRIMBLE NETR9
           Satellite System         : GPS+GLO+GAL+BDS+SBAS
           Serial Number            : 77739
           Firmware Version         : 4.7
           Elevation Cutoff Setting : 3 deg
           Date Installed           : 2013-04-03T13:35Z
           Date Removed             : (CCYY-MM-DDThh:mmZ)
           Temperature Stabiliz.    : 25 C +/- 5 C
           Additional Information    : (multiple lines)

     3.x   Receiver Type             : (A20, from rcvr_ant.tab; see instructions)
           Satellite System         : (GPS+GLO+GAL+BDS+QZSS+SBAS)
           Serial Number            : (A20, but note the first A5 is used in SINEX)
           Firmware Version         : (A11)
           Elevation Cutoff Setting : (deg)
           Date Installed           : (CCYY-MM-DDThh:mmZ)
           Date Removed             : (CCYY-MM-DDThh:mmZ)
           Temperature Stabiliz.    : (none or tolerance in degrees C)
           Additional Information    : (multiple lines)

     4.   GNSS Antenna Information

     4.1   Antenna Type             : TRM59800.00     NONE
           Serial Number            : 54209
           Antenna Reference Point  : BPA
           Marker->ARP Up Ecc. (m)  : 000.4291
           Marker->ARP North Ecc(m) : 000.0000
           Marker->ARP East Ecc(m)  : -000.0006
           Alignment from True N     : 0
           Antenna Radome Type      : NONE
           Radome Serial Number     :
           Antenna Cable Type       : TRIMBLE
           Antenna Cable Length     : 45 m
           Date Installed           : 2013-01-11T00:00Z
           Date Removed             :(CCYY-MM-DDThh:mmZ)
           Additional Information    :(multiple lines)

     4.x   Antenna Type             : (A20, from rcvr_ant.tab; see instructions)
           Serial Number            : (A*, but note the first A5 is used in SINEX)
           Antenna Reference Point  : (BPA/BCR/XXX from "antenna.gra"; see instr.)
           Marker->ARP Up Ecc. (m)  : (F8.4)
           Marker->ARP North Ecc(m) : (F8.4)
           Marker->ARP East Ecc(m)  : (F8.4)
           Alignment from True N     : (deg; + is clockwise/east)
           Antenna Radome Type      : (A4 from rcvr_ant.tab; see instructions)
           Radome Serial Number     :
           Antenna Cable Type       : (vendor & type number)
           Antenna Cable Length     : (m)
           Date Installed           : (CCYY-MM-DDThh:mmZ)
           Date Removed             : (CCYY-MM-DDThh:mmZ)
           Additional Information    : (multiple lines)

     5.   Surveyed Local Ties

     5.1   Tied Marker Name         : AREQ
           Tied Marker Usage        : GNSS
           Tied Marker CDP Number   :
           Tied Marker DOMES Number : 42202M005
           Differential Components from GNSS Marker to the tied monument (ITRS)
             dx (m)                 : 9.8607
             dy (m)                 : 6.8035
             dz (m)                 : -9.7636
           Accuracy (mm)            : 1
           Survey method            : TRIANGULATION
           Date Measured            : 2013-01-12
           Additional Information    : high geodetic surveying proceed by IGN-F

     5.2   Tied Marker Name         : DORIS antenna ref. pt.(ARFB)
           Tied Marker Usage        : (SLR/VLBI/LOCAL CONTROL/FOOTPRINT/etc)
           Tied Marker CDP Number   :
           Tied Marker DOMES Number : 42202S007
           Differential Components from GNSS Marker to the tied monument (ITRS)
             dx (m)                 : -13.0116
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 43/78

```
             dy (m)                   : 5.5708
             dz (m)                   : -37.7147
         Accuracy (mm)                : 1
         Survey method                : TRIANGULATION
         Date Measured                : 2013-01-12
         Additional Information       : high geodetic surveying proceed by IGN-F

    5.3  Tied Marker Name            : Marker DORIS
         Tied Marker Usage           : (SLR/VLBI/LOCAL CONTROL/FOOTPRINT/etc)
         Tied Marker CDP Number      :
         Tied Marker DOMES Number : 42202M007
         Differential Components from GNSS Marker to the tied monument (ITRS)
             dx (m)                   : -13.2056
             dy (m)                   : 6.1479
             dz (m)                   : -37.5341
         Accuracy (mm)                : 1
         Survey method                : TRIANGULATION
         Date Measured                : 2013-01-12
         Additional Information       : high geodetic surveying proceed by IGN-F

    5.x  Tied Marker Name            :
         Tied Marker Usage           : (SLR/VLBI/LOCAL CONTROL/FOOTPRINT/etc)
         Tied Marker CDP Number      : (A4)
         Tied Marker DOMES Number : (A9)
         Differential Components from GNSS Marker to the tied monument (ITRS)
             dx (m)                   :
             dy (m)                   :
             dz (m)                   :
         Accuracy (mm)                : (mm)
         Survey method                : (GPS CAMPAIGN/TRILATERATION/TRIANGULATION/etc)
         Date Measured                : (CCYY-MM-DDThh:mmZ)
         Additional Information       : (multiple lines)

    6.   Frequency Standard


    6.1  Standard Type               : INTERNAL
         Input Frequency             :
         Effective Dates             : 2013-01-11T00:00Z/CCYY-MM-DD
         Notes                       : steering enabled
    6.x  Standard Type               : (INTERNAL or EXTERNAL H-MASER/CESIUM/etc)
         Input Frequency             : (if external)
         Effective Dates             : (CCYY-MM-DD/CCYY-MM-DD)
         Notes                       : (multiple lines)

    7.   Collocation Information

    7.1  Instrumentation Type        : DORIS
         Status                      : PERMANENT
         Effective Dates             : (1988-12-16/CCYY-MM-DD)
         Notes                       : (multiple lines)

    7.2  Instrumentation Type        : GPS
         Status                      : PERMANENT
         Effective Dates             : (1994-02-01/CCYY-MM-DD)
         Notes                       : (multiple lines)

    7.3  Instrumentation Type        : SLR
         Status                      : PERMANENT
         Effective Dates             : (1992-07-10/CCYY-MM-DD)
         Notes                       : (multiple lines)

    7.x  Instrumentation Type        : (GPS/GLONASS/DORIS/PRARE/SLR/VLBI/TIME/etc)
         Status                      : (PERMANENT/MOBILE)
         Effective Dates             : (CCYY-MM-DD/CCYY-MM-DD)
         Notes                       : (multiple lines)


    8.   Meteorological Instrumentation


    8.1.1  Humidity Sensor Model  :
         Manufacturer              :
         Serial Number             :
         Data Sampling Interval :
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 44/78

```
          Accuracy (% rel h)     : (% rel h)
          Aspiration             : (UNASPIRATED/NATURAL/FAN/etc)
          Height Diff to Ant     : (m)
          Calibration date       : (CCYY-MM-DD)
          Effective Dates        : CCYY-MM-DD/CCYY-MM-DD
          Notes                  : (multiple lines)

   8.1.x  Humidity Sensor Model  :
          Manufacturer           :
          Serial Number          :
          Data Sampling Interval : (sec)
          Accuracy (% rel h)     : (% rel h)
          Aspiration             : (UNASPIRATED/NATURAL/FAN/etc)
          Height Diff to Ant     : (m)
          Calibration date       : (CCYY-MM-DD)
          Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
          Notes                  : (multiple lines)

   8.2.1  Pressure Sensor Model  :
          Manufacturer           :
          Serial Number          :
          Data Sampling Interval :
          Accuracy               : (mbar)
          Height Diff to Ant     : (m)
          Calibration date       : (CCYY-MM-DD)
          Effective Dates        : CCYY-MM-DD/CCYY-MM-DD
          Notes                  : (multiple lines)

   8.2.x  Pressure Sensor Model  :
          Manufacturer           :
          Serial Number          :
          Data Sampling Interval : (sec)
          Accuracy               : (hPa)
          Height Diff to Ant     : (m)
          Calibration date       : (CCYY-MM-DD)
          Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
          Notes                  : (multiple lines)

   8.3.1  Temp. Sensor Model     :
          Manufacturer           :
          Serial Number          :
          Data Sampling Interval :
          Accuracy               : (deg C)
          Aspiration             : (UNASPIRATED/NATURAL/FAN/etc)
          Height Diff to Ant     : (m)
          Calibration date       : (CCYY-MM-DD)
          Effective Dates        : CCYY-MM-DD/CCYY-MM-DD
          Notes                  : (multiple lines)

   8.3.x  Temp. Sensor Model     :
          Manufacturer           :
          Serial Number          :
          Data Sampling Interval : (sec)
          Accuracy               : (hPa)
          Aspiration             : (UNASPIRATED/NATURAL/FAN/etc)
          Height Diff to Ant     : (m)
          Calibration date       : (CCYY-MM-DD)
          Effective Dates        : (CCYY-MM-DD/CCYY-MM-DD)
          Notes                  : (multiple lines)

   8.4.1  Water Vapor Radiometer :
          Manufacturer           :
          Serial Number          :
          Distance to Antenna    : (m)
          Height Diff to Ant     : (m)
          Calibration date       : (CCYY-MM-DD)
          Effective Dates        : CCYY-MM-DD/CCYY-MM-DD
          Notes                  : (multiple lines)

   8.4.x  Water Vapor Radiometer :
          Manufacturer           :
          Serial Number          :
          Distance to Antenna    : (m)
          Height Diff to Ant     : (m)
          Calibration date       : (CCYY-MM-DD)
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 45/78

```
                Effective Dates       : (CCYY-MM-DD/CCYY-MM-DD)
                Notes                 : (multiple lines)

        8.5.1   Other Instrumentation : (multiple lines)

        8.5.x   Other Instrumentation :

        9.    Local Ongoing Conditions Possibly Affecting Computed Position


        9.1.x   Radio Interferences   : (TV/CELL PHONE ANTENNA/RADAR/etc)
                Observed Degredations  : (SN RATIO/DATA GAPS/etc)
                Effective Dates       : (CCYY-MM-DD/CCYY-MM-DD)
                Additional Information : (multiple lines)

        9.2.x   Multipath Sources     : (METAL ROOF/DOME/VLBI ANTENNA/etc)
                Effective Dates       : (CCYY-MM-DD/CCYY-MM-DD)
                Additional Information : (multiple lines)

        9.3.x   Signal Obstructions   : (TREES/BUILDLINGS/etc)
                Effective Dates       : (CCYY-MM-DD/CCYY-MM-DD)
                Additional Information : (multiple lines)

        10.    Local Episodic Effects Possibly Affecting Data Quality


        10.x Date                     : (CCYY-MM-DD/CCYY-MM-DD)
             Event                    : (TREE CLEARING/CONSTRUCTION/etc)

        11.    On-Site, Point of Contact Agency Information

                Agency                : Observatory of Characato
                                      : Universitad National de San Agustin
                Preferred Abbreviation : UNSA
                Mailing Address       : UNIVERSIDAD NACIONAL DE SAN AGUSTIN
                                      : Observatorio de Characato
                                      : AREQUIPA
                Primary Contact
                  Contact Name        : Pablo Raul Yanyachi
                  Telephone (primary) : +51 54 236876
                  Telephone (secondary) : +51 959626624
                  Fax                 :
                  E-mail              : raulpab1@hotmail.com
                Secondary Contact
                  Contact Name        :
                  Telephone (primary) :
                  Telephone (secondary) :
                  Fax                 :
                  E-mail              :
                Additional Information  : (multiple lines)

        12.    Responsible Agency (if different from 11.)

                Agency                : Centre National d'Etudes Spatiales
                Preferred Abbreviation : CNES
                Mailing Address       : CNES DCT/ME/NC 18, avenue Edouard Belin
                                      : 31401 Toulouse cedex 09 - France
                Primary Contact
                  Contact Name        : Alain Brissaud
                  Telephone (primary) :
                  Telephone (secondary) :
                  Fax                 :
                  E-mail              : alain.brissaud@cnes.fr
                Secondary Contact
                  Contact Name        : Jean Paul Cardaliaguet
                  Telephone (primary) : (33) 5.61.27.31.98
                  Telephone (secondary) : (33) 5.61.28.35.22
                  Fax                 :
                  E-mail              : jean-paul.cardaliaguet@cnes.fr
                  Additional Information  : generic email - regina.operation@cnes.fr

        13.    More Information

                Primary Data Center   : IGN
                Secondary Data Center : CDDIS
```
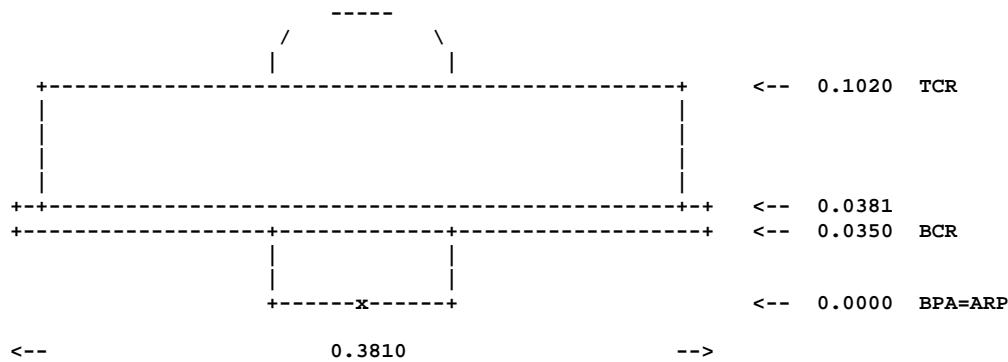
IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 46/78

```
            URL for More Information :
            Hardcopy on File
              Site Map              : (Y or URL)
              Site Diagram          : (Y or URL)
              Horizon Mask          : (Y or URL)
              Monument Description   : (Y or URL)
              Site Pictures         : (Y or URL)
              Additional Information  : (multiple lines)
              Antenna Graphics with Dimensions


     TRM59800.00


                            -----
                        /           \
                        |           |
            +-------------------------------------------------+     <--  0.1020   TCR
            |                                                 |
            |                                                 |
            |                                                 |
            |                                                 |
          +-+-----------------------------------------------+-+     <--  0.0381
          +------------------+------------+------------------+     <--  0.0350   BCR
                        |            |
                        |            |
                        +------x------+                            <--  0.0000   BPA=ARP

          <--                    0.3810                    -->


     Abbreviations
     -------------
     ARP: antenna reference point
     BCR: bottom of chokering
     BPA: bottom of preamplifier
     TCR: top of chokering

     Dimensions
     ----------
     All dimensions are in meters.
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 47/78

6.4. « AREL » SLR station site log (extract)

Note : only the most relevant information relating to this survey is provided in the following extract. The complete version of the site log is available at : **http://ilrs.gsfc.nasa.gov/network/stations/active/AREL_sitelog.html**

```
ILRS Site and System Information Form International Laser Ranging Service

0.    Form

      Prepared by (Full Name)   : Nikki Desch
      Preparer E-mail           : nikki.desch@exelisinc.com
      Date Prepared             : 2012-09-12
      Report Type               : UPDATE
      Format Version            : 1.1

1.    Identification of the Ranging System Reference Point (SRP)

      Site Name                 : Arequipa
      IERS DOMES Number         : 42202M003
      CDP Pad ID                : 7403
      Subnetwork                : NASA
      Description               : MONUMENT
      Monument Description       : STANDARD NASA DISK
      Monument Inscription      : NASA 7403-1989
      Mark Description          : Brass Plate
      Date Installed            : 1992-07-10
      Date Removed              : (yyyy-mm-dd)
      Geologic Characteristic   : Eugeosynclinal belt of Mesozoic Age
                                    : Quaternary alluvium overlying
                                    : granodioritic upper Cretaceous lower
                                    : Tertiary coastal batholith. This
                                    : batholith contains faulted inliers
                                    : of Precambrian gneiss.
      Additional Information    : (multiple lines)

2.    Site Location Information

      City or Town              : Characato
      State or Province         : Arequipa
      Country                   : Peru
      Tectonic Plate            : South American
      Approximate Position
        X coordinate      [m]: 1942808.1
        Y coordinate      [m]: -5804069.7
        Z coordinate      [m]: -1796915.4
        Latitude        [deg]: 16.4657 S
        Longitude       [deg]: 71.4930 W
        Elevation         [m]: 2489.05
      Additional Information    : Measured against Mean Sea Level,
                                    : ITRF2008, NAD83, WGS84

3.    General System Information

3.01 System Name                : TLRS 3
      4-Character Code          : AREL
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 48/78

```
            CDP System Number         : 13
            CDP Occupation Number     : 03
            Eccentricity to SRP (if Not Identical With SRP)
              North              [m]: 0.010 +- 0.002
              East               [m]:-0.006 +- 0.002
              Up                 [m]: 2.695 +- 0.002
              Date Measured          : 1994-03-18
            Date Installed           : 1992-07-10
            Date Removed             : (yyyy-mm-dd)
            Additional Information   : (multiple lines)

   3.02 System Name              : TLRS 3
            4-Character Code         : AREL
            CDP System Number        : 13
            CDP Occupation Number    : 03
            Eccentricity to SRP (if Not Identical With SRP)
              North              [m]: 0.0112 +- 0.002
              East               [m]:-0.0046 +- 0.002
              Up                 [m]: 2.6951  +- 0.002
              Date Measured          : 2001-06-27
            Date Installed           : 1992-07-10
            Date Removed             : (yyyy-mm-dd)
            Additional Information   : Based on crew measurements to horizontal
                                      : ground targets on June 4 and June 21
                                      : and then again on June 27. No significant
                                      : change from March 1994 survey

   3.02 System Name              : TLRS 3
            4-Character Code         : AREL
            CDP System Number        : 13
            CDP Occupation Number    : 04
            Eccentricity to SRP (if Not Identical With SRP)
              North              [m]:
              East               [m]:
              Up                 [m]:
              Date Measured          :
            Date Installed           : 1992-07-10
            Date Removed             : (yyyy-mm-dd)
            Additional Information   : Crew will perform survey measurements in future.

   4.   Telescope Information
   (…)

   5.   Laser System Information
   (…)

   6.   Receiver System
   (…)

   7.   Tracking Capabilities
   (…)

   8.   Calibration
   (…)

   9.   Time and Frequency Standards
   (…)

   10.  Preprocessing Information
   (…)
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 49/78

```
11.    Aircraft Detection
(…)


12.    Meteorological Instrumentation
(…)


13.    Local Ties, Eccentricities, and Collocation Information

13.01 Collocated Permanent Geodetic Systems

       GPS                    : IGS
         Date Installed       : 1994-02-01
         Date Removed         : (yyyy-mm-dd)
         Additional Information : (multiple lines)
       GLONASS                : NO
         Date Installed       : (yyyy-mm-dd)
         Date Removed         : (yyyy-mm-dd)
         Additional Information : (multiple lines)
       DORIS                  : IDS
         Date Installed       : 1988-12-16
         Date Removed         : (yyyy-mm-dd)
         Additional Information : (multiple lines)
       PRARE                  : NO
         Date Installed       : (yyyy-mm-dd)
         Date Removed         : (yyyy-mm-dd)
         Additional Information : (multiple lines)
       VLBI                   : NO
         Date Installed       : (yyyy-mm-dd)
         Date Removed         : (yyyy-mm-dd)
         Additional Information : (multiple lines)
       Gravimeter             : NO
         Date Installed       : (yyyy-mm-dd)
         Date Removed         : (yyyy-mm-dd)
         Additional Information : (multiple lines)

13.02.xx Local Ties from the SRP to Other Monuments or Systems on Site

         Monument Name         :
         Instrumentation Type  : (GPS/GLONASS/DORIS/PRARE/SLR/VLBI/NONE)
         Instrumentation Status : (PERMANENT/MOBILE)
         DOMES Number          : (XXXXXXXXX)
         CDP Number            : (XXXX)
         Differential Components (ITRS)
           dx              [m]: (m +- m)
           dy              [m]: (m +- m)
           dz              [m]: (m +- m)
          Date Measured        : (yyyy-mm-dd)
          Determined by        :
         Date Installed        : (yyyy-mm-dd)
         Date Removed          : (yyyy-mm-dd)
         Additional Information : (multiple lines)

13.03.01 Eccentricities Between Other Monuments on Site

         From: Monument Name   : Mark SLR
               DOMES Number    : 42202M003
               CDP Number      : 7403
         To:   Monument Name   : SAO-2 fixed laser
               DOMES Number    : 42202S001
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 50/78

```
                        CDP Number        : 7907
            Differential Components (ITRS)
              dx              [m]: -16.021 +- 0.002
              dy              [m]:  -7.914 +- 0.002
              dz              [m]:  -3.651 +- 0.002
              Date Measured        : 1994-03-18
              Determined by        : HTSI
            Additional Information  : (multiple lines)


13.03.02 Eccentricities Between Other Monuments on Site

            From: Monument Name      : Mark SLR
                  DOMES Number       : 42202M003
                  CDP Number         : 7403
            To:   Monument Name      : GPS marker JPL 4021-s
                  DOMES Number       : 42202M005
                  CDP Number         : N.A.
            Differential Components (ITRS)
              dx              [m]:  18.615 +- 0.002
              dy              [m]:  -0.548 +- 0.002
              dz              [m]:  21.499 +- 0.002
              Date Measured        : 1994-03-18
              Determined by        : HTSI
            Additional Information  : (multiple lines)


13.03.03 Eccentricities Between Other Monuments on Site

            From: Monument Name      : Mark SLR
                  DOMES Number       : 42202M003
                  CDP Number         : 7403
            To:   Monument Name      : DORIS antenna ref. pt
                  DOMES Number       : 42202S005
                  CDP Number         : N.A.
            Differential Components (ITRS)
              dx              [m]: -11.368 +- 0.002
              dy              [m]:  -8.020 +- 0.002
              dz              [m]:  -3.627 +- 0.002
              Date Measured        : 1994-03-18
              Determined by        : HTSI
            Additional Information  : (multiple lines)


13.03.03 Eccentricities Between Other Monuments on Site

            From: Monument Name      : Mark SLR
                  DOMES Number       : 42202M003
                  CDP Number         : 7403
            To:   Monument Name      : DORIS antenna ref. pt
                  DOMES Number       : 42202S005
                  CDP Number         : N.A.
            Differential Components (ITRS)
              dx              [m]:
              dy              [m]:
              dz              [m]:
              Date Measured        :
              Determined by        : HTSI
            Additional Information  : (Measurements did not occur in 2007)


14.   Local Events Possibly Affecting Computed Position


14.01 Date                     : 2001-06-23 20:33 UT
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 51/78

```
             Event                       : EARTHQUAKE
             Additional Information      : 8.4 earthquake was centered 180Km west of
                                          : site

 14.02 Date                              : 2001-07-07 09:38 UT
             Event                       : EARTHQUAKE
             Additional Information      : 7.6 aftershock of the June 23rd earthquake
                                          : was centered 100Km South of the site

 15.     On-Site, Point of Contact Agency Information

             Agency                      : UNSA
             Mailing Address             : Cerro San Francisco s/n, Observatorio de Characato
UNSA - Arequipa
             Primary Contact
                Contact Name             : Dr. Pablo Raul Yanyachi
                Telephone (station)      : 51-54-448211
                Telephone (secondary)    : 51-54-959626624
                Fax                      : 51-54-448418
                E-mail                   : t3mgr@unsa.edu.pe, raulpab@unsa.edu.pe
             Secondary Contact
                Contact Name             :
                Telephone (station)      :
                Telephone (secondary)    :
                Fax                      :
                E-mail                   :
             Additional Information      : (multiple lines)

 16.     Responsible Agency (if different from 15.)

             Agency                      : NASA, Code 453
             Mailing Address             : Code 453
                                             : NASA/GSFC
                                             : Greenbelt, MD 20771 USA
             Primary Contact
                Contact Name             : Dave McCormick
                Telephone (primary)      : 301-286-2354
                Telephone (secondary)    : 301-377-2711
                Fax                      : 301-286-0328
                E-mail                   : Dave.Mccormick@nasa.gov
             Secondary Contact
                Contact Name             : Curtis Emerson
                Telephone (primary)      : 301-286-7670
                Telephone (secondary)    : 301-286-3065
                Fax                      : 301-286-0328
                E-mail                   : Curtis.Emerson@nasa.gov
             Additional Information      : (multiple lines)

 17.     More Information

             URL for More Information    : http://www.unsa.edu.pe/index.php/investigacion/ins-
titutos-de-investigacion/nasa-laser-tracking-station
             Hardcopy on File
                Site Map                 : YES
                Site Diagram             : YES
                Horizon Mask             : YES
                Monument Description      : YES
                Site Pictures            : YES
             Additional Information      : (multiple lines)
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   52/78

6.5. Leica Geo Office report file

- when it has to be **right**

Leica
Geosystems

Récapitulatif du Traitement

AREQUIPA

Informations sur le Projet

Nom du Projet:	AREQUIPA
Date de création:	02/07/2013 08:43:38
Fuseau Horaire:	1h 00'
Nom Syst. Coordonnées:	WGS 1984
Logiciel d'application:	LEICA Geo Office 8.1
Date et heure de début:	01/11/2013 14:27:14
Date et heure de fin:	01/11/2013 23:57:44
Points occupés manuellement:	2
Noyau de Post-Traitement:	PSI-Pro 3.0
Traité:	07/08/2013 11:44:00

Paramètres de Traitement

Paramètres	Sélectionnés
Angle de Coupure:	5°
Type d'Ephémérides:	Précises
Type de solution:	Automatique
Type GNSS:	Automatique
Fréquence:	Automatique
Fixer les ambiguïtés jusqu'à:	80 km
Durée mini pour solution flottante (statique):	5' 00"
Taux d'échantillonnage:	Tout Utiliser
Modèle Troposphérique:	Hopfield
Modèle Ionosphérique:	Automatique
Utiliser modélisation statistique:	Oui
Distance mini.:	8 km
Activité ionosphérique:	Automatique

Ligne de Base - Aperçu

AREQ - Pier D	Référence: AREQ	Mobile: Pier D
Type de capteur / N° S:	ASHTECH / 220010401	GX1230GG / 472271
Type d'antenne / N° S:	AOAD/M_T NONE / -	LEIAX1202GG NONE / -
Hauteur d'antenne:	0.0610 m	0.0000 m

Coordonnées:

Latitude:	16° 27' 55.85865" S	16° 27' 58.09551" S
Longitude:	71° 29' 34.06706" O	71° 29' 35.39914" O
Hteur Ellip.:	2488.9212 m	2488.7680 m

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   53/78

Type de solution:	Phase: toutes fixes		
Type GNSS:	GPS		
Fréquence:	L1/E1 et L2		
Ambiguïté:	Oui		
Plage horaire:	01/11/2013 14:41:14 - 01/11/2013 23:19:44		
Durée:	8h 38' 30"		

Qualité:	ET Lat: 0.0000 m	ET Lon: 0.0000 m	ET Alt: 0.0001 m
	Qlté Pos: 0.0001 m	ET Pente: 0.0000 m	

Vecteur Ligne Base:	dLat: -0° 00' 02.23686"	dLon: -0° 00' 01.33208"	dAlt: -0.1533 m
	Pente: 79.3361 m		

DOP (min-max):	GDOP: 1.4 - 12.6		
	PDOP: 1.3 - 10.6	HDOP: 0.7 - 1.7	VDOP: 1.1 - 10.4

Nombre de satellites utilisés:	GPS: 21		
	GLONASS: -		

AREQ - Pier A	**Référence: AREQ**	**Mobile: Pier A**
Type de capteur / N° S:	ASHTECH / 220010401	GX1230GG / 472277
Type d'antenne / N° S:	AOAD/M_T NONE / -	LEIAX1202GG NONE / -
Hauteur d'antenne:	0.0610 m	0.0000 m

Coordonnées:		
Latitude:	16° 27' 55.85865" S	16° 27' 53.21506" S
Longitude:	71° 29' 34.06706" O	71° 29' 33.94386" O
Hteur Ellip.:	2488.9212 m	2487.8462 m

Type de solution:	Phase: toutes fixes		
Type GNSS:	GPS		
Fréquence:	L1/E1 et L2		
Ambiguïté:	Oui		
Plage horaire:	01/11/2013 14:27:14 - 01/11/2013 23:57:44		
Durée:	9h 30' 30"		

Qualité:	ET Lat: 0.0000 m	ET Lon: 0.0000 m	ET Alt: 0.0001 m
	Qlté Pos: 0.0001 m	ET Pente: 0.0000 m	

Vecteur Ligne Base:	dLat: 0° 00' 02.64358"	dLon: 0° 00' 00.12321"	dAlt: -1.0750 m
	Pente: 81.3846 m		

DOP (min-max):	GDOP: 1.4 - 12.6		
	PDOP: 1.3 - 10.6	HDOP: 0.7 - 1.7	VDOP: 1.1 - 10.4

Nombre de satellites utilisés:	GPS: 22		
	GLONASS: -		

IGN	Thomas DONAL	RT/G 186
Service		v 1
de Géodésie	**Arequipa ITRF co-location survey**	
et Nivellement		page 54/78

6.6. Adjustment input file

```
TITL  AREG (AREQUIPA) REGINA-DORIS-AREQ-SLR TIES - JANUARY 2013 SURVEY
COMP ADJ
ELIP GRS 80              6378137.000  6356752.3142   0.0000   0.0000   0.0000 m
MAXI         15
CONF YES YES YES YES NO
PSOL NO   YES
PMIS NO   NO
PRES YES NO
PADJ NO   NO   YES YES YES NO
VARF YES YES NO
RTST TAU MAX
LUNT m    1.000000000000
CONV    0.00010
CLEV     95.000
ANGT GRD
LDEC 4
FCOV YES
PGEO YES

GFIL D:\Logiciels\Technique\Geolab\Geoids\egm08.gsp

***********************************************************************************************************
*                        ITRF ACRONYMS, n°DOMES and POINTS DESCRIPTION                                  *
***********************************************************************************************************
*DORIS:
*ARFB: DORIS Ant. Ref. Pt. (Starec type)                              DOMES    42202S007
*ARFB_marker: DORIS concrete pillar / domed brass mark                DOMES    42202M007

*GNSS permanent station
*AREQ: IGS Ref. Pt.       (mark on steel disk)                                     DOMES    42202M005

*GNSS permanent station
*AREG: Ref. Pt. (domed brass mark)                                                 DOMES    42202M008

*TLRS-3 SLR
*7403:   TLRS-3 reference station mark                                             DOMES    42202M003

*GEODETIC POINTS
*Brass disk "BM.CHR-5 1961"
DOMES    42202M001
*Brass disk "Est Satellite-1961-IGM-PERU"                                          DOMES    42202M002
*Brass disk "Est Satellite-1961-IGM-PERU Mark REF1"             DOMES    42202M004
*Brass disk "NASA-GSFC 7403 RM2 89"                                                DOMES
42202M009
*Brass disk "Aux-satellite AREQ 1958"                                              DOMES    42202M010


***********************************************************************************************************
*                        LIST OF POINTS for the SURVEY ADJUSTMENT                                       *
***********************************************************************************************************

*1002:   station on 42202M004
*2001:   mini reflector pole on 42202M002
*2002:   station on 42202M002
*4001:   mini reflector pole on 42202M009
*4002:   station on 42202M009
*10000: mini reflector pole on 42202M010
*20000: mini reflector pole on 42202M001
*AREG_ARP: AREG antenna ARP
*DORIS_2GHz: DORIS antenna, upper part
*TLRS-3_SRP:     TLRS-3 Ranging system reference point (axis intersection)
*TLRS-3_mount:   TLRS-3 survey mount
*TLRS-3_prism:   prism or total station on TLRS-3 survey mount
*101: mini-prism under AREG antenna ARP

*Temporary points
*3002: station
*5002: station
*6002: station
*7002: station
*8002: station

**************************AZIMUT DEDUCTED FROM THE GPS DETERMINATION********************************
3DD
PLH  000 AREQ       S 16 27 55.85865 W 71 29 34.06706    2488.9211 m       0
PLH  000 PierA      S 16 27 53.21506 W 71 29 33.94386    2487.9035 m       0
COV  LG DIAG
ELEM            0.000001            0.000001              0.1
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 55/78

```
 3DD
 PLH  000 AREQ          S 16 27  55.85865 W 71 29  34.06706    2488.9211 m         0
 PLH  000 PierD         S 16 27  58.09551 W 71 29  35.39914    2488.8394 m         0
 COV  LG DIAG
 ELEM              0.000001              0.000001                    0.1


*****************************************POINT COORDINATES*********************************************
*FORCED ITRF2008 EPOCH 2013:03 COORDINATES
*Coordinates from igs13P1722.ssc (combinaison week 1722)
 3DC
 XYZ  000 AREQ               1942826.225        -5804070.342        -1796894.191 m
 COV  CT DIAG                   1
 ELEM              0.000001              0.000001              0.000001



****************************************APPROXIMATE COORDINATES****************************************
 PLH  000 10000         S 16 27  56.19182 W 71 29  35.26263    2488.9154 m         0
 PLH  000 20000         S 16 27  56.50463 W 71 29  35.46507    2488.7937 m         0
 PLH  000 101           S 16 27  55.52614 W 71 29  34.45595    2489.6504 m         0
 PLH  000 1002          S 16 27  56.47485 W 71 29  35.03927    2493.0426 m         0
 PLH  000 2001          S 16 27  56.41538 W 71 29  35.52172    2491.5889 m         0
 PLH  000 2002          S 16 27  56.41544 W 71 29  35.52172    2493.0805 m         0
 PLH  000 3002          S 16 27  55.38207 W 71 29  34.32764    2489.6413 m         0
 PLH  000 4001          S 16 27  55.83326 W 71 29  34.20198    2488.6731 m         0
 PLH  000 4002          S 16 27  55.83329 W 71 29  34.20200    2489.8261 m         0
 PLH  000 5002          S 16 27  56.70231 W 71 29  34.88787    2490.4570 m         0
 PLH  000 6002          S 16 27  56.87537 W 71 29  34.36608    2490.2631 m         0
 PLH  000 7002          S 16 27  56.01339 W 71 29  34.52672    2490.2199 m         0
 PLH  000 8002          S 16 27  55.48980 W 71 29  34.59884    2489.5295 m         0
 PLH  000 PierA         S 16 27  53.21724 W 71 29  33.94478    2487.9047 m         0
 PLH  000 PierB         S 16 27  54.29339 W 71 29  31.99774    2489.2074 m         0
 PLH  000 PierD         S 16 27  58.09773 W 71 29  35.39988    2488.8414 m         0
 PLH  000 AREG          S 16 27  55.52613 W 71 29  34.45592    2489.3407 m         0
 PLH  000 AREG_ARP      S 16 27  55.52614 W 71 29  34.45594    2489.7694 m         0
 PLH  000 ARFB          S 16 27  56.78903 W 71 29  34.81210    2491.0037 m         0
 PLH  000 ARFB_marker   S 16 27  56.78902 W 71 29  34.81213    2490.3685 m         0
 PLH  000 DORIS_2GHz    S 16 27  56.78900 W 71 29  34.81212    2491.4749 m         0
 PLH  000 TLRS-3_prism  S 16 27  56.59047 W 71 29  34.65709    2491.9465 m         0
 PLH  000 42202M009     S 16 27  55.83326 W 71 29  34.20200    2488.4741 m         0



****************************************CENTRING EQUATIONS*******************************************

*Total station height over survey mark: 1,591m
 3DD
 PLH  000 1002          S 16 27  56.47485 W 71 29  35.03927    2493.0426 m         0
 PLH  000 42202M004     S 16 27  56.47485 W 71 29  35.03927    2491.4516 m         0
 COV  LG DIAG
 ELEM              0.000001              0.000001              0.000002

*Total station height over survey mark: 1,69m
 3DD
 PLH  000 2002          S 16 27  56.41544 W 71 29  35.52172    2493.0805 m         0
 PLH  000 42202M002     S 16 27  56.41544 W 71 29  35.52172    2491.3905 m         0
 COV  LG DIAG
 ELEM              0.000001              0.000001              0.000002

*mini reflector pole, prism height over survey mark of 20cm
 3DD
 PLH  000 2001          S 16 27  56.41538 W 71 29  35.52172    2491.5889 m         0
 PLH  000 42202M002     S 16 27  56.41544 W 71 29  35.52172    2491.3889 m         0
 COV  LG DIAG
 ELEM              0.000004              0.000004              0.0000006

*mini reflector pole, prism height over survey mark of 20cm
 3DD
 PLH  000 4001          S 16 27  55.83326 W 71 29  34.20200    2488.6731 m         0
 PLH  000 42202M009     S 16 27  55.83326 W 71 29  34.20200    2488.4731 m         0
 COV  LG DIAG
 ELEM              0.000004              0.000004              0.0000006

*Total station height over survey mark: 1,352m
 3DD
 PLH  000 4002          S 16 27  55.83329 W 71 29  34.20200    2489.8261 m         0
 PLH  000 42202M009     S 16 27  55.83326 W 71 29  34.20200    2488.4741 m         0
 COV  LG DIAG
 ELEM              0.000001              0.000001              0.000002

*mini reflector pole, prism height over survey mark of 20cm
 3DD
 PLH  000 10000         S 16 27  56.19182 W 71 29  35.26263    2488.9154 m         0
 PLH  000 42202M010     S 16 27  56.19182 W 71 29  35.26263    2488.7154 m         0
 COV  LG DIAG
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 56/78

```
 ELEM             0.000004            0.000004            0.0000006


*mini reflector pole, prism height over survey mark of 20cm
 3DD
 PLH  000 20000       S 16 27  56.50463 W 71 29  35.46507    2488.7937 m       0
 PLH  000 42202M001   S 16 27  56.50463 W 71 29  35.46507    2488.5937 m       0
 COV  LG DIAG
 ELEM             0.000004            0.000004            0.0000006


*vertical offset prism->ARP = 11,81cm (prism+adaptator+plaque)
 3DD
 PLH  000 AREG_ARP    S 16 27  55.52614 W 71 29  34.45595    2489.7694 m       0
 PLH  000 101         S 16 27  55.52614 W 71 29  34.45595    2489.6513 m       0
 COV  LG DIAG
 ELEM             0.0000009           0.0000009           0.0000006


*vertical offset TLRS-3 survey mount-> TLRS-3 prism = 0,2385m
 3DD
 PLH  000 TLRS-3_prism S 16 27  56.59047 W 71 29  34.65709   2491.9465 m       0
 PLH  000 TLRS-3_mount S 16 27  56.59047 W 71 29  34.65709   2491.7080 m       0
 COV  LG DIAG
 ELEM             0.000001            0.000001            0.0000006


*vertical offset TLRS-3 SRP (axis)->TLRS-3 survey mount = 0.174m
 3DD
 PLH  000 TLRS-3_mount S 16 27  56.59047 W 71 29  34.65709   2491.7080 m       0
 PLH  000 TLRS-3_SRP   S 16 27  56.59047 W 71 29  34.65709   2491.5340 m       0
 COV  LG DIAG
 ELEM             0.000001            0.000001            0.0000006


*Eccentricity TLRS-3 reference mark (CDP:7403)->TLRS-3 SRP (axis)
*North [m]: 0.0112 +- 0.002    -> 0.0003621033"
*East  [m]:-0.0046 +- 0.002    ->-0.0001550809"
*Up    [m]: 2.6951 +- 0.002
 3DD
 PLH  000 TLRS-3_SRP  s 16 27 56.590470 w 71 29 34.657090    2491.5340 m  0
 PLH  000 7403        s 16 27 56.590832 w 71 29 34.656935    2488.8389 m  0
 COV  LG DIAG
 ELEM             0.000006            0.000006            0.000006


 *******************************************************************************************************
 *                         Total Station Observations 2013 T.DONAL                                     *
 *******************************************************************************************************


 *Tours d'horizon
  SIGM AH      8.0
  HIST NEW
  DSET AH
  DIR     4002        PierA                    0   0     0.0
  DIR     4002        PierB                   54   8    41.8
  DIR     4002        1002                   251  25    23.8
  DIR     4002        2002                   266  68     1.1
  DIR     4002        3002                   377  26    73.0
  DIR     4002        AREG                   351  11    23.4
  DIR     4002        101                    351  10    82.2
 *DIR     4002        102                    350  76    79.1
 *DIR     4002        103                    351  45    18.1
  DIR     4002        AREG_ARP               351  10    98.6
  DIR     4002        AREQ                   107  51    89.1
  DIR     4002        5002                   235  41    37.0
  DSET AH
  DIR     3002        PierA                    0   0     0.0
  DIR     3002        PierB                   60  52    91.8
  DIR     3002        1002                   224  95    42.2
  DIR     3002        2002                   242  69    72.0
  DIR     3002        4002                   172  52    98.2
  DIR     3002        AREG                   234  42    82.8
  DIR     3002        42202M009              172  52    67.0
  DIR     3002        101                    234  43    30.0
 *DIR     3002        102                    233  72    33.4
 *DIR     3002        103                    235  14    16.3
  DIR     3002        AREG_ARP               234  43    24.8
  DIR     3002        AREQ                   158  56    82.4
  DIR     3002        5002                   213  97    96.9
  DIR     3002        ARFB_marker            209  66    23.5
 *DIR     3002        201                    209  62    25.3
 *DIR     3002        202                    209  69    88.2
  DIR     3002        ARFB                   209  66    06.7
 *DIR     3002        203                    209  64    62.9
 *DIR     3002        204                    209  67    65.7
  DIR     3002        DORIS_2GHz             209  66    14.3
 *DIR     3002        401                    205  61    54.6
 *DIR     3002        402                    205  61    54.8
  DIR     3002        TLRS-3_prism           205  61    54.7
  DSET AH
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 57/78

```
DIR      3002      PierA              0   0      0.0
DIR      3002      4001             172  52     68.1
DSET AH
DIR      3002      PierA              0   0      0.0
DIR      3002      PierD            212  41     14.2
DSET AH
DIR      2002      PierA              0   0      0.0
DIR      2002      PierB             36  20     97.1
DIR      2002      1002              79  81      7.3
DIR      2002      AREQ              47  77     50.1
DIR      2002      4002              44  43     16.5
DIR      2002      3002              25  18     78.8
DIR      2002      AREG              26  33     86.8
DIR      2002      101               26  33     80.1
*DIR     2002      102               26  23     86.6
*DIR     2002      103               26  43     71.5
DIR      2002      AREG_ARP          26  33     79.0
*DIR     2002      401               84  89     33.6
*DIR     2002      402               84  89     28.6
DIR      2002      TLRS-3_prism      84  89     31.1
*DIR     2002      201              103  45     15.5
*DIR     2002      202              103  59     67.9
DIR      2002      ARFB             103  52     41.7
*DIR     2002      203              103  49     33.6
*DIR     2002      204              103  55     39.6
DIR      2002      DORIS_2GHz       103  52     41.7
DIR      2002      PierD            167  28     62.4          12
DSET AH
DIR      1002      PierA              0   0      0.0
DIR      1002      PierB             39  34     97.0
DIR      1002      4002              37  31     68.9
DIR      1002      AREQ              43  13     64.4
DIR      1002      3002              15  75     95.2
DIR      1002      5002             143  69     69.3
*DIR     1002      401               99  38     45.5
*DIR     1002      402               99  38     37.3
DIR      1002      TLRS-3_prism      99  38     41.4
DIR      1002      ARFB_marker      141  26     25.1
*DIR     1002      201              141  11      8.4
*DIR     1002      202              141  40     74.1
DIR      1002      ARFB             141  25     91.2
*DIR     1002      203              141  19     60.1
*DIR     1002      204              141  31     95.8
DIR      1002      DORIS_2GHz       141  25     77.9
DIR      1002      101               14  13     15.6
*DIR     1002      102               14   0     74.5
*DIR     1002      103               14  25     32.0
DIR      1002      AREG_ARP          14  13     03.2
DIR      1002      PierD            193  48     90.7
DIR      1002      2002             288  12     26.2
DIR      1002      2001             288  12     39.6
DSET AH
DIR      1002      PierA              0   0      0.0
DIR      1002      PierB             39  34     92.7
DIR      1002      AREQ              43  13     57.4
DIR      1002      5002             143  69     37.6
DIR      1002      3002              15  75     65.6
DIR      1002      ARFB_marker      141  25     97.7
*DIR     1002      201              141  11      5.3
*DIR     1002      202              141  40     59.4
DIR      1002      ARFB             141  25     82.3
*DIR     1002      203              141  19     64.7
*DIR     1002      204              141  31     95.2
DIR      1002      DORIS_2GHz       141  25     79.9
*DIR     1002      401               99  38     27.8
*DIR     1002      402               99  38     25.4
DIR      1002      TLRS-3_prism      99  38     26.6
DIR      1002      PierD            193  48     89.5
DIR      1002      2002             288  12     11.5
DIR      1002      101               14  13      0.7
*DIR     1002      102               14   0     67.1
*DIR     1002      103               14  25     21.4
DIR      1002      AREG_ARP          14  12     94.2
DIR      1002      4002              37  31     42.7
DSET AH
DIR      5002      PierD              0   0      0.0
DIR      5002      1002             141  99     38.8
DIR      5002      3002             203   8     18.0
DIR      5002      101              200   1     98.1
*DIR     5002      102              199  91     22.0
*DIR     5002      103              200  12     87.2
DIR      5002      AREG_ARP         200  02     04.6
DIR      5002      4002             219  77     54.5
DIR      5002      4001             219  77     51.2
DIR      5002      ARFB_marker      333  75     52.5
*DIR     5002      201              333  25     53.7
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 58/78

```
       *DIR    5002       202              334 24    89.6
        DIR    5002       ARFB             333 75    21.6
       *DIR    5002       203              333 54    66.6
       *DIR    5002       204              333 95    70.9
        DIR    5002       DORIS_2GHz       333 75    18.7
       *DIR    5002       401              248 71    26.0
       *DIR    5002       402              248 70    98.4
        DIR    5002       TLRS-3_prism     248 71    11.8
        DSET AH
        DIR    6002       PierA              0  0     0.0
        DIR    6002       1002             328 13     6.2
        DIR    6002       2002             317 85    99.9
        DIR    6002       3002             394 53    87.0
        DIR    6002       AREQ              10 54    75.2
        DIR    6002       4002               2 55    48.1
        DIR    6002       42202M009          2 55    47.4
        DIR    6002       AREG             388 87    17.0
        DIR    6002       101              388 87     5.1
       *DIR    6002       102              388 77     6.3
       *DIR    6002       103              388 97     4.6
        DIR    6002       AREG_ARP         388 87     5.4
        DIR    6002       ARFB_marker      305 56     0.0
       *DIR    6002       201              305 43     6.0
       *DIR    6002       202              305 68    71.0
        DIR    6002       ARFB             305 55    88.5
       *DIR    6002       203              305 50    87.3
       *DIR    6002       204              305 61    66.1
        DIR    6002       DORIS_2GHz       305 56    26.7
       *DIR    6002       401              343 41    55.3
       *DIR    6002       402              343 41    53.1
        DIR    6002       TLRS-3_prism     343 41    54.2

        DSET AH
        DIR    6002       PierA              0  0     0.0
        DIR    6002       4001               2 55    54.8
*left and right edge from antenna AREQ
       *DIR    6002       301               10 43    25.6
       *DIR    6002       302               10 66    68.1
        DIR    6002       AREQ              10 54    96.8
        DSET AH
        DIR    6002       PierA              0  0     0.0
        DIR    6002       8002             382 72    55.9
        DIR    6002       7002             381 62    82.3
        DSET AH
        DIR    7002       PierA              0  0     0.0
        DIR    7002       PierB             48 29    77.1
        DIR    7002       AREQ              66 30    22.9
        DIR    7002       8002             378 97    29.0
        DIR    7002       4002              54 17    23.6
        DIR    7002       42202M009         54 16    88.5
        DIR    7002       AREG             396 25    33.0       12
        DIR    7002       101              396 24    89.6
       *DIR    7002       102              395 97    54.0
       *DIR    7002       103              396 52    41.1
        DIR    7002       AREG_ARP         396 24    97.5
        DIR    7002       10000            271 71    11.8
        DIR    7002       1002             239 58    80.0
        DIR    7002       ARFB_marker      209 10    39.4
       *DIR    7002       201              209  3    29.3
       *DIR    7002       202              209 16    93.7
        DIR    7002       ARFB             209 10    11.5
       *DIR    7002       203              209  7    62.8
       *DIR    7002       204              209 13    23.7
        DIR    7002       DORIS_2GHz       209 10    43.2
        DIR    7002       6002             176  5    50.5
        DSET AH
        DIR    7002       PierA              0  0     0.0
        DIR    7002       4001              54 16    93.7
       *DIR    7002       401              201  4    61.4
       *DIR    7002       402              201  4    67.5
        DIR    7002       TLRS-3_prism     201  4    64.5
        DSET AH
        DIR    7002       PierA              0  0     0.0
        DIR    7002       PierD            211 83    69.4
        DSET AH
        DIR    8002       PierA              0  0     0.0
        DIR    8002       PierB             54 43    76.8
        DIR    8002       AREG              99 15    50.6
        DIR    8002       101               99 16    15.8
        DIR    8002       42202M009        129 30    14.2
        DIR    8002       4002             129 30    18.5
        DIR    8002       AREQ             122 69    53.5
        DIR    8002       7002             174 34    26.5
        DIR    8002       6002             172 52    45.4
        DIR    8002       1002             208 68    53.6
        DIR    8002       ARFB_marker      192 75    76.6
```

```
*DIR       8002        201               192 71    17.9
*DIR       8002        202               192 79    76.8
 DIR       8002        ARFB              192 75    47.3
*DIR       8002        203               192 73    90.1
*DIR       8002        204               192 77    45.7
 DIR       8002        DORIS_2GHz        192 75    67.9
*DIR       8002        401               186  0    20.1
*DIR       8002        402               186  0    22.9
 DIR       8002        TLRS-3_prism      186  0    21.5
 DSET AH
 DIR       8002        PierA               0  0     0.0
 DIR       8002        4001              129 29    95.6
 DIR       8002        10000             229 84    16.6
 DIR       8002        20000             226 61    81.3
*DIR       8002        104                98 21    27.3
*DIR       8002        105               100 10    57.9
 DIR       8002        AREG_ARP           99 15    92.6
 DSET AH
 DIR       8002        PierA               0  0     0.0
*DIR       8002        102                96 39     8.5
*DIR       8002        103               101 92    34.8
 DIR       8002        AREG_ARP           99 15    71.6
*DSET AH
*DIR       TLRS-3_prism PierA              0  0     0.0
*DIR       TLRS-3_prism PierB             40 15    13.8
*DSET AH
*DIR       TLRS-3_prism PierA              0  0     0.0
*DIR       TLRS-3_prism PierB             40 64    24.2

 HIST GEN Tours d'horizon

 * Zenithales

 SIGM ZA       8.0
 SIGM ZB      20.0
 HIST NEW

 ZANG ZA  4002        PierA             101 51    29.4
 ZANG ZA  4002        PierB             100 48    79.2
 ZANG ZA  4002        1002               93 56    75.2
 ZANG ZA  4002        2002               95 19    77.5
 ZANG ZA  4002        3002              100 81    81.6
 ZANG ZA  4002        AREG              102 55    62.0
 ZANG ZA  4002        101               100 92    58.7
*ZANG ZA  4002        102               100 30    27.6
*ZANG ZA  4002        103               100 30    26.3
 ZANG ZB  4002        AREG_ARP          100 30    27.0
 ZANG ZA  4002        AREQ              113 91    48.1
 ZANG ZA  4002        5002               98 80    39.9
 ZANG ZA  3002        PierA             101 63    71.5
 ZANG ZA  3002        PierB             100 35    93.8
 ZANG ZA  3002        1002               94 55    79.7
 ZANG ZA  3002        2002               95 40    81.4
 ZANG ZA  3002        4002               99 18     5.1
 ZANG ZA  3002        AREG              103 27    39.3
 ZANG ZA  3002        42202M009         105 15    94.5
 ZANG ZA  3002        101                99 90     5.0
*ZANG ZA  3002        102                98 59    54.8
*ZANG ZA  3002        103                98 59    44.4
 ZANG ZB  3002        AREG_ARP           98 59    49.6
 ZANG ZA  3002        AREQ              102 75     1.1
 ZANG ZA  3002        5002               98 81    74.0
 ZANG ZA  3002        ARFB_marker        98 98    35.7
*ZANG ZA  3002        201                98  9    75.2
*ZANG ZA  3002        202                98  9    79.8
 ZANG ZA  3002        ARFB               98  9    77.5
*ZANG ZA  3002        203                97 43     9.1
*ZANG ZA  3002        204                97 43    10.8
*ZANG ZB  3002        DORIS_2GHz         97 43    10.0
*ZANG ZA  3002        401                96 18    56.9
*ZANG ZA  3002        402                96 18    57.0
 ZANG ZA  3002        TLRS-3_prism       96 18    57.0
 ZANG ZA  3002        PierA             101 63    56.2
 ZANG ZA  3002        4001              104 28    17.7
 ZANG ZA  3002        PierA             101 63    71.7
 ZANG ZA  3002        PierD             100 57     0.2
 ZANG ZA  2002        PierA             103  2    40.3
 ZANG ZA  2002        PierB             102  0     7.4
 ZANG ZA  2002        1002              100 16    65.5
 ZANG ZA  2002        AREQ              105 69    11.9
 ZANG ZA  2002        4002              104 80    29.5
 ZANG ZA  2002        3002              104 59    23.5
 ZANG ZA  2002        AREG              105 67    96.2
 ZANG ZA  2002        101               105 21    18.8
*ZANG ZA  2002        102               105  3    24.2
*ZANG ZA  2002        103               105  3    23.9
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 60/78

```
    ZANG ZA  2002    AREG_ARP          105  3   24.0
   *ZANG ZA  2002    401               102 75   24.9
   *ZANG ZA  2002    402               102 75   22.4
    ZANG ZA  2002    TLRS-3_prism      102 75   23.7
   *ZANG ZA  2002    201               105 49   85.4
   *ZANG ZA  2002    202               105 49   87.5
    ZANG ZA  2002    ARFB              105 49   86.5
   *ZANG ZA  2002    203               104 26    0.4
   *ZANG ZA  2002    204               104 26    0.9
    ZANG ZB  2002    DORIS_2GHz        104 26    0.6
    ZANG ZA  2002    PierD             105 19   27.6                    12
    ZANG ZA  1002    PierA             103 10   41.0
    ZANG ZA  1002    PierB             102 17    1.0
    ZANG ZA  1002    4002              106 43   25.6
    ZANG ZA  1002    AREQ              107 57   75.8
    ZANG ZA  1002    3002              105 44   27.2
    ZANG ZA  1002    5002              119 19   57.4
   *ZANG ZA  1002    401               105 85   52.6
   *ZANG ZA  1002    402               105 85   55.3
    ZANG ZA  1002    TLRS-3_prism      105 85   53.8
    ZANG ZA  1002    ARFB_marker       114 21   18.8
   *ZANG ZA  1002    201               110 91   23.5
   *ZANG ZA  1002    202               110 91   24.5
    ZANG ZA  1002    ARFB              110 91   24.0
   *ZANG ZA  1002    203               108 42   38.6
   *ZANG ZA  1002    204               108 42   37.7
    ZANG ZB  1002    DORIS_2GHz        108 42   38.0
    ZANG ZA  1002    101               106 34   54.6
   *ZANG ZA  1002    102               106 12   33.2
   *ZANG ZA  1002    103               106 12   36.0
    ZANG ZA  1002    AREG_ARP          106 12   34.6
    ZANG ZA  1002    PierD             105 22   78.1
    ZANG ZA  1002    2002               99 83   28.6
    ZANG ZA  1002    2001              106 39   17.2
    ZANG ZA  1002    PierA             103 10   45.5
    ZANG ZA  1002    PierB             102 17   11.7
    ZANG ZA  1002    AREQ              107 57   73.6
    ZANG ZA  1002    5002              119 19   54.7
    ZANG ZA  1002    3002              105 44   39.1
    ZANG ZA  1002    ARFB_marker       114 21   24.6
   *ZANG ZA  1002    201               110 91   20.5
   *ZANG ZA  1002    202               110 91   19.9
    ZANG ZA  1002    ARFB              110 91   20.2
   *ZANG ZA  1002    203               108 39   57.2
   *ZANG ZA  1002    204               108 39   56.6
   *ZANG ZB  1002    DORIS_2GHz        108 39   56.9
   *ZANG ZA  1002    401               105 85   56.2
   *ZANG ZA  1002    402               105 85   63.8
    ZANG ZA  1002    TLRS-3_prism      105 85   59.5
    ZANG ZA  1002    PierD             105 22   82.7
    ZANG ZA  1002    2002               99 83   30.7
    ZANG ZA  1002    101               106 34   50.6
   *ZANG ZA  1002    102               106 12   25.0
   *ZANG ZA  1002    103               106 12   28.9
    ZANG ZA  1002    AREG_ARP          106 12   27.0
    ZANG ZA  1002    4002              106 43   23.4
    ZANG ZA  5002    PierD             102 25   95.1
    ZANG ZA  5002    1002               80 80   33.4
    ZANG ZA  5002    3002              101 18   47.5
    ZANG ZA  5002    101               101 33   85.3
   *ZANG ZA  5002    102               101 14    6.0
   *ZANG ZA  5002    103               101 14   14.3
    ZANG ZA  5002    AREG_ARP          101 14   10.1
    ZANG ZA  5002    4002              101 19   56.0
    ZANG ZA  5002    4001              103 37   78.1
    ZANG ZA  5002    ARFB_marker       101 61   32.9
   *ZANG ZA  5002    201                90  9   30.0
   *ZANG ZA  5002    202                90  9   39.6
   *ZANG ZA  5002    ARFB               90  9   34.8
   *ZANG ZA  5002    203                82 49   49.0
   *ZANG ZA  5002    204                82 49   48.4
   *ZANG ZA  5002    401                87 77   74.1
   *ZANG ZA  5002    402                87 77   75.0
    ZANG ZA  5002    TLRS-3_prism       87 77   74.6
    ZANG ZA  6002    PierA             101 32   74.9
    ZANG ZA  6002    1002               92 49   59.9
    ZANG ZA  6002    2002               95 17   33.6
    ZANG ZA  6002    3002              100 85   99.9
    ZANG ZA  6002    AREQ              102 63   22.5
    ZANG ZA  6002    4002              100 85   83.1
    ZANG ZA  6002    42202M009         103 51   14.6
    ZANG ZA  6002    AREG              101 41   27.7
    ZANG ZA  6002    101               100 93   77.6
   *ZANG ZA  6002    102               100 75   62.3
   *ZANG ZA  6002    103               100 75   60.6
    ZANG ZA  6002    AREG_ARP          100 75   61.0
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 61/78

```
     ZANG ZA  6002        ARFB_marker        99 50    36.8
    *ZANG ZA  6002        201                96 50    99.0
    *ZANG ZA  6002        202                96 50    93.4
     ZANG ZA  6002        ARFB               96 50    96.0
    *ZANG ZA  6002        203                94 26    62.2
    *ZANG ZA  6002        204                94 26    62.6
    *ZANG ZA  6002        401                91 34    27.6
    *ZANG ZA  6002        402                91 34    26.8
     ZANG ZA  6002        TLRS-3_prism       91 34    27.2
     ZANG ZA  6002        PierA             101 32    66.1
     ZANG ZA  6002        4001              103 12    19.6
    *ZANG ZA  6002        301               102 51    46.7
    *ZANG ZA  6002        302               102 51    46.7
     ZANG ZA  6002        PierA             101 32    76.1
     ZANG ZA  6002        8002              101  8    27.5
     ZANG ZA  6002        7002              100 10    20.0
     ZANG ZA  7002        PierA             101 68     3.1
     ZANG ZA  7002        PierB             100 70    27.5
     ZANG ZA  7002        AREQ              105 72    34.3
     ZANG ZA  7002        8002              102 70    31.3
     ZANG ZA  7002        4002              102 25    40.2
     ZANG ZA  7002        42202M009         109 91    97.8
     ZANG ZA  7002        AREG              103 69    42.7          12
     ZANG ZA  7002        101               102 39    58.3
    *ZANG ZA  7002        102               101 89    74.5
    *ZANG ZA  7002        103               101 89    74.7
    *ZANG ZA  7002        AREG_ARP          101 89    74.6
     ZANG ZA  7002        10000             103 68    41.4
     ZANG ZA  7002        1002               91 41    45.5
     ZANG ZA  7002        ARFB_marker        99 62    71.4
    *ZANG ZA  7002        201                98  2    75.5
    *ZANG ZA  7002        202                98  2    80.6
     ZANG ZA  7002        ARFB               98  2    78.1
    *ZANG ZA  7002        203                96 84    23.3
    *ZANG ZA  7002        204                96 84    21.0
     ZANG ZB  7002        DORIS_2GHz         96 84    22.6
     ZANG ZA  7002        6002               99 89    80.3
     ZANG ZA  7002        PierA             101 67    99.5
     ZANG ZA  7002        4001              108 80    44.0
   * ZANG ZA  7002        401                93 96    79.5
   * ZANG ZA  7002        402                93 96    74.6
     ZANG ZA  7002        TLRS-3_prism       93 96    77.0
     ZANG ZA  7002        PierA             101 68    11.4
     ZANG ZA  7002        PierD             101 27     4.6
     ZANG ZA  8002        PierA             101 42    72.2
     ZANG ZA  8002        PierB             100 24     9.7
     ZANG ZA  8002        AREG              102 74     3.4
     ZANG ZA  8002        101                98 24    48.0
     ZANG ZA  8002        42202M009         104 24    16.7
     ZANG ZA  8002        4002               98 80    57.9
     ZANG ZA  8002        AREQ              101 98    64.3
     ZANG ZA  8002        7002               97 29    42.3
     ZANG ZA  8002        6002               98 91    83.0
     ZANG ZA  8002        1002               93 24    78.8
     ZANG ZA  8002        ARFB_marker        98 67    91.8
    *ZANG ZA  8002        201                97 67    99.8
    *ZANG ZA  8002        202                97 67    98.0
     ZANG ZA  8002        ARFB               97 67    98.9
    *ZANG ZA  8002        203                96 93    66.8                    *
    *ZANG ZA  8002        204                96 93    69.4
     ZANG ZB  8002        DORIS_2GHz         96 93    68.1
    *ZANG ZA  8002        401                95 46    76.7
    *ZANG ZA  8002        402                95 46    81.0
     ZANG ZA  8002        TLRS-3_prism       95 46    78.9
     ZANG ZA  8002        PierA             101 42    70.2
     ZANG ZA  8002        4001              103 44    28.2
     ZANG ZA  8002        10000             101 33    80.2
     ZANG ZA  8002        20000             101 15    87.2
   **ZANG ZA  8002        104                96  2    85.5
   **ZANG ZA  8002        105                96  2    77.4
     ZANG ZA  8002        PierA             101 42    74.3
   **ZANG ZA  8002        102                95 82    91.3
   **ZANG ZA  8002        103                95 82    56.5
    *Station 400 instable (mount SLR).
    *ZANG ZA  TLRS-3_prism PierA            102 43     8.2
    *ZANG ZA  TLRS-3_prism PierB            101 64    80.4
    *ZANG ZA  TLRS-3_prism PierA            102 42    98.5
    *ZANG ZA  TLRS-3_prism PierB            101 64    95.5

     HIST GEN Zénithales

     Distances

     SIGM DP   0.0010
     SIGM DQ   0.0015
     HIST NEW
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 62/78

```
*Distancemeter from TCRA1201 has to be checked. Some wrong distances.
*wrong distance
*DIST DP  4002         1                         62.83263
 DIST DQ  4002         PierA                     80.81693
 DIST DQ  4002         PierB                     80.75282
 DIST DP  4002         1002                      31.88788
 DIST DP  4002         2002                      43.18137
 DIST DP  4002         3002                      14.36902
 DIST DP  4002         101                       12.08440
 DIST DP  4002         5002                      33.59726
 DIST DP  3002         PierA                     67.54216
*wrong distance
*DIST DP  3002         PierB                     82.81094
*DIST DP  3002         1002                       3.86574
 DIST DP  3002         2002                      47.71994
 DIST DP  3002         4002                      14.36883
 DIST DP  3002         101                        5.84184
*wrong distance
*DIST DP  3002         5002                      25.89485
*DIST DP  3002         401                       38.70952
*DIST DP  3002         402                       38.70942
 DIST DQ  3002         PierA                     67.54203
 DIST DP  3002         4001                      14.40028
 DIST DQ  3002         PierA                     67.54185
 DIST DQ  2002         PierA                    109.02225
*wrong distance
*DIST DP  2002         PierB                     75.36297
 DIST DP  2002         1002                      14.43209
 DIST DP  2002         4002                      43.18130
 DIST DP  2002         3002                      47.72009
 DIST DP  2002         101                       41.94951
*DIST DP  2002         401                       26.24033
*DIST DP  2002         402                       26.23957
 DIST DP  2002         TLRS-3_prism              26.23995
 DIST DP  1002         PierA                    105.42020
 DIST DQ  1002         PierB                    112.51865
 DIST DP  1002         4002                      31.88775
 DIST DP  1002         3002                      39.83426
 DIST DP  1002         5002                       8.70577
*DIST DP  1002         401                       11.93602
*DIST DP  1002         402                       11.93572
 DIST DP  1002         TLRS-3_prism              11.93587
 DIST DP  1002         101                       34.09212
 DIST DQ  1002         PierD                     51.22333
 DIST DP  1002         2002                      14.43201
 DIST DP  1002         2001                      14.50461
 DIST DQ  1002         PierA                    105.42030
 DIST DQ  1002         PierB                    112.51834
* DIST DP  1002         401                       11.93582
* DIST DP  1002         402                       11.93562
 DIST DP  1002         TLRS-3_prism              11.93572
 DIST DP  1002         5002                       8.70597
 DIST DP  1002         3002                      39.83436
 DIST DQ  1002         PierD                     51.22273
 DIST DP  1002         2002                      14.43171
 DIST DP  1002         101                       34.09152
 DIST DP  1002         4002                      31.88775
 DIST DQ  5002         PierD                     45.56123
 DIST DP  5002         1002                       8.70603
 DIST DP  5002         3002                      43.87864
 DIST DP  5002         101                       38.38101
 DIST DP  5002         4002                      33.59694
 DIST DP  5002         4001                      33.63909
** DIST DP  5002         401                        7.80676
** DIST DP  5002         402                        7.80661
 DIST DP  5002         TLRS-3_prism               7.80668
 DIST DQ  6002         PierA                    113.19545
 DIST DP  6002         1002                      23.63188
 DIST DP  6002         2002                      37.20107
 DIST DP  6002         3002                      45.93990
 DIST DP  6002         4002                      32.41635
 DIST DP  6002         101                       41.58141
*DIST DP  6002         401                       12.41581
*DIST DP  6002         402                       12.41636
 DIST DP  6002         TLRS-3_prism              12.41608
 DIST DQ  6002         PierA                    113.19550
 DIST DP  6002         4001                      32.45381
*wrong distance
*DIST DP  6002         PierA                     62.57216
*DIST DP  6002         8002                      43.29669
 DIST DP  6002         7002                      26.93393
 DIST DQ  7002         PierA                     87.71941
*wrong distance
*DIST DP  7002         PierB                     49.63482
*DIST DP  7002         8002                      16.34866
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G   186
v   1

page   63/78

```
           DIST DP  7002           4002                             11.12085
           DIST DP  7002           101                              15.14121
           DIST DP  7002           10000                            22.55088
           DIST DP  7002           1002                             20.99126
           DIST DP  7002           6002                             26.93407
           DIST DP  7002           PierA                            87.71959
           DIST DP  7002           4001                             11.22186
          *wrong distance
          *DIST DP  7002           401                              17.94338
           DIST DP  7002           TLRS-3_prism                     18.24490
          *wrong distance
          *DIST DP  7002           PierA                            67.39665
          *DIST DQ  7002           PierD                            80.89702
          *DIST DP  8002           PierA                            72.21422
          *DIST DP  8002           PierB                            85.50009
          *DIST DP  8002           101                               4.42995
          *DIST DP  8002           4002                             16.12477
          *DIST DP  8002           7002                             16.31668
          *DIST DP  8002           6002                             43.26961
           DIST DP  8002           1002                             33.17666
          *DIST DP  8002           401                              10.45007
          *DIST DP  8002           402                              10.45015
          *DIST DP  8002           TLRS-3_prism                     10.45011
          *DIST DP  8002           PierA                            72.21394
          *DIST DP  8002           4001                             16.44550
           DIST DP  8002           10000                            29.23250
           DIST DP  8002           20000                            40.43758
          *wrong distance
          *DIST DQ  8002           PierA                            72.21449
          *Station 400 instable (mount SLR).
           DIST DQ  TLRS-3_prism PierA                             105.92662
           DIST DQ  TLRS-3_prism PierB                             105.94473
           DIST DQ  TLRS-3_prism PierA                             105.92647
           DIST DQ  TLRS-3_prism PierB                             105.94498

           HIST GEN Distances
           HIST ALL Toutes les observations
           END
```

6.7. Adjustement output file

```
================================================================================
          AREG (AREQUIPA) REGINA-DORIS-AREQ-SLR TIES - JANUARY 2013 SURVEY
Microsearch GeoLab, V2001.9.20.0            GRS 80      UNITS: m,GRAD
================================================================================
Tue Jan 13 12:12:17 2015

Input file:  ..\Arequipa\Rattachement\AREG_egm08.iob
Output file: ..\Arequipa\Rattachement\AREG_egm08.lst
Options file:..\Microsearch\GeoLab\default.gpj

Geoid File:  ..\Geolab\Geoids\egm08.gsp
   -----------------------------------------------------------------------
  |        PARAMETERS           |            OBSERVATIONS                  |
  |-----------------------------|-----------------------------------------|
  |   Description  |   Number    |   Description        |    Number        |
  |-----------------------------|-----------------------------------------|
  | No. of Stations|       31    | Directions           |      143         |
  | Coord Parameters|      93    | Distances            |       72         |
  | Free Latitudes |       31    | Azimuths             |        0         |
  | Free Longitudes|       31    | Vertical Angles      |        0         |
  | Free Heights   |       31    | Zenithal Angles      |      134         |
  | 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. |       17    | 2-D Coords.          |        0         |
  | Direction Pars.|       17    | 2-D Coord. Diffs.    |        0         |
  | Scale Parameters|       0    | 3-D Coords.          |        3         |
  | Constant Pars. |        0    | 3-D Coord. Diffs.    |       39         |
  | Rotation Pars. |        0    |                      |                  |
  | Translation Pars.|      0    |                      |                  |
  |                |             |                      |                  |
  |                |   --------  |                      |    --------      |
  | Total Parameters|      110   | Total Observations   |      391         |
  |-----------------------------------------------------------------------|
  |              Degrees of Freedom =       281                            |
   -----------------------------------------------------------------------
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 64/78

```
--------------------------------------------------------------------------------
                        SUMMARY OF SELECTED OPTIONS
--------------------------------------------------------------------------------
    OPTION                          |  SELECTION
--------------------------------------------------------------------------------
    Computation Mode                |  Adjustment
    Maximum Iterations              |  15
    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
    Generate Initial Coordinates    |  Yes
    Re-Transform Obs After 1st Pass |  Yes
    Geoid Interpolation Method      |  Bi-Quadratic
```

```
Geoid Values:
CODE      STATION           N/S DEFLECTION    E/W DEFLECTION    UNDULATION
----      -------------     ----------------  ----------------  ------------
GEOI      10000        -  0  0    5.58 -  0  0    15.99       39.8551 m
GEOI      1002         -  0  0    5.58 -  0  0    15.99       39.8551 m
GEOI      101          -  0  0    5.59 -  0  0    16.01       39.8583 m
GEOI      20000        -  0  0    5.58 -  0  0    15.99       39.8551 m
GEOI      2001         -  0  0    5.58 -  0  0    15.99       39.8551 m
GEOI      2002         -  0  0    5.58 -  0  0    15.99       39.8551 m
GEOI      3002         -  0  0    5.59 -  0  0    16.01       39.8583 m
GEOI      4001         -  0  0    5.59 -  0  0    16.01       39.8583 m
GEOI      4002         -  0  0    5.59 -  0  0    16.01       39.8583 m
GEOI      42202M001    -  0  0    5.58 -  0  0    15.99       39.8551 m
GEOI      42202M002    -  0  0    5.58 -  0  0    15.99       39.8551 m
GEOI      42202M004    -  0  0    5.58 -  0  0    15.99       39.8551 m
GEOI      42202M009    -  0  0    5.59 -  0  0    16.01       39.8583 m
GEOI      42202M010    -  0  0    5.58 -  0  0    15.99       39.8551 m
GEOI      5002         -  0  0    5.59 -  0  0    16.00       39.8574 m
GEOI      6002         -  0  0    5.59 -  0  0    16.00       39.8574 m
GEOI      7002         -  0  0    5.59 -  0  0    16.00       39.8574 m
GEOI      7403         -  0  0    5.59 -  0  0    16.00       39.8574 m
GEOI      8002         -  0  0    5.59 -  0  0    16.01       39.8583 m
GEOI      AREG         -  0  0    5.59 -  0  0    16.01       39.8583 m
GEOI      AREG_ARP     -  0  0    5.59 -  0  0    16.01       39.8583 m
GEOI      AREQ         -  0  0    5.59 -  0  0    16.01       39.8583 m
GEOI      ARFB         -  0  0    5.59 -  0  0    16.00       39.8574 m
GEOI      ARFB_marker  -  0  0    5.59 -  0  0    16.00       39.8574 m
GEOI      DORIS_2GHz   -  0  0    5.59 -  0  0    16.00       39.8574 m
GEOI      PierA        -  0  0    5.61 -  0  0    16.05       39.8623 m
GEOI      PierB        -  0  0    5.63 -  0  0    16.07       39.8661 m
GEOI      PierD        -  0  0    5.57 -  0  0    15.96       39.8534 m
GEOI      TLRS-3_SRP   -  0  0    5.59 -  0  0    16.00       39.8574 m
GEOI      TLRS-3_mount -  0  0    5.59 -  0  0    16.00       39.8574 m
GEOI      TLRS-3_prism -  0  0    5.59 -  0  0    16.00       39.8574 m
```

```
Residuals (critical value = 3.952):
NOTE: Observation values shown are reduced to mark-to-mark.
                                              OBSERVATION RESIDUAL  STD RES
TYPE AT           FROM          TO              STD DEV   STD DEV     PPM
---- ------------ ------------  ------------  ------------- -------- --------
ELAT              AREQ          PierA       0 00   2.64359  -0.0031  -0.0031
                                                   0.0010  -0.0013   37.93
ELON              AREQ          PierA       0 00   0.12320   0.0002   0.0018
                                                   0.0010   0.1291    2.91
EHGT              AREQ          PierA              -1.01760 -0.0001  -0.0002
                                                   0.3162   0.2910    0.66
ELAT              AREQ          PierD       0 00   2.23686   0.0015   0.0015
                                                   0.0010  -0.0013   18.57
ELON              AREQ          PierD       0 00   1.33208   0.0013   0.0100
                                                   0.0010   0.1291   16.27
EHGT              AREQ          PierD              -0.08170 -0.0001  -0.0005
                                                   0.3162   0.2910    1.68
XCT  AREQ                                     1942826.22500   0.0000   0.0000
                                                   0.0010   0.0000       *
YCT  AREQ                                    -5804070.34200  -0.0000  -0.0000
                                                   0.0010   0.0000       *
ZCT  AREQ                                    -1796894.19100  -0.0000  -0.0000
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 65/78

```
                                              0.0010    0.0000       *
     ELAT          1002        42202M004    0 00   0.00000   -0.0000   -0.0000
                                              0.0010    0.0000     0.00*
     ELON          1002        42202M004    0 00   0.00000    0.0000    0.0000
                                              0.0010    0.0000     0.00*
     EHGT          1002        42202M004         -1.59100   -0.0000   -0.0000
                                              0.0014    0.0000     0.00*
     ELAT          2002        42202M002    0 00   0.00000   -0.0003   -0.7776
                                              0.0010    0.0004   194.77
     ELON          2002        42202M002    0 00   0.00000    0.0001    0.1843
                                              0.0010    0.0006    68.16
     EHGT          2002        42202M002         -1.69000   -0.0013   -1.1453
                                              0.0014    0.0011   774.17
     ELAT          2001        42202M002    0 00   0.00006    0.0013    0.7916
                                              0.0020    0.0017  6601.12
     ELON          2001        42202M002    0 00   0.00000   -0.0005   -0.2834
                                              0.0020    0.0016  2309.98
     EHGT          2001        42202M002         -0.20000    0.0004    0.5408
                                              0.0008    0.0007  1967.91
     ELAT          4001        42202M009    0 00   0.00000   -0.0001   -0.0581
                                              0.0020    0.0020   579.78
     ELON          4001        42202M009    0 00   0.00000   -0.0004   -0.2112
                                              0.0020    0.0020  2109.45
     EHGT          4001        42202M009         -0.20000    0.0009    1.1916
                                              0.0008    0.0008  4569.53
     ELAT          4002        42202M009    0 00   0.00003   -0.0002   -0.1881
                                              0.0010    0.0010   137.29
     ELON          4002        42202M009    0 00   0.00000    0.0002    0.2256
                                              0.0010    0.0010   164.77
     EHGT          4002        42202M009         -1.35200   -0.0001   -0.0705
                                              0.0014    0.0014    73.47
     ELAT         10000        42202M010    0 00   0.00000   -0.0000   -0.0000
                                              0.0020    0.0000     0.00*
     ELON         10000        42202M010    0 00   0.00000    0.0000    0.0000
                                              0.0020    0.0000     0.00*
     EHGT         10000        42202M010         -0.20000   -0.0000   -0.0000
                                              0.0008    0.0000     0.00*
     ELAT         20000        42202M001    0 00   0.00000    0.0000    0.0000
                                              0.0020    0.0000     0.00*
     ELON         20000        42202M001    0 00   0.00000   -0.0000   -0.0000
                                              0.0020    0.0000     0.00*
     EHGT         20000        42202M001         -0.20000   -0.0000   -0.0000
                                              0.0008    0.0000     0.00*
     ELAT       AREG_ARP       101          0 00   0.00000   -0.0002   -0.1966
                                              0.0009    0.0009  1558.93
     ELON       AREG_ARP       101          0 00   0.00000   -0.0002   -0.1992
                                              0.0009    0.0009  1574.76
     EHGT       AREG_ARP       101               -0.11810   -0.0012   -1.6165
                                              0.0008    0.0008 10325.46
     ELAT     TLRS-3_prism TLRS-3_mount     0 00   0.00000   -0.0000   -0.0000
                                              0.0010    0.0000     0.00*
     ELON     TLRS-3_prism TLRS-3_mount     0 00   0.00000    0.0000    0.0000
                                              0.0010    0.0000     0.00*
     EHGT     TLRS-3_prism TLRS-3_mount         -0.23850   -0.0000   -0.0000
                                              0.0008    0.0000     0.00*
     ELAT     TLRS-3_mount TLRS-3_SRP       0 00   0.00000   -0.0000   -0.0000
                                              0.0010    0.0000     0.00*
     ELON     TLRS-3_mount TLRS-3_SRP       0 00   0.00000    0.0000    0.0000
                                              0.0010    0.0000     0.00*
     EHGT     TLRS-3_mount TLRS-3_SRP           -0.17400    0.0000    0.0000
                                              0.0008    0.0000     0.00*
     ELAT      TLRS-3_SRP    7403           0 00   0.00036   -0.0000   -0.0000
                                              0.0024    0.0000     0.00*
     ELON      TLRS-3_SRP    7403           0 00   0.00015    0.0000    0.0000
                                              0.0024    0.0000     0.00*
     EHGT      TLRS-3_SRP    7403               -2.69510   -0.0000   -0.0000
                                              0.0024    0.0000     0.00*
     DIR           4002        PierA        0  0     0.0    -17.6     -2.5
                                                8.0     7.0
     DIR           4002        PierB       54  8    41.8     3.9      0.6
                                                8.0     6.6
     DIR           4002        1002       251 25    23.8    -1.5     -0.2
                                                8.0     6.9
     DIR           4002        2002       266 68     1.1    10.4      1.5
                                                8.0     6.9
     DIR           4002        3002       377 26    73.0     5.5      0.9
                                                8.0     6.1
     DIR           4002        AREG       351 11    23.4     1.8      0.3
                                                8.0     6.2
     DIR           4002        101        351 10    82.2     1.2      0.2
                                                8.0     6.4
     DIR           4002        AREG_ARP   351 10    98.6    -0.8     -0.1
                                                8.0     6.3
     DIR           4002        AREQ       107 51    89.1     2.0      0.9
                                                8.0     2.2
     DIR           4002        5002       235 41    37.0    -4.8     -0.7
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 66/78

```
                                                    8.0     6.7
        DIR         3002      PierA         0   0    0.0   -15.4    -2.3
                                                    8.0     6.8
        DIR         3002      PierB        60  52   91.8     6.6     1.0
                                                    8.0     6.6
        DIR         3002      1002        224  95   42.2     6.1     0.8
                                                    8.0     7.4
        DIR         3002      2002        242  69   72.0     3.4     0.5
                                                    8.0     7.1
        DIR         3002      4002        172  52   98.2    -8.7    -1.3
                                                    8.0     6.5
        DIR         3002      AREG        234  42   82.8    -1.6    -0.6
                                                    8.0     2.7
        DIR         3002      42202M009   172  52   67.0     9.4     1.9
                                                    8.0     5.0
        DIR         3002      101         234  43   30.0     0.2     0.0
                                                    8.0     3.5
        DIR         3002      AREG_ARP    234  43   24.8     2.5     0.7
                                                    8.0     3.5
        DIR         3002      AREQ        158  56   82.4    -2.5    -0.5
                                                    8.0     5.6
        DIR         3002      5002        213  97   96.9     5.4     0.7
                                                    8.0     7.4
        DIR         3002      ARFB_marker 209  66   23.5    -6.5    -0.9
                                                    8.0     7.2
        DIR         3002      ARFB        209  66    6.7    -3.2    -0.4
                                                    8.0     7.2
        DIR         3002      DORIS_2GHz  209  66   14.3     2.8     0.4
                                                    8.0     7.2
        DIR         3002      TLRS-3_prism 205 61   54.7     1.7     0.2
                                                    8.0     7.3
        DIR         3002      PierA         0   0    0.0    -1.8    -0.5
                                                    8.0     3.9
        DIR         3002      4001        172  52   68.1     1.8     0.5
                                                    8.0     3.9
        DIR         3002      PierA         0   0    0.0    -8.4    -1.6
                                                    8.0     5.3
        DIR         3002      PierD       212  41   14.2     8.4     1.6
                                                    8.0     5.3
        DIR         2002      PierA         0   0    0.0    13.6     1.9
                                                    8.0     7.3
        DIR         2002      PierB        36  20   97.1     3.0     0.4
                                                    8.0     7.2
        DIR         2002      1002         79  81    7.3   -13.7    -2.0
                                                    8.0     7.0
        DIR         2002      AREQ         47  77   50.1   -10.9    -1.5
                                                    8.0     7.4
        DIR         2002      4002         44  43   16.5    -2.5    -0.3
                                                    8.0     7.5
        DIR         2002      3002         25  18   78.8   -11.8    -1.6
                                                    8.0     7.5
        DIR         2002      AREG         26  33   86.8     0.6     0.1
                                                    8.0     7.4
        DIR         2002      101          26  33   80.1     2.2     0.3
                                                    8.0     7.4
        DIR         2002      AREG_ARP     26  33   79.0     3.1     0.4
                                                    8.0     7.4
        DIR         2002      TLRS-3_prism 84  89   31.1     1.6     0.2
                                                    8.0     7.3
        DIR         2002      ARFB        103  52   41.7     7.6     1.1
                                                    8.0     6.8
        DIR         2002      DORIS_2GHz  103  52   41.7    -4.7    -0.7
                                                    8.0     6.8
        DIR         2002      PierD       167  28   62.4    38.5     3.0
                                                   14.4    13.0
        DIR         1002      PierA         0   0    0.0     9.0     1.2
                                                    8.0     7.4
        DIR         1002      PierB        39  34   97.0     0.0     0.0
                                                    8.0     7.2
        DIR         1002      4002         37  31   68.9    -7.1    -1.0
                                                    8.0     7.4
        DIR         1002      AREQ         43  13   64.4     1.3     0.2
                                                    8.0     7.2
        DIR         1002      3002         15  75   95.2   -18.3    -2.4
                                                    8.0     7.5
        DIR         1002      5002        143  69   69.3   -24.2    -3.4
                                                    8.0     7.1
        DIR         1002      TLRS-3_prism 99  38   41.4    -4.4    -0.7
                                                    8.0     6.2
        DIR         1002      ARFB_marker 141  26   25.1    -4.8    -0.7
                                                    8.0     7.2
        DIR         1002      ARFB        141  25   91.2    12.4     1.7
                                                    8.0     7.2
        DIR         1002      DORIS_2GHz  141  25   77.9    29.1     4.1
                                                    8.0     7.2
                          ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 67/78

DIR	1002	101	14 13	15.6	-1.9	-0.3	
				8.0	7.4		
DIR	1002	AREG_ARP	14 13	3.2	11.9	1.6	
				8.0	7.4		
DIR	1002	PierD	193 48	90.7	-7.8	-1.2	
				8.0	6.6		
DIR	1002	2002	288 12	26.2	4.4	0.7	
				8.0	6.3		
DIR	1002	2001	288 12	39.6	0.5	0.7	
				8.0	0.6		
DIR	1002	PierA	0 0	0.0	-4.4	-0.6	
				8.0	7.4		
DIR	1002	PierB	39 34	92.7	-9.0	-1.3	
				8.0	7.2		
DIR	1002	AREQ	43 13	57.4	-5.1	-0.7	
				8.0	7.2		
DIR	1002	5002	143 69	37.6	-5.9	-0.8	
				8.0	7.1		
DIR	1002	3002	15 75	65.6	-2.1	-0.3	
				8.0	7.5		
DIR	1002	ARFB_marker	141 25	97.7	9.2	1.3	
				8.0	7.2		
DIR	1002	ARFB	141 25	82.3	7.9	1.1	
				8.0	7.2		
DIR	1002	DORIS_2GHz	141 25	79.9	13.8	1.9	
				8.0	7.2		
DIR	1002	TLRS-3_prism	99 38	26.6	-3.0	-0.5	
				8.0	6.2		
DIR	1002	PierD	193 48	89.5	-20.0	-3.0	
				8.0	6.6		
DIR	1002	2002	288 12	11.5	5.7	0.9	
				8.0	6.3		
DIR	1002	101	14 13	0.7	-0.3	-0.0	
				8.0	7.4		
DIR	1002	AREG_ARP	14 12	94.2	7.5	1.0	
				8.0	7.4		
DIR	1002	4002	37 31	42.7	5.7	0.8	
				8.0	7.4		
DIR	5002	PierD	0 0	0.0	15.0	2.7	
				8.0	5.6		
DIR	5002	1002	141 99	38.8	-8.9	-1.4	
				8.0	6.4		
DIR	5002	3002	203 8	18.0	-2.4	-0.3	
				8.0	7.4		
DIR	5002	101	200 1	98.1	2.9	0.4	
				8.0	7.3		
DIR	5002	AREG_ARP	200 2	4.6	-1.6	-0.2	
				8.0	7.3		
DIR	5002	4002	219 77	54.5	2.0	0.3	
				8.0	7.2		
DIR	5002	4001	219 77	51.2	4.2	0.6	
				8.0	6.8		
DIR	5002	ARFB_marker	333 75	52.5	1.7	0.6	
				8.0	3.1		
DIR	5002	ARFB	333 75	21.6	-7.2	-2.3	
				8.0	3.1		
DIR	5002	DORIS_2GHz	333 75	18.7	-12.0	-3.9	
				8.0	3.1		
DIR	5002	TLRS-3_prism	248 71	11.8	6.2	2.3	
				8.0	2.7		
DIR	6002	PierA	0 0	0.0	9.1	1.3	
				8.0	7.1		
DIR	6002	1002	328 13	6.2	-3.3	-0.4	
				8.0	7.3		
DIR	6002	2002	317 85	99.9	1.3	0.2	
				8.0	7.1		
DIR	6002	3002	394 53	87.0	-17.5	-2.3	
				8.0	7.5		
DIR	6002	AREQ	10 54	75.2	15.4	2.3	
				8.0	6.8		
DIR	6002	4002	2 55	48.1	-0.4	-0.1	
				8.0	7.2		
DIR	6002	42202M009	2 55	47.4	0.6	0.1	
				8.0	7.0		
DIR	6002	AREG	388 87	17.0	-4.8	-0.7	
				8.0	7.4		
DIR	6002	101	388 87	5.1	-5.6	-0.7	
				8.0	7.4		
DIR	6002	AREG_ARP	388 87	5.4	-2.7	-0.4	
				8.0	7.4		
DIR	6002	ARFB_marker	305 56	0.0	9.2	2.0	
				8.0	4.7		
DIR	6002	ARFB	305 55	88.5	-0.8	-0.2	
				8.0	4.9		
DIR	6002	DORIS_2GHz	305 56	26.7	-3.1	-0.6	
				8.0	4.9		

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1
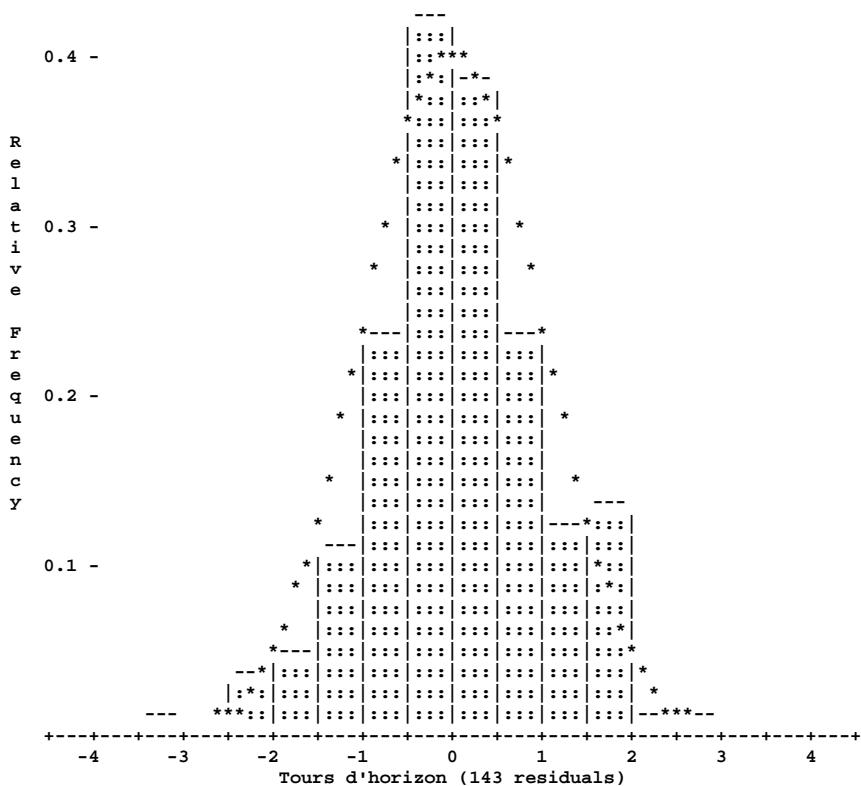
page 68/78

```
DIR       6002      TLRS-3_prism   343 41    54.2      2.6      0.5
                                             8.0       5.0
DIR       6002      PierA            0  0     0.0       7.7      1.3
                                             8.0       5.9
DIR       6002      4001             2 55    54.8      -0.1     -0.0
                                             8.0       6.0
DIR       6002      AREQ            10 54    96.8      -7.6     -1.3
                                             8.0       6.0
DIR       6002      PierA            0  0     0.0       5.1      0.8
                                             8.0       6.2
DIR       6002      8002           382 72    55.9      -2.9     -0.5
                                             8.0       6.4
DIR       6002      7002           381 62    82.3      -2.2     -0.4
                                             8.0       6.2
DIR       7002      PierA            0  0     0.0       3.1      0.4
                                             8.0       7.3
DIR       7002      PierB           48 29    77.1       0.6      0.1
                                             8.0       7.0
DIR       7002      AREQ            66 30    22.9       0.4      0.1
                                             8.0       5.7
DIR       7002      8002           378 97    29.0      -1.8     -0.3
                                             8.0       5.8
DIR       7002      4002            54 17    23.6       0.0      0.0
                                             8.0       5.4
DIR       7002      42202M009       54 16    88.5       3.7      1.4
                                             8.0       2.7
DIR       7002      AREG           396 25    33.0     -11.8     -0.9
                                            14.4      13.3
DIR       7002      101            396 24    89.6      -0.7     -0.1
                                             8.0       6.3
DIR       7002      AREG_ARP       396 24    97.5      -1.5     -0.2
                                             8.0       6.3
DIR       7002      10000          271 71    11.8       1.0      0.3
                                             8.0       3.0
DIR       7002      1002           239 58    80.0       0.8      0.1
                                             8.0       6.3
DIR       7002      ARFB_marker    209 10    39.4      -3.3     -0.5
                                             8.0       6.1
DIR       7002      ARFB           209 10    11.5      -0.0     -0.0
                                             8.0       6.2
DIR       7002      DORIS_2GHz     209 10    43.2      -6.9     -1.1
                                             8.0       6.2
DIR       7002      6002           176  5    50.5       8.2      1.3
                                             8.0       6.1
DIR       7002      PierA            0  0     0.0      -2.6     -0.5
                                             8.0       5.1
DIR       7002      4001            54 16    93.7      -0.7     -0.2
                                             8.0       2.9
DIR       7002      TLRS-3_prism   201  4    64.5       3.2      0.7
                                             8.0       4.7
DIR       7002      PierA            0  0     0.0       0.2      0.0
                                             8.0       5.3
DIR       7002      PierD          211 83    69.4      -0.2     -0.0
                                             8.0       5.3
DIR       8002      PierA            0  0     0.0       3.5      0.5
                                             8.0       6.5
DIR       8002      PierB           54 43    76.8      -6.8     -1.0
                                             8.0       6.5
DIR       8002      AREG            99 15    50.6      -0.3     -0.1
                                             8.0       2.5
DIR       8002      101             99 16    15.8       0.3      0.1
                                             8.0       2.6
DIR       8002      42202M009      129 30    14.2     -10.3     -1.9
                                             8.0       5.3
DIR       8002      4002           129 30    18.5       9.6      1.4
                                             8.0       7.1
DIR       8002      AREQ           122 69    53.5      -1.0     -0.1
                                             8.0       6.9
DIR       8002      7002           174 34    26.5      11.8      1.8
                                             8.0       6.6
DIR       8002      6002           172 52    45.4      -2.8     -0.4
                                             8.0       7.2
DIR       8002      1002           208 68    53.6      -1.9     -0.3
                                             8.0       7.2
DIR       8002      ARFB_marker    192 75    76.6     -12.1     -1.7
                                             8.0       7.2
DIR       8002      ARFB           192 75    47.3       3.0      0.4
                                             8.0       7.2
DIR       8002      DORIS_2GHz     192 75    67.9      -4.1     -0.6
                                             8.0       7.2
DIR       8002      TLRS-3_prism   186  0    21.5      11.1      1.6
                                             8.0       7.0
DIR       8002      PierA            0  0     0.0       9.9      1.8
                                             8.0       5.6
DIR       8002      4001           129 29    95.6      -0.5     -0.1
                                             8.0       4.2
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 69/78

```
DIR          8002         10000        229 84    16.6      -5.5      -1.4
                                                  8.0       3.9
DIR          8002         20000        226 61    81.3       0.0       0.0
                                                  8.0       0.0          *
DIR          8002         AREG_ARP      99 15    92.6      -3.9      -0.9
                                                  8.0       4.4
DIR          8002         PierA          0  0     0.0      -3.6      -0.8
                                                  8.0       4.3
DIR          8002         AREG_ARP      99 15    71.6       3.6       0.8
                                                  8.0       4.3
```

```
                                    ---
                                   |:::|
         0.4 -                     |:.***
                                   |:*:|-*-
                                   |*::|::*|
                                   *:::|:::*
       R                           |:::|:::|
       e                         *|:::|:::|*
       l                           |:::|:::|
       a                           |:::|:::|
       t   0.3 -               *   |:::|:::|  *
       i                           |:::|:::|
       v                       *   |:::|:::|    *
       e                           |:::|:::|
                                   |:::|:::|
       F                       *---|:::|:::|---*
       r                         |:::|:::|:::|:::|
       e                       * |:::|:::|:::|:::|*
       q   0.2 -                 |:::|:::|:::|:::|
       u                     *  |:::|:::|:::|:::|  *
       e                        |:::|:::|:::|:::|
       n                        |:::|:::|:::|:::|
       c                    *   |:::|:::|:::|:::|     *
       y                        |:::|:::|:::|:::|        ---
                            *   |:::|:::|:::|:::|---*:::|
                          ---|:::|:::|:::|:::|:::|:::|
         0.1 -           *|:::|:::|:::|:::|:::|:::|*::|
                        *  |:::|:::|:::|:::|:::|:::|:*:|
                           |:::|:::|:::|:::|:::|:::|:::|
                      *    |:::|:::|:::|:::|:::|:::|::*|
                      *---|:::|:::|:::|:::|:::|:::|:::*
                    --*|:::|:::|:::|:::|:::|:::|:::|*
                    |:*:|:::|:::|:::|:::|:::|:::|:::| *
              ---   ***:|:::|:::|:::|:::|:::|:::|:::|--***--
           +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
             -4      -3      -2      -1       0       1       2       3       4
                            Tours d'horizon (143 residuals)
```

```
Residuals (critical value = 3.952):
NOTE: Observation values shown are reduced to mark-to-mark.
                                         OBSERVATION RESIDUAL  STD RES
TYPE AT         FROM         TO              STD DEV  STD DEV     PPM
---- ------------ ------------ ------------ ---------------- -------- --------
ZANG         4002         PierA        101 51    29.4     -10.1      -1.3
                                                  8.0       7.7
ZANG         4002         PierB        100 48    79.2      -2.3      -0.3
                                                  8.0       7.2
ZANG         4002         1002          93 56    75.2      -0.6      -0.1
                                                  8.0       7.8
ZANG         4002         2002          95 19    77.5       1.0       0.1
                                                  8.0       7.8
ZANG         4002         3002         100 81    81.6     -13.2      -1.8
                                                  8.0       7.5
ZANG         4002         AREG         102 55    62.0      -7.0      -1.0
                                                  8.0       7.1
ZANG         4002         101          100 92    58.7      -1.1      -0.2
                                                  8.0       7.2
ZANG         4002         AREG_ARP     100 30    27.0      53.9       2.9
                                                 20.0      18.6
ZANG         4002         AREQ         113 91    48.1      -2.5      -0.8
                                                  8.0       3.2
ZANG         4002         5002          98 80    39.9      -5.9      -0.8
                                                  8.0       7.8
ZANG         3002         PierA        101 63    71.5       1.0       0.1
                                                  8.0       7.6
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 70/78

```
ZANG        3002      PierB         100 35     93.8     -4.7     -0.7
                                                8.0      7.1
ZANG        3002      1002           94 55     79.7      6.0      0.8
                                                8.0      7.9
ZANG        3002      2002           95 40     81.4      3.7      0.5
                                                8.0      7.9
ZANG        3002      4002           99 18      5.1     -1.6     -0.2
                                                8.0      7.5
ZANG        3002      AREG          103 27     39.3      4.9      0.9
                                                8.0      5.4
ZANG        3002      42202M009     105 15     94.5    -10.7     -1.6
                                                8.0      6.6
ZANG        3002      101            99 90      5.0      6.4      1.2
                                                8.0      5.5
ZANG        3002      AREG_ARP       98 59     49.6    -45.6     -3.3
                                               20.0     13.9
ZANG        3002      AREQ          102 75      1.1      2.0      0.3
                                                8.0      7.5
ZANG        3002      5002           98 81     74.0      9.6      1.2
                                                8.0      7.9
ZANG        3002      ARFB_marker    98 98     35.7    -10.2     -1.3
                                                8.0      7.9
ZANG        3002      ARFB           98  9     77.5     -6.1     -0.8
                                                8.0      7.9
ZANG        3002      TLRS-3_prism   96 18     57.0      3.3      0.4
                                                8.0      7.9
ZANG        3002      PierA         101 63     56.2    -14.3     -1.9
                                                8.0      7.6
ZANG        3002      4001          104 28     17.7    -14.2     -2.1
                                                8.0      6.6
ZANG        3002      PierA         101 63     71.7      1.2      0.2
                                                8.0      7.6
ZANG        3002      PierD         100 57      0.2     -5.7     -0.7
                                                8.0      7.7
ZANG        2002      PierA         103  2     40.3      1.0      0.1
                                                8.0      7.8
ZANG        2002      PierB         102  0      7.4      3.5      0.5
                                                8.0      7.7
ZANG        2002      1002          100 16     65.5     -6.8     -1.0
                                                8.0      7.1
ZANG        2002      AREQ          105 69     11.9     -9.9     -1.3
                                                8.0      7.9
ZANG        2002      4002          104 80     29.5      1.7      0.2
                                                8.0      7.8
ZANG        2002      3002          104 59     23.5     -3.6     -0.5
                                                8.0      7.9
ZANG        2002      AREG          105 67     96.2     -1.2     -0.1
                                                8.0      7.8
ZANG        2002      101           105 21     18.8      2.8      0.4
                                                8.0      7.8
ZANG        2002      AREG_ARP      105  3     24.0     13.6      1.8
                                                8.0      7.7
ZANG        2002      TLRS-3_prism  102 75     23.7     -1.6     -0.2
                                                8.0      7.6
ZANG        2002      ARFB          105 49     86.5      0.7      0.1
                                                8.0      7.4
ZANG        2002      DORIS_2GHz    104 26      0.6     47.9      2.6
                                               20.0     18.2
ZANG        2002      PierD         105 19     27.0      2.7      0.4
                                                8.0      7.2
ZANG        1002      PierA         103 10     41.0     -2.9     -0.4
                                                8.0      7.8
ZANG        1002      PierB         102 17      1.0     -8.4     -1.1
                                                8.0      7.6
ZANG        1002      4002          106 43     25.6     -1.8     -0.2
                                                8.0      7.8
ZANG        1002      AREQ          107 57     75.8     -6.4     -0.8
                                                8.0      7.8
ZANG        1002      3002          105 44     27.2     -3.1     -0.4
                                                8.0      7.9
ZANG        1002      5002          119 19     57.4    -13.4     -1.9
                                                8.0      7.2
ZANG        1002      TLRS-3_prism  105 85     53.8     -0.5     -0.1
                                                8.0      7.1
ZANG        1002      ARFB_marker   114 21     18.8     11.6      1.6
                                                8.0      7.4
ZANG        1002      ARFB          110 91     24.0     17.4      2.6
                                                8.0      6.6
ZANG        1002      DORIS_2GHz    108 42     38.0      6.2      0.5
                                               20.0     11.9
ZANG        1002      101           106 34     54.6      1.2      0.2
                                                8.0      7.9
ZANG        1002      AREG_ARP      106 12     34.6     -0.2     -0.0
                                                8.0      7.6
ZANG        1002      PierD         105 22     78.1     -5.6     -0.8
                                                8.0      7.2
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1
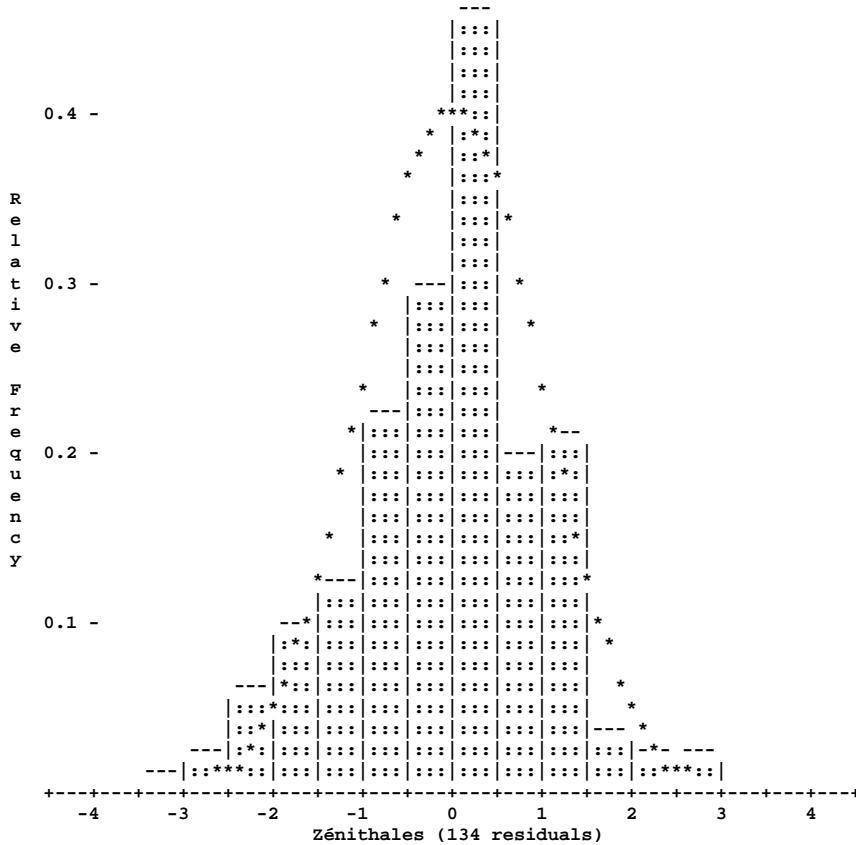
page 71/78

ZANG	1002	2002	99 83	28.6	-0.5	-0.1	
				8.0	7.1		
ZANG	1002	2001	106 39	17.2	1.0	1.1	
				8.0	0.9		
ZANG	1002	PierA	103 10	45.5	1.6	0.2	
				8.0	7.8		
ZANG	1002	PierB	102 17	11.7	2.3	0.3	
				8.0	7.6		
ZANG	1002	AREQ	107 57	73.6	-8.6	-1.1	
				8.0	7.8		
ZANG	1002	5002	119 19	54.7	-16.1	-2.2	
				8.0	7.2		
ZANG	1002	3002	105 44	39.1	8.8	1.1	
				8.0	7.9		
ZANG	1002	ARFB_marker	114 21	24.6	17.4	2.3	
				8.0	7.4		
ZANG	1002	ARFB	110 91	20.2	13.6	2.1	
				8.0	6.6		
ZANG	1002	TLRS-3_prism	105 85	59.5	5.2	0.7	
				8.0	7.1		
ZANG	1002	PierD	105 22	82.7	-1.0	-0.1	
				8.0	7.2		
ZANG	1002	2002	99 83	30.7	1.6	0.2	
				8.0	7.1		
ZANG	1002	101	106 34	50.6	-2.8	-0.4	
				8.0	7.9		
ZANG	1002	AREG_ARP	106 12	27.0	-7.8	-1.0	
				8.0	7.6		
ZANG	1002	4002	106 43	23.4	-4.0	-0.5	
				8.0	7.8		
ZANG	5002	PierD	102 25	95.1	3.7	0.5	
				8.0	6.9		
ZANG	5002	1002	80 80	33.4	3.4	0.5	
				8.0	7.2		
ZANG	5002	3002	101 18	47.5	7.5	1.0	
				8.0	7.9		
ZANG	5002	101	101 33	85.3	2.3	0.3	
				8.0	7.9		
ZANG	5002	AREG_ARP	101 14	10.1	6.2	0.8	
				8.0	7.6		
ZANG	5002	4002	101 19	56.0	-1.5	-0.2	
				8.0	7.8		
ZANG	5002	4001	103 37	78.1	0.0	0.0	
				8.0	7.7		
ZANG	5002	ARFB_marker	101 61	32.9	-9.9	-3.2	
				8.0	3.1		
ZANG	5002	TLRS-3_prism	87 77	74.6	-9.2	-1.6	
				8.0	5.8		
ZANG	6002	PierA	101 32	74.9	5.2	0.7	
				8.0	7.8		
ZANG	6002	1002	92 49	59.9	9.9	1.3	
				8.0	7.7		
ZANG	6002	2002	95 17	33.6	-8.1	-1.0	
				8.0	7.8		
ZANG	6002	3002	100 85	99.9	-22.1	-2.8	
				8.0	7.9		
ZANG	6002	AREQ	102 63	22.5	7.8	1.0	
				8.0	7.7		
ZANG	6002	4002	100 85	83.1	-2.0	-0.3	
				8.0	7.8		
ZANG	6002	42202M009	103 51	14.6	9.2	1.2	
				8.0	7.6		
ZANG	6002	AREG	101 41	27.7	1.4	0.2	
				8.0	7.9		
ZANG	6002	101	100 93	77.6	-7.1	-0.9	
				8.0	7.9		
ZANG	6002	AREG_ARP	100 75	61.0	3.3	0.4	
				8.0	7.7		
ZANG	6002	ARFB_marker	99 50	36.8	7.4	1.1	
				8.0	6.8		
ZANG	6002	ARFB	96 50	96.0	-18.5	-2.9	
				8.0	6.4		
ZANG	6002	TLRS-3_prism	91 34	27.2	2.3	0.4	
				8.0	6.5		
ZANG	6002	PierA	101 32	66.1	-3.6	-0.5	
				8.0	7.8		
ZANG	6002	4001	103 12	19.6	13.9	1.8	
				8.0	7.6		
ZANG	6002	PierA	101 32	76.1	6.4	0.8	
				8.0	7.8		
ZANG	6002	8002	101 8	27.5	5.3	0.7	
				8.0	7.9		
ZANG	6002	7002	100 10	20.0	-2.4	-0.3	
				8.0	7.7		
ZANG	7002	PierA	101 68	3.1	-4.9	-0.6	
				8.0	7.8		

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 72/78

ZANG	7002	PierB	100 70	27.5	2.2	0.3
				8.0	7.4	
ZANG	7002	AREQ	105 72	34.3	4.2	0.6
				8.0	7.2	
ZANG	7002	8002	102 70	31.3	-16.6	-2.2
				8.0	7.5	
ZANG	7002	4002	102 25	40.2	-11.6	-1.7
				8.0	6.9	
ZANG	7002	42202M009	109 91	97.8	2.4	0.4
				8.0	5.7	
ZANG	7002	AREG	103 69	42.7	-16.6	-1.2
				14.4	14.1	
ZANG	7002	101	102 39	58.3	2.1	0.3
				8.0	7.4	
ZANG	7002	10000	103 68	41.4	-3.5	-0.7
				8.0	4.8	
ZANG	7002	1002	91 41	45.5	8.8	1.2
				8.0	7.6	
ZANG	7002	ARFB_marker	99 62	71.4	8.0	1.0
				8.0	7.7	
ZANG	7002	ARFB	98 2	78.1	-19.1	-2.5
				8.0	7.5	
ZANG	7002	DORIS_2GHz	96 84	22.6	-38.7	-2.1
				20.0	18.4	
ZANG	7002	6002	99 89	80.3	-0.0	-0.0
				8.0	7.7	
ZANG	7002	PierA	101 67	99.5	-8.5	-1.1
				8.0	7.8	
ZANG	7002	4001	108 80	44.0	10.3	1.8
				8.0	5.8	
ZANG	7002	TLRS-3_prism	93 96	77.0	9.3	1.3
				8.0	7.3	
ZANG	7002	PierA	101 68	11.4	3.4	0.4
				8.0	7.8	
ZANG	7002	PierD	101 27	4.6	4.1	0.5
				8.0	7.5	
ZANG	8002	PierA	101 42	72.2	8.6	1.1
				8.0	7.7	
ZANG	8002	PierB	100 24	9.7	7.7	1.1
				8.0	7.3	
ZANG	8002	AREG	102 74	3.4	0.3	0.1
				8.0	4.2	
ZANG	8002	101	98 24	48.0	-3.7	-0.9
				8.0	4.4	
ZANG	8002	42202M009	104 24	16.7	1.5	0.2
				8.0	6.9	
ZANG	8002	4002	98 80	57.9	-5.9	-0.8
				8.0	7.6	
ZANG	8002	AREQ	101 98	64.3	11.0	1.4
				8.0	7.6	
ZANG	8002	7002	97 29	42.3	-11.4	-1.5
				8.0	7.5	
ZANG	8002	6002	98 91	83.0	0.9	0.1
				8.0	7.9	
ZANG	8002	1002	93 24	78.8	16.1	2.0
				8.0	7.9	
ZANG	8002	ARFB_marker	98 67	91.8	-6.1	-0.8
				8.0	7.9	
ZANG	8002	ARFB	97 67	98.9	-13.5	-1.7
				8.0	7.8	
ZANG	8002	DORIS_2GHz	96 93	68.1	-39.6	-2.0
				20.0	19.4	
ZANG	8002	TLRS-3_prism	95 46	78.9	1.2	0.2
				8.0	7.8	
ZANG	8002	PierA	101 42	70.2	6.6	0.9
				8.0	7.7	
ZANG	8002	4001	103 44	28.2	-3.2	-0.5
				8.0	6.9	
ZANG	8002	10000	101 33	80.2	4.6	0.7
				8.0	6.3	
ZANG	8002	20000	101 15	87.2	0.0	0.0
				8.0	0.0	*
ZANG	8002	PierA	101 42	74.3	10.7	1.4
				8.0	7.7	

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 73/78

```
                                        ---
                                       |:::|
                                       |:::|
                                       |:::|
                                       |:::|
        0.4 -                         ***::|
                                   *  |:*:|
                                   *  |::*|
                                   *  |:::*
      R                               |:::|
      e                            *  |:::|*
      l                               |:::|
      a                               |:::|
      t   0.3 -                  *  ---|:::| *
      i                             |:::|:::|
      v                          *  |:::|:::|   *
      e                             |:::|:::|
                                    |:::|:::|
      F                          *  |:::|:::|     *
      r                         ---|:::|:::|
      e                       *|:::|:::|:::|     *--
      q   0.2 -                |:::|:::|:::|---|:::|
      u                      * |:::|:::|:::|:::|:*:|
      e                        |:::|:::|:::|:::|:::|
      n                        |:::|:::|:::|:::|:::|
      c                      * |:::|:::|:::|:::|::*|
      y                        |:::|:::|:::|:::|:::|
                            *---|:::|:::|:::|:::|:::*
                               |:::|:::|:::|:::|:::|
        0.1 -              --*|:::|:::|:::|:::|:::|*
                          |:*:|:::|:::|:::|:::|:::| *
                          |:::|:::|:::|:::|:::|:::|
                        ---|*::|:::|:::|:::|:::|:::|  *
                        |:::*::|:::|:::|:::|:::|:::|   *
                        |::*|:::|:::|:::|:::|:::|:::|--- *
                    ---|:*:|:::|:::|:::|:::|:::|:::|:::|-*- ---
                    ---|::***::|:::|:::|:::|:::|:::|:::|:::|::***::|
              +---+---+---+---+---+---+---+---+---+---+---+---+---+---+
                -4      -3      -2      -1       0       1       2       3       4
                            Zénithales (134 residuals)
```

Residuals (critical value = 3.952):
NOTE: Observation values shown are reduced to mark-to-mark.

TYPE	AT	FROM	TO	OBSERVATION STD DEV	RESIDUAL STD DEV	STD RES PPM
DIST		4002	PierA	80.81690	0.0008	0.5525
				0.0015	0.0015	9.96
DIST		4002	PierB	80.75280	-0.0004	-0.3205
				0.0015	0.0013	5.30
DIST		4002	1002	31.88780	0.0002	0.2266
				0.0010	0.0010	6.99
DIST		4002	2002	43.18130	0.0003	0.2899
				0.0010	0.0010	6.50
DIST		4002	3002	14.36900	-0.0000	-0.0142
				0.0010	0.0010	0.97
DIST		4002	101	12.08440	-0.0002	-0.2215
				0.0010	0.0010	18.12
DIST		4002	5002	33.59720	-0.0003	-0.3139
				0.0010	0.0010	9.17
DIST		3002	PierA	67.54210	0.0004	0.4671
				0.0010	0.0009	6.42
DIST		3002	2002	47.71990	-0.0006	-0.5878
				0.0010	0.0010	11.90
DIST		3002	4002	14.36880	0.0002	0.1888
				0.0010	0.0010	12.95
DIST		3002	101	5.84180	-0.0003	-0.2565
				0.0010	0.0010	43.42
DIST		3002	PierA	67.54200	0.0005	0.3672
				0.0015	0.0015	7.90
DIST		3002	4001	14.40020	-0.0005	-0.4968
				0.0010	0.0010	33.63
DIST		3002	PierA	67.54180	0.0007	0.5048
				0.0015	0.0015	10.86
DIST		2002	PierA	109.02220	0.0010	0.6807
				0.0015	0.0015	9.07
DIST		2002	1002	14.43200	0.0003	0.3225

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1
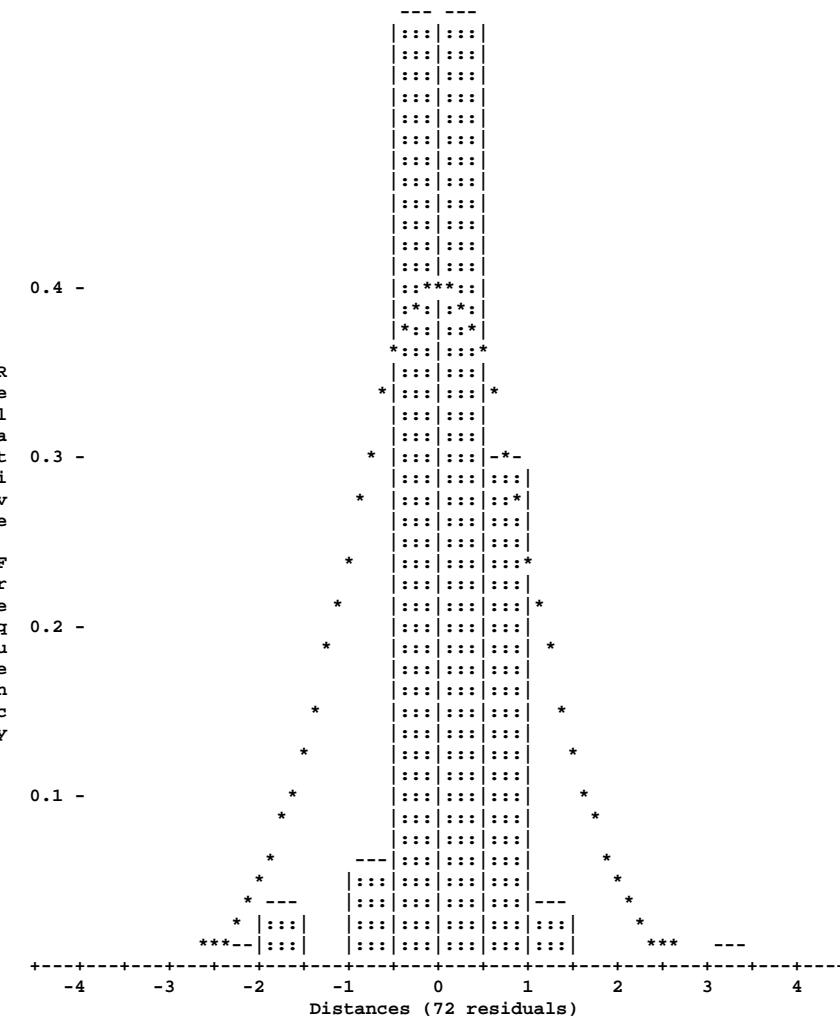
page 74/78

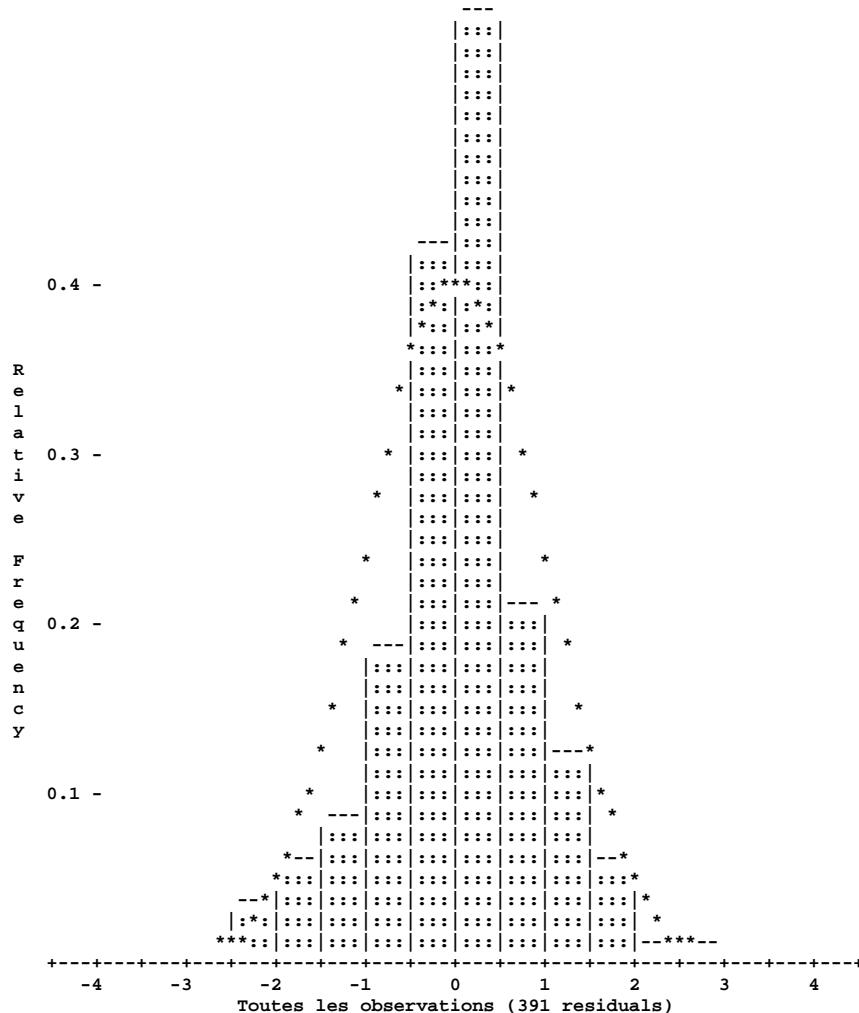|					
				0.0010	0.0010	21.74
DIST	2002	4002	43.18130	0.0003	0.2899
				0.0010	0.0010	6.50
DIST	2002	3002	47.72000	-0.0007	-0.6913
				0.0010	0.0010	13.99
DIST	2002	101	41.94950	0.0007	0.6742
				0.0010	0.0010	15.61
DIST	2002	TLRS-3_prism	26.23990	-0.0001	-0.0699
				0.0010	0.0010	2.56
DIST	1002	PierA	105.42020	0.0008	0.8438
				0.0010	0.0009	7.47
DIST	1002	PierB	112.51860	-0.0004	-0.2652
				0.0015	0.0013	3.16
DIST	1002	4002	31.88770	0.0003	0.3282
				0.0010	0.0010	10.13
DIST	1002	3002	39.83420	0.0000	0.0383
				0.0010	0.0010	0.94
DIST	1002	5002	8.70570	0.0003	0.2915
				0.0010	0.0010	33.01
DIST	1002	TLRS-3_prism	11.93580	-0.0004	-0.4233
				0.0010	0.0010	34.83
DIST	1002	101	34.09210	-0.0000	-0.0174
				0.0010	0.0010	0.50
DIST	1002	PierD	51.22330	0.0012	0.8869
				0.0015	0.0014	23.39
DIST	1002	2002	14.43200	0.0003	0.3225
				0.0010	0.0010	21.74
DIST	1002	2001	14.50460	0.0002	0.3843
				0.0010	0.0004	10.81
DIST	1002	PierA	105.42030	0.0007	0.4721
				0.0015	0.0015	6.52
DIST	1002	PierB	112.51830	-0.0001	-0.0414
				0.0015	0.0013	0.49
DIST	1002	TLRS-3_prism	11.93570	-0.0003	-0.3215
				0.0010	0.0010	26.46
DIST	1002	5002	8.70590	0.0001	0.0886
				0.0010	0.0010	10.04
DIST	1002	3002	39.83430	-0.0001	-0.0642
				0.0010	0.0010	1.57
DIST	1002	PierD	51.22270	0.0018	1.3311
				0.0015	0.0014	35.10
DIST	1002	2002	14.43170	0.0006	0.6308
				0.0010	0.0010	42.53
DIST	1002	101	34.09150	0.0006	0.5940
				0.0010	0.0010	17.10
DIST	1002	4002	31.88770	0.0003	0.3282
				0.0010	0.0010	10.13
DIST	5002	PierD	45.56120	0.0007	0.5263
				0.0015	0.0014	15.61
DIST	5002	1002	8.70600	-0.0000	-0.0128
				0.0010	0.0010	1.45
DIST	5002	3002	43.87860	-0.0001	-0.1157
				0.0010	0.0010	2.56
DIST	5002	101	38.38100	0.0001	0.0864
				0.0010	0.0010	2.20
DIST	5002	4002	33.59690	-0.0000	-0.0082
				0.0010	0.0010	0.24
DIST	5002	4001	33.63900	0.0004	0.3792
				0.0010	0.0010	10.90
DIST	5002	TLRS-3_prism	7.80660	-0.0004	-0.3648
				0.0010	0.0010	46.28
DIST	6002	PierA	113.19540	0.0008	0.5364
				0.0015	0.0015	6.88
DIST	6002	1002	23.63180	0.0001	0.1125
				0.0010	0.0010	4.62
DIST	6002	2002	37.20100	0.0003	0.3490
				0.0010	0.0009	8.86
DIST	6002	3002	45.93990	-0.0003	-0.2921
				0.0010	0.0010	6.14
DIST	6002	4002	32.41630	-0.0001	-0.0733
				0.0010	0.0010	2.21
DIST	6002	101	41.58140	-0.0004	-0.3921
				0.0010	0.0010	9.17
DIST	6002	TLRS-3_prism	12.41600	0.0001	0.0866
				0.0010	0.0010	6.80
DIST	6002	PierA	113.19550	0.0007	0.4675
				0.0015	0.0015	6.00
DIST	6002	4001	32.45380	-0.0006	-0.6260
				0.0010	0.0010	18.65
DIST	6002	7002	26.93390	-0.0016	-1.6280
				0.0010	0.0010	58.97
DIST	7002	PierA	87.71940	-0.0001	-0.0362
				0.0015	0.0015	0.60
DIST	7002	4002	11.12080	0.0001	0.1279
				0.0010	0.0010	11.35
DIST	7002	101	15.14120	-0.0002	-0.1673

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 75/78

```
                                              0.0010    0.0010     10.86
        DIST            7002       10000      22.55080   0.0027     3.4223
                                              0.0010    0.0008    120.45
        DIST            7002       1002       20.99120   0.0007     0.6969
                                              0.0010    0.0010     32.58
        DIST            7002       6002       26.93400  -0.0017    -1.7305
                                              0.0010    0.0010     62.68
        DIST            7002       PierA      87.71950  -0.0002    -0.1642
                                              0.0010    0.0009      1.74
        DIST            7002       4001       11.22180   0.0003     0.2600
                                              0.0010    0.0010     22.57
        DIST            7002       TLRS-3_prism 18.24490 -0.0001   -0.1233
                                              0.0010    0.0010      6.63
        DIST            8002       1002       33.17660   0.0011     1.1048
                                              0.0010    0.0010     32.69
        DIST            8002       10000      29.23250  -0.0020    -2.4670
                                              0.0010    0.0008     68.77
        DIST            8002       20000      40.43750   0.0000     0.0000
                                              0.0010    0.0000      0.00*
        DIST            TLRS-3_prism PierA    105.92660  0.0002     0.1387
                                              0.0015    0.0015      1.91
        DIST            TLRS-3_prism PierB    105.94470  0.0006     0.4153
                                              0.0015    0.0013      5.27
        DIST            TLRS-3_prism PierA    105.92640  0.0004     0.2761
                                              0.0015    0.0015      3.79
        DIST            TLRS-3_prism PierB    105.94490  0.0004     0.2664
                                              0.0015    0.0013      3.38
```

```
                              --- ---
                              |:::|:::|
                              |:::|:::|
                              |:::|:::|
                              |:::|:::|
                              |:::|:::|
                              |:::|:::|
                              |:::|:::|
                              |:::|:::|
                              |:::|:::|
                              |:::|:::|
                              |:::|:::|
                              |:::|:::|
         0.4 -                |::***::|
                              |:*:|:*:|
                              |*::|::*|
                              *:::|:::*
     R                        |:::|:::|
     e                      *|:::|:::|*
     l                        |:::|:::|
     a                        |:::|:::|
     t   0.3 -              * |:::|:::|-*-
     i                        |:::|:::|:::|
     v                      * |:::|:::|::*|
     e                        |:::|:::|:::|
                              |:::|:::|:::|
     F                    *   |:::|:::|:::*
     r                        |:::|:::|:::|
     e                    *   |:::|:::|:::|*
     q   0.2 -                |:::|:::|:::|
     u                   *    |:::|:::|:::| *
     e                        |:::|:::|:::|
     n                        |:::|:::|:::|
     c                 *      |:::|:::|:::|  *
     y                        |:::|:::|:::|
                       *      |:::|:::|:::|   *
                              |:::|:::|:::|
         0.1 -         *      |:::|:::|:::|   *
                    *         |:::|:::|:::|  *
                              |:::|:::|:::|
                  *      ---|:::|:::|:::|      *
                   *       |:::|:::|:::|:::|     *
                * ---     |:::|:::|:::|:::|---   *
               * |:::|   |:::|:::|:::|:::|:::|    *
              ***--|:::|  |:::|:::|:::|:::|:::|  ***  ---
          +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
          -4      -3      -2      -1       0       1       2       3       4
                          Distances (72 residuals)
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 76/78

```
                                         ---
                                        |:::|
                                        |:::|
                                        |:::|
                                        |:::|
                                        |:::|
                                        |:::|
                                        |:::|
                                        |:::|
                                        |:::|
                                        |:::|
                                     ---|:::|
                                    |:::|:::|
          0.4 -                     |:::|:::|
                                    |:::***:|
                                    |:*:|:*:|
                                    |*::|::*|
                                    *:::|:::*
   R                                |:::|:::|
   e                               *|:::|:::|*
   l                                |:::|:::|
   a                                |:::|:::|
   t   0.3 -                      * |:::|:::| *
   i                                |:::|:::|
   v                             *  |:::|:::|   *
   e                                |:::|:::|
                                    |:::|:::|
   F                            *   |:::|:::|    *
   r                                |:::|:::|
   e                            *   |:::|:::|--- *
   q   0.2 -                        |:::|:::|:::|
   u                           * ---|:::|:::|:::| *
   e                              |:::|:::|:::|:::|
   n                              |:::|:::|:::|:::|
   c                          *   |:::|:::|:::|:::|   *
   y                              |:::|:::|:::|:::|
                               *  |:::|:::|:::|:::|---*
                                  |:::|:::|:::|:::|:::|
          0.1 -               *   |:::|:::|:::|:::|:::|*
                          * ---|:::|:::|:::|:::|:::| *
                              |:::|:::|:::|:::|:::|:::|
                          *--|:::|:::|:::|:::|:::|:::|--*
                        *:::|:::|:::|:::|:::|:::|:::|:::*
                      --*|:::|:::|:::|:::|:::|:::|:::|:::|*
                      |:*:|:::|:::|:::|:::|:::|:::|:::|:::| *
                    ***:|:::|:::|:::|:::|:::|:::|:::|--***--
               +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
               -4      -3      -2      -1       0       1       2       3       4
                         Toutes les observations (391 residuals)
```

```
     ----------------------------------------------------------------------
    |                                                                      |
    |              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      |           3.9519                   |
    |    Number of Flagged Residuals  |              1                     |
    |    Convergence Criterion        |           0.0001                   |
    |    Final Iteration Counter Value|              4                     |
    |    Confidence Level Used        |          95.0000                   |
    |    Estimated Variance Factor    |           1.1680                   |
    |    Number of Degrees of Freedom |            281                     |
    |                                 |                                    |
    |----------------------------------------------------------------------|
    |                                                                      |
    |       Chi-Square Test on the Variance Factor:                        |
    |                                                                      |
    |       9.9663e-01  <  1.0000  <  1.3881e+00  ?                        |
    |                                                                      |
    |                   THE TEST PASSES                                    |
    |                                                                      |
     ----------------------------------------------------------------------
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 77/78

```
--------------------------------------------------------------------------
|                                                                        |
| NOTE:  All confidence regions were computed using the following factors:|
|        ----------------------------------------------------------------|
|        Variance factor used      =          1.1680                      |
|        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.                               |
|                                                                        |
--------------------------------------------------------------------------

2-D and 1-D Station Confidence Regions (95.000 and 95.000 percent):
STATION          MAJOR SEMI-AXIS  AZ    MINOR SEMI-AXIS            VERTICAL
------------     ---------------- ---   ------------------     ------------
10000                     0.0032  67                 0.0029           0.0022
1002                      0.0028 141                 0.0027           0.0021
101                       0.0027  86                 0.0027           0.0021
20000                     0.0038  33                 0.0033           0.0024
2001                      0.0037 103                 0.0029           0.0022
2002                      0.0029 151                 0.0027           0.0021
3002                      0.0027  84                 0.0027           0.0021
4001                      0.0027  80                 0.0027           0.0021
4002                      0.0027 103                 0.0027           0.0021
42202M001                 0.0065  33                 0.0063           0.0029
42202M002                 0.0038 147                 0.0036           0.0026
42202M004                 0.0039 141                 0.0038           0.0037
42202M009                 0.0027 100                 0.0027           0.0021
42202M010                 0.0062  67                 0.0060           0.0027
5002                      0.0028 131                 0.0027           0.0021
6002                      0.0029 103                 0.0027           0.0021
7002                      0.0027  85                 0.0027           0.0021
7403                      0.0080 119                 0.0080           0.0061
8002                      0.0027  97                 0.0027           0.0021
AREG                      0.0027  89                 0.0027           0.0021
AREG_ARP                  0.0027  84                 0.0027           0.0021
AREQ                      0.0026  90                 0.0026           0.0021
ARFB                      0.0029 129                 0.0027           0.0021
ARFB_marker               0.0029 130                 0.0027           0.0021
DORIS_2GHz                0.0029 129                 0.0027           0.0022
PierA                     0.0033  93                 0.0028           0.0022
PierB                     0.0035 130                 0.0032           0.0023
PierD                     0.0033 130                 0.0031           0.0022
TLRS-3_SRP                0.0047 119                 0.0046           0.0031
TLRS-3_mount              0.0038 119                 0.0038           0.0027
TLRS-3_prism              0.0028 119                 0.0027           0.0021

3D Station Confidence Regions (95.000 percent):
STATION          MAJ-SEMI (AZ,VANG)    MED-SEMI (AZ,VANG)     MIN-SEMI (AZ,VANG)
------------     -------------------   -------------------    -------------------
10000            0.0036 ( 67,  0)      0.0033 (157,  0)       0.0031 (331, 90)
1002             0.0032 (141,  0)      0.0031 ( 51,  0)       0.0030 (268, 90)
101              0.0031 ( 86,  0)      0.0031 (176,  0)       0.0030 (337, 90)
20000            0.0043 (213,  0)      0.0038 (123,  0)       0.0034 (310, 90)
2001             0.0042 (103,  0)      0.0033 (193,  0)       0.0031 (354, 90)
2002             0.0034 (151,  0)      0.0031 ( 61,  0)       0.0030 (277, 90)
3002             0.0031 ( 84,  0)      0.0031 (174,  0)       0.0030 (349, 90)
4001             0.0031 ( 80,  0)      0.0031 (170,  0)       0.0030 (329, 90)
4002             0.0031 (103,  0)      0.0030 (193,  0)       0.0030 (360, 90)
42202M001        0.0074 (213,  0)      0.0071 (123,  0)       0.0041 (313, 90)
42202M002        0.0043 (147,  0)      0.0042 ( 57,  0)       0.0037 (302, 90)
42202M004        0.0052 (122, 90)      0.0044 (321,  0)       0.0043 (231,  0)
42202M009        0.0031 (100,  0)      0.0031 (190,  0)       0.0030 (320, 90)
42202M010        0.0070 ( 67,  0)      0.0069 (157,  0)       0.0039 (317, 90)
5002             0.0032 (131,  0)      0.0031 ( 41,  0)       0.0030 (248, 90)
6002             0.0033 (103,  0)      0.0031 ( 13,  0)       0.0030 (258, 90)
7002             0.0031 ( 85,  0)      0.0031 (175,  0)       0.0030 (308, 90)
7403             0.0091 (119,  0)      0.0091 ( 29,  0)       0.0087 (285, 90)
8002             0.0031 ( 97,  0)      0.0031 (187,  0)       0.0030 (339, 90)
AREG             0.0031 ( 89,  0)      0.0031 (179,  0)       0.0030 (338, 90)
AREG_ARP         0.0031 ( 84,  0)      0.0031 (174,  0)       0.0031 (343, 90)
AREQ             0.0030 (110,  0)      0.0030 ( 20,  1)       0.0030 (211, 89)
ARFB             0.0033 (129,  0)      0.0031 ( 39,  0)       0.0030 (244, 90)
ARFB_marker      0.0033 (130,  0)      0.0031 ( 40,  0)       0.0030 (246, 90)
DORIS_2GHz       0.0033 (129,  0)      0.0032 (348, 90)       0.0031 (219,  0)
PierA            0.0038 (273,  0)      0.0032 (183,  0)       0.0031 (  4, 90)
PierB            0.0040 (310,  0)      0.0037 ( 40,  0)       0.0033 (183, 90)
PierD            0.0038 (310,  0)      0.0036 ( 40,  0)       0.0032 (210, 90)
TLRS-3_SRP       0.0053 (119,  0)      0.0053 ( 29,  0)       0.0045 (285, 90)
TLRS-3_mount     0.0044 (119,  0)      0.0043 ( 29,  0)       0.0038 (285, 90)
TLRS-3_prism     0.0032 (119,  0)      0.0031 ( 29,  0)       0.0030 (262, 90)
```

IGN
Service
de Géodésie
et Nivellement

Thomas DONAL

Arequipa ITRF co-location survey

RT/G 186
v 1

page 78/78

6.8. Arequipa SINEX file

```
%=SNX 1.00 IGN 15:013:00000 IGN 13:012:00000 13:012:00000 C 00012
*-------------------------------------------------------------------------------
+FILE/COMMENT
* File created by geotosnx software (Z.Altamimi)
* Original input file: AREG_SINEX.cov
* Matrix Scalling Factor used:         1.0000000000
-FILE/COMMENT
*-------------------------------------------------------------------------------
+SITE/ID
*CODE PT __DOMES__ T _STATION DESCRIPTION__ APPROX_LON_ APPROX_LAT_ _APP_H_
 AREQ  A 42202M005    42202M005              288 30 25.9 -16 27 55.8 2488.9
 AREG  A 42202M008    42202M008              288 30 25.5 -16 27 55.5 2489.3
 ARFB  A 42202S007    42202S007              288 30 25.1 -16 27 56.7 2491.0
 7403  A 42202M003    42202M003              288 30 25.3 -16 27 56.5 2488.8
-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   AREQ  A    1 13:012:00000 m    2 0.194282622510000E+07 0.10808E-02
     2 STAY   AREQ  A    1 13:012:00000 m    2 -.580407034190000E+07 0.10808E-02
     3 STAZ   AREQ  A    1 13:012:00000 m    2 -.179689419100000E+07 0.10808E-02
     4 STAX   AREG  A    1 13:012:00000 m    2 0.194281636440000E+07 0.10858E-02
     5 STAY   AREG  A    1 13:012:00000 m    2 -.580407714550000E+07 0.10992E-02
     6 STAZ   AREG  A    1 13:012:00000 m    2 -.179688442740000E+07 0.11046E-02
     7 STAX   ARFB  A    1 13:012:00000 m    2 0.194280335280000E+07 0.10946E-02
     8 STAY   ARFB  A    1 13:012:00000 m    2 -.580407157560000E+07 0.11154E-02
     9 STAZ   ARFB  A    1 13:012:00000 m    2 -.179692214240000E+07 0.11640E-02
    10 STAX   7403  A    1 13:012:00000 m    2 0.194280760860000E+07 0.31104E-02
    11 STAY   7403  A    1 13:012:00000 m    2 -.580406978370000E+07 0.32498E-02
    12 STAZ   7403  A    1 13:012:00000 m    2 -.179691568370000E+07 0.32499E-02
-SOLUTION/ESTIMATE
*-------------------------------------------------------------------------------
+SOLUTION/MATRIX_ESTIMATE L COVA
*PARA1 PARA2 ____PARA2+0_____ ____PARA2+1_____ ____PARA2+2_____
     1     1 0.116804140794147E-05
     2     1 0.317614087534460E-17 0.116804140819676E-05
     3     1 0.750839554698113E-16 -.887466190363948E-18 0.116804140817600E-05
     4     1 0.116804142554657E-05 -.204975703847419E-12 0.618228242840096E-14
     4     4 0.117906959058384E-05
     5     1 0.270183305183891E-13 0.116804138374542E-05 0.659367710311525E-12
     5     4 -.183758179755569E-08 0.120817311188861E-05
     6     1 -.199300428853617E-12 -.693527042822759E-12 0.116804150537073E-05
     6     4 0.132856755913197E-07 -.621670394840600E-08 0.122009437861255E-05
     7     1 0.116804162094127E-05 0.319614058258793E-12 -.571422233974173E-12
     7     4 0.117307570925776E-05 -.446644394864905E-08 0.356353566812742E-08
     7     7 0.119824571991847E-05
     8     1 -.357230571690768E-12 0.116804170200644E-05 -.120866538117988E-11
     8     4 0.149996861069079E-07 0.119243109100719E-05 0.507050065038914E-07
     8     7 0.156632357777747E-07 0.124414367798010E-05
     9     1 -.506234575967480E-13 0.100436673795330E-11 0.116804161855348E-05
     9     4 0.356385174473352E-08 -.151118426995819E-07 0.118408116344187E-05
     9     7 0.507481078517394E-07 0.529949106288304E-07 0.135494964155327E-05
    10     1 0.116804181602874E-05 -.286593748722066E-12 -.118735775882925E-12
    10     4 0.117345356094195E-05 0.112199018462780E-07 0.486800593684455E-08
    10     7 0.118479459616499E-05 0.660594419493146E-08 0.323958900240632E-07
    10    10 0.967470876550616E-05
    11     1 0.246408742748969E-12 0.116804166537964E-05 0.807924264183456E-12
    11     4 -.372357936145162E-08 0.118768314799776E-05 -.125983833753348E-07
    11     7 0.646843611097486E-08 0.121547335655408E-05 0.218852784665253E-07
    11    10 0.465663781982682E-08 0.105613124072894E-04
    12     1 -.496384469211641E-12 -.963757052157149E-12 0.116804156634204E-05
    12     4 0.486783351626992E-08 0.379619912170133E-07 0.118848599644001E-05
    12     7 0.323960342415406E-07 0.223504777793106E-07 0.128482978457586E-05
    12    10 0.287390466366696E-06 0.157552076014788E-07 0.105621257139719E-04
-SOLUTION/MATRIX_ESTIMATE L COVA
%ENDSNX
```