Report no. 19-04811-12

# ITRF Local tie survey at the geodetic observatory at Brandal, Ny-Ålesund Svalbard

**Document information:**

Title: ITRF Local tie survey at the geodetic observatory at Brandal, Ny-Ålesund Svalbard

Date: 18 June 2021

Report no.: 19-04811-12

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Classification: Free

Summary: Determination of local ties at the geodetic observatory of Brandal, Ny-Ålesund. Description of survey methods, computations and results.

Keywords: VLBI, GNSS, Doris, Total station, Reference points

Reviewer: Per Chr. Bratheim

## ABSTRACT

The ITRF2014 realization (the most recent frame of the International Terrestrial Reference System) computed by the ITRF Product Centre (IGN Geodesy research team from IPGP) is the result of the reference frames combinations from four space geodetic techniques (GNSS, DORIS, SLR and VLBI). The next ITRF update is intended to be ITRF2020, planned to be realised in 2021.

Local ties of reference points at sites with multiple techniques are crucial for the realise of ITRF. The geodetic observatory of Brandal, Ny-Ålesund at Svalbard is equipped with two VLBI telescopes, DORIS station and three permanent GNSS stations. One of the GNSS-stations is proposed to become part of the IGS network. The other two GNSS stations have stability problems. The observatory is also equipped with a gravimetric lab, and a SLR site is under construction. This report describes the local tie survey carried out in August/September 2019 and 2020.

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# 1 Introduction

## 1.1 Context

The International Terrestrial Reference Frame (ITRF) is the result of a combination of different terrestrial reference frames provided by the four space geodetic techniques (GNSS, DORIS, SLR and VLBI). To combine the technique specific reference frames to ITRF, local tie surveys between co-located space geodetic instruments are necessary. The ties are expressed in three dimensions with a precision reflecting the accuracy of the reference frame. To improve the ITRF realization, local tie vectors from new co-located sites need to be added to the ITRF combination. At the new observatory at Brandal, Ny Ålesund three space geodetic techniques are now present: VLBI, GNSS and DORIS.

The goals were the following:

• Assign coordinates to the reference points of the two VLBI-telescopes, DORIS antenna and GNSS sites.

• Provide tie vectors between instrument reference points (i.e. DORIS, GNSS and VLBI intersection point)

• Produce a survey result file in SINEX format.

## 1.2 Glossary

| | |
|---|---|
| ARP: | Antenna Reference Point |
| CNES: | Centre National d'Études Spatiales (France) |
| DOMES: | Directory of MERIT Sites |
| DORIS: | Doppler Orbitography and Radiopositioning Integrated by Satellite |
| GGOS: | Global Geodetic Observing System |
| GNSS: | Global Navigation Satellite System |
| IDS: | International DORIS Service |
| IERS: | International Earth Rotation and Reference Systems Service |
| IGN: | Institut National de l'Information Géographique et Forestière (France) |
| IGS: | International GNSS Service |
| Kartverket: | Norwegian Mapping Authority |
| SINEX: | Solution INdependent Exchange |
| SLR: | Satellite Laser Ranging |
| VLBI: | Very Long Baseline Interferometry |
| Wasoft: | GNSS software from University of Dresden by prof. L. Wanninger |

# 2 Co-location site description

## 2.1 Site information

The new geodetic observatory at is located close to Ny Ålesund at Svalbard about 1.5 km north of the old observatory at Rabben. The observatory at Rabben include the VLBI antenna NYALES20 and the GNSS stations NYAL and NYA1. The new observatory, except the DORIS equipment, is owned by Kartverket (Norwegian Mapping Authority).


*Figure 1 Map of Spitsbergen, Svalbard*

## 2.2 Co-located points

The observatory at Brandal, Ny-Ålesund is equipped with VLBI 2010 twin telescopes, three GNSS-stations, DORIS station, gravimetric lab, and SLR site under construction. For local tie purposes, there are nine control points and one automatic total station for stability monitoring. One of the GNSS-stations, NABG is proposed as IGS and EPN-stations. The other two stations, NABD and NABE are not stable and show annual variations in GNSS position.

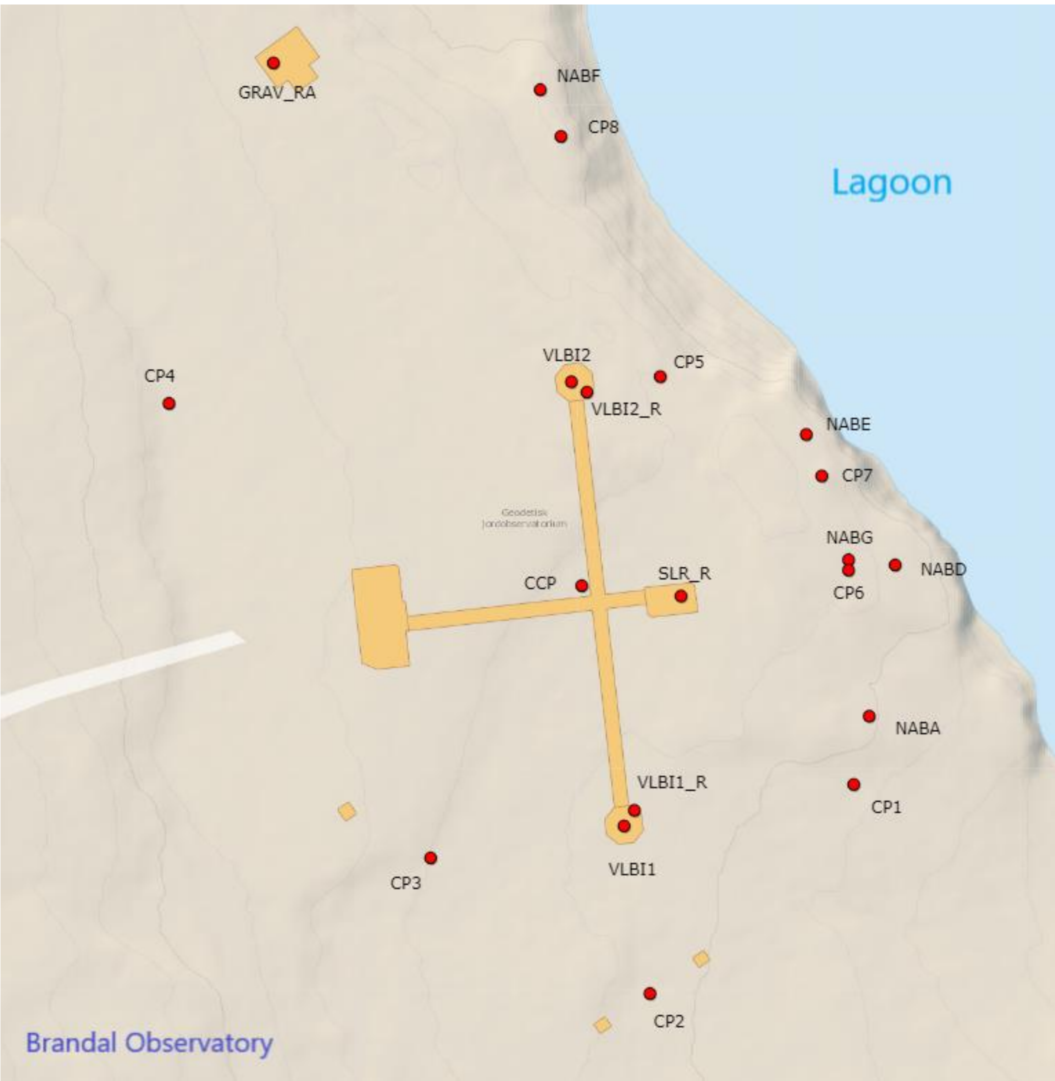


*Figure 2 Map of Brandal Geodetic Observatory*

*Table 1 Co-located points*

| Technique Name | Domes no. | Description | Acronym |
|---|---|---|---|
| GNSS | 10338M008 | ARP, BAM. Top steel grid mast | NABG |
| VLBI | 10338S001 | VLBI1, south, intersection point | 7392 |
| VLBI | 10338S002 | VLBI2, north, intersection point | 7393 |
| DORIS | 10338S003 | DORIS antenna reference point | SVAC |

The co-located points are listed in table 1. All the control points are listed in table 2. Figures 3 - 5 show some of the co-located points and control points.

*Figure 3 Control points. From left: CP2 with GNSS antenna, CP7 with prism, CP7 with total station*

*Figure 4 DORIS*

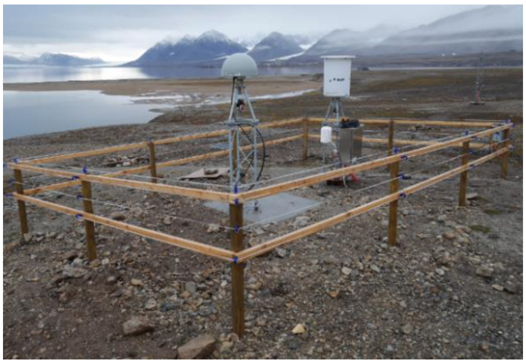

*Figure 5 Permanent GNSS station NABG and CP6 with continuosly operating Trimble total station*

*Table 2 Markers used in the local tie survey*

| Technique name | Description | Name or number |
|---|---|---|
| GNSS | GNSS station. Slightly unstable ~ 2 -3 mm | NABD |
| GNSS | GNSS station. Slightly unstable ~ 3 -4 mm | NABE |
| TS, prism | Prism holder under NABD antenna mount | NABD_U |
| TS, prism | Prism holder under NABE antenna mount | NABE_U |
| Total station/GNSS | Control points, short steel grid masts. All more or less unstable. Equipped with GNSS for monitoring stability. | CP1 – CP10 |
| Total station/GNSS | Control point on 5 m steel grid mast. Unstable | CCP |
| TS, prism | Prism holder on steel grid mast, previous GNSS | NABA_R |
| TS, prism | Prism holder on steel grid mast, previous GNSS | NABF_R |
| GNSS | Bolt in concrete monument, far away point | S01T0001 |
| GNSS | Bolt, screw in concrete monument, far away point | S01T0015 |
| GNSS | Bolt, screw in concrete monument, far away point | S01T0016 |
| TS, prism, GNSS | Bolt, screw in bedrock, far away point | S01T0017 |
| TS, prism, GNSS | Bolt, screw in bedrock, far away point | S01T0018 |
| TS, prism, GNSS | Bolt, screw in bedrock, far away point | S01T0020 |
| TS, prism, GNSS | Bolt, screw in concrete monument, far away point | S01T0021 |
| | | |
| Continuously operating TS | Trimble Total Station installed and operated by company Cautus Geo. Stability measurement, VLBI, SLR, and GNSS monuments | CP6 |

# 3 Local tie survey description

## 3.1 Organization

The local tie survey observations were done from 23 August to 1 September 2019 and from 24 August to 5 September 2020 by Oddvar Tangen and Torbjørn Nørbech. Working outdoor at the observatory calls for a polar bear guard.

## 3.2 Equipment

All instruments are owned by Kartverket. The total Station is calibrated and maintained annually.

*Table 3 Equipment used in the survey*

| Equipment | Trade mark, Serial number | Specifications |
|---|---|---|
| Total Station | Leica TS 15 , 1622095 | EDM st.. dev. 1.0 mm + 1 ppm Angular st. dev. 0.6 mgon |
| Total Station | Leica TS 15, 1612188 | EDM st.. dev. 1.0 mm + 1 ppm Angular st. dev. 0.6 mgon |
| Reflector/Prism | Leica GPH1P | Centring accuracy 0.3 mm |
| Reflector/Prism, Magnetic | Leica Red Ring Reflector (RRR) | Centring accuracy 0.0254 mm |
| GNSS antenna<br>(GNSS campaign network) | ASH700936E, CR15811<br>ASH700936E_M, CR520023605<br>ASH700936C_M, 11783<br>ASH700936C_M, 11978 | |
| GNSS antenna<br>(GNSS campaign network) | TRM29659.00, 0220098649<br>TRM29659.00, 0220098660<br>TRM29659.00, 0220098656<br>TRM29659.00, 0220098661 | |
| GNSS receiver<br>(GNSS campaign network) | TRIMBLE NETRS 4345228744<br>TRIMBLE NETRS 4439239161<br>TRIMBLE NETRS 4422234356<br>TRIMBLE NETRS 4422234369<br>TRIMBLE NETRS 4541260288<br>TRIMBLE NETRS 4422234360<br>TRIMBLE NETRS 4412232899<br>TRIMBLE NETRS 4345228724 | |

Metrological data are taken from the AWIPEV research station and confirmed with an older Thommen barometer and Kern psycrometer for temperature.

## 3.3 Survey method

The total station has observed to all control points with visible lines of sight. Horizontal directions, zenith angles and distances are observed in data sets, first defining the set by aiming the targets, and then the total station runs through the sets automatically. Five readings in both theodolite positions and four full sets are measured. The relatively high number of readings is chosen in order to compensate for the slightly lower accuracy of the Leica TS 15 compared to the best total stations available. The short steel grid mast design of the control points provides a very stable instrument setup for the duration of one campaign, but due to unstable ground conditions, they are not stable over longer time periods.

The GNSS network is a combination of observations in 2016 and in 2019-2020. The 2016 campaign was carried out with seven days of observations on the points named S01T00**. The GNSS observations from 2019 and 2020 include the permanent stations NYA1 and NABG, and the unstable stations NABD and NABE

The control points CCP, CP1, CP2, CP3, CP4 CP7 and CP8 at Brandal are normally equipped with GNSS. The GNSS antennas were replaced with the total station and reflectors during the local tie campaign. On CP9 and CP10 we made GNSS observations during the local tie campaign in 2020.

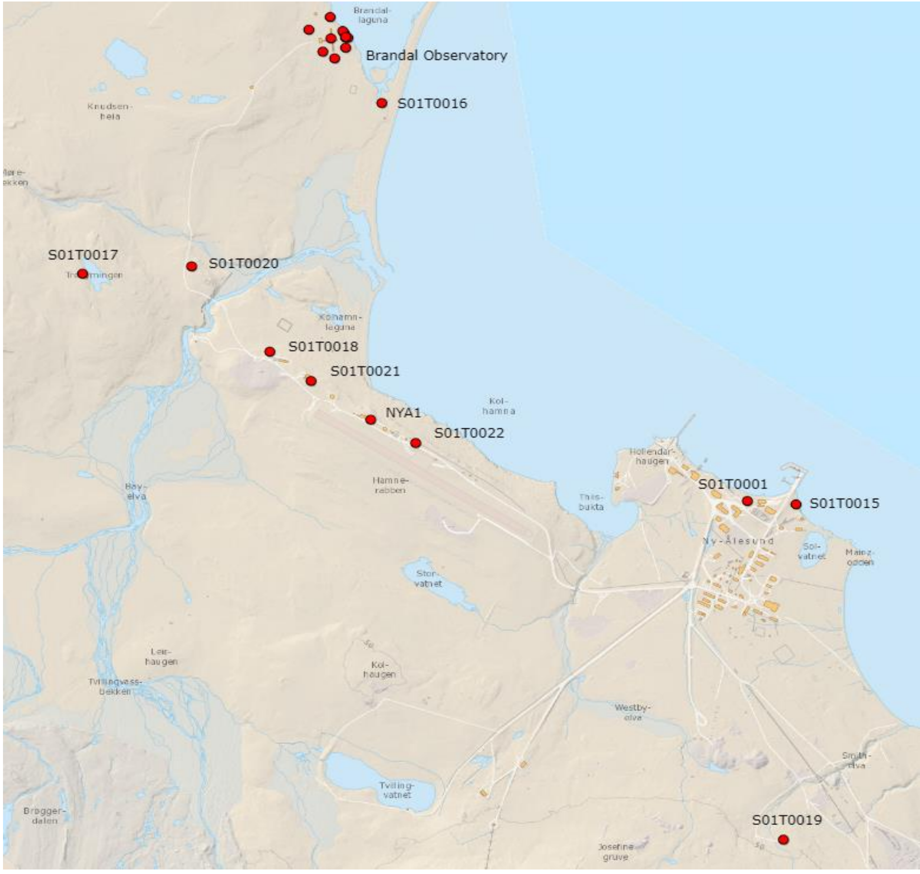


*Figure 6 GNSS observation points*

### 3.3.1 VLBI reference points

The VLBI reference points are in this survey determined by combined observations to targets inside the azimuth cabins and the control points outside. The azimuth cabins are each equipped with eight magnetic prism holders for RRR-prisms. The positions of the prism holders are determined in an internal coordinate system by the manufacturer Asturfeito. The total station is placed on a tripod in a position that provides lines of sight to at least three control points outside and the eight RRR-prisms inside the cabins. The VLBI telescopes has to be set in a certain azimuth position to get access to the outside control points through a small hatch and the two doors on each side of the cabins.

*Figure 7 RRR-prism*


*Figure 8 VLBI1, door and hatch*

*Figure 9 Total station inside azimuth cabin*

### 3.3.2 GNSS reference point

The reference point, ARP/BAM, of the GNSS-station NABG was observed with total station directly on the reference point before the antenna was mounted in September 2019. The IGS14 coordinates of NABG are determined by GPS L1 baselines from the IGS station NYA1.

*Figure 10 From left: NABG with total station, NABG with prism and NABG_U, NABG GNSS and NABG_U*

### 3.3.3 DORIS reference point

Figure 11 DORIS antenna and prism DORIS_R

The DORIS station is located 350 meters southwest of the VLBI telescopes, behind a hilltop. To get the connection between DORIS and the control point network, two new control points CP9 and CP10 were established in 2019. To determine the DORIS reference point we use two temporary tripod setups close to the DORIS station. From these setups, we do total station observations to the DORIS-antenna and to the control points. On the antenna, we measure with tangential sightlines at the top, the red ring and the bottom, left and right side. The most precise vertical observations were done to the red ring. The very bottom of the antenna is not visible due to the slightly rising sightlines from the total station. An eccentric prism holder was mounted on the top of the mast. This provides a precise target for stability monitoring. On the ground plate there is a small marker or hole. In 2020, this marker had become almost invisible because of rust. A nail was put in the hole to make the observations easier.

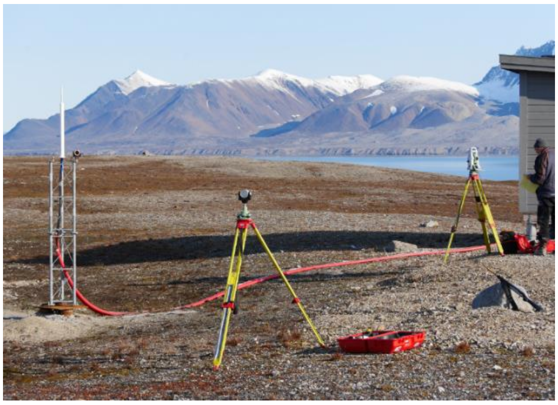

Figure 12 Tripod setups

Figure 13 Marker in ground plate, a nail in the hole to make the observations easier

# 4 Computation and data analysis

This chapter describes the computation of the 2019 and 2020 survey campaigns.

## 4.1 GNSS network

The points NABG, S01T0017, S01T0018, S01T0020 and S01T0021 are determined by GNSS observations. GPS L1 baselines are processed with Wasoft GNSS SW from observations in 2016 and 2019-2020. The network adjustment is done at Kartverket with the domestic softwares Gunda and Hoyde.  The IGS station NYA1 was fixed in the computation with its official IGS14 coordinates and velocities. Least square network adjustment was done separately for horizontal and vertical coordinates, and the coordinates are determined with a standard deviation at ~ 1 mm in both dimensions.

## 4.2 Final adjustment

The final adjustment was done at IGN by Damien Pesce. The data was processed using 3D least-square adjustment with IGN COMP3d version 5.19 software. The input file comes from:

- Total station observations : horizontal and zenith angles, distances ;
- Height differences between points of NABG and DORIS stations;
- Centring equations : relative position between points ;
- Orientation points coordinates constrained at 1 mm to its IGS14 epoch 2018.00 values;
- NABG reference point coordinates, constrained at 0.1 mm to its IGS14 epoch 2018.00 values.

The a priori standard deviations used for most of the observations with total station are:

- 0.3 mgon for horizontal angles
- 0.6 mgon for vertical angles,
- 0.6 mm + 1 PPM for distances on prism.

The input and output coordinates are in the UTM 33N projection but the computations are done in local stereographic projection. This adjustment provides coordinates and a covariance matrix of the survey work.

The terrestrial adjustment was processed taking into account the mean vertical deflection on the site from the geoid model HREF_BRANDAL_2021A.

Vertical deflection: east-west ($\eta$) = 8.4 arcsec and north-south ($\xi$) = 4.21 arcsec

### 4.2.1 Description of HREF_BRANDAL

**Starting point**

As starting point we use the Arctic Gravity Project geoid, arcgp-2006-sk. A smaller grid is extracted covering the area; latitude 78.930000 - 78.945000; longitude 11.810000 - 11.870000. The smaller grid is re-gridded to a spacing of 0.001x 0.002 degrees or approximately 100 m.

**Estimation**

The Height REFerence (HREF) model is estimated in three steps:

1. The difference between the geoid and the connection points is estimated. A long wavelength surface is estimated using collocation/second degree Gauss-Markov with a correlation length of 10 km and noise of 5 mm. This surface is added to the original geoid.
2. Item 1 is repeated with correlation length of 1 km, noise 1 mm and geoid from item 1.
3. Item 1 is repeated with correlation length of 0.3 km, noise 0.5 mm and geoid from item 2.

**Brandal HREF**

The resulting HREF model is named HREF_BRANDAL_2021A.bin

### 4.2.2 VLBI reference points determination

The telescope manufacturer provides the coordinates of the 8 prisms inside the azimuth cabin for the two telescopes. Those coordinates are given in a local Cartesian frame with the VLBI reference point as origin. The accuracy of the local coordinates is 0.01mm.

A 6-parameter transformation was adjusted between the local coordinates in the azimuth cabin-fixed frame and the coordinates in the frame of the data adjustment using all available observations.

This transformation is working well for the north telescope. For the south telescope, we need to invert the sign of the x components of the manufacturer azimuth cabin-frame to make it fit to the survey observations. With this change, the adjustment works well.

# 5 Results

## 5.1 Adjusted coordinates and confidence intervals

The results of the adjustment are the coordinates of all points and their confidence ellipsoids in IGS14 at epoch 2018.00.

The tables below provide the 3D coordinates. The tenth of a millimetre is given as an indication.

*Table 4 Cartesian Coordinates in IGS14 epoch 2018.00 from the 2019 survey campaign*

| Point – *process name* | X (m) | Y (m) | Z (m) |
|---|---|---|---|
| SVAC - *DORIS* | 1201299.7299 | 251874.6071 | 6238000.5855 |
| NABG - *NABG* | 1201009.2593 | 252158.0768 | 6238022.1881 |
| 7392 - *VLBI1A19* | 1201070.6352 | 252129.3262 | 6238022.4990 |
| 7393 - *VLBI2A19* | 1200992.6719 | 252098.6298 | 6238038.6421 |

*Table 5 Cartesian Coordinates in IGS14 epoch 2018.00 from the 2020 survey campaign*

| Point – *process name* | X (m) | Y (m) | Z (m) |
|---|---|---|---|
| SVAC – *DORIS2* | 1201299.7299 | 251874.6077 | 6238000.5904 |
| NABG - *NABG* | 1201009.2593 | 252158.0768 | 6238022.1881 |
| 7392 - *VLBI1A20* | 1201070.6347 | 252129.3267 | 6238022.4996 |
| 7393 - *VLBI2A20* | 1200992.6713 | 252098.6293 | 6238038.6429 |

The tables below provide confidence ellipsoid (3D) at 2.5σ. (That means the results have 90% of probability to be inside the ellipsoid)

*Table 6 3D confidence regions 2.5 σ (90 percent) from the 2019 survey campaign in the local reference frame*

| Point – *process nb* | ½ axis (mm) | Azimuth (gr) | Tilt (gr) |
|---|---|---|---|
| SVAC - *DORIS* | 1.3 | 32.40 | 100 |
| | 1.0 | 152.14 | 0 |
| | 1.0 | 52.14 | 0 |
| NABG - *NABG* | 0.3 | 27.31 | 100 |
| | 0.3 | 111.00 | 0 |
| | 0.3 | 11.00 | 0 |
| 7392 - *VLBI1A19* | 0.8 | 107.02 | 200 |
| | 0.8 | 7.23 | 17 |
| | 0.8 | 4.20 | 83 |
| 7393 - *VLBI2A19* | 0.8 | 87.36 | 150 |
| | 0.5 | 85.33 | 50 |
| | 0.3 | 186.34 | 200 |

*Table 7 3D confidence regions 2.5 σ (90 percent) from the 2020 survey campaign in the local reference frame*

| Point – *process nb* | ½ axis (mm) | Azimuth (gr) | Tilt (gr) |
|---|---|---|---|
| SVAC – *DORIS2* | 1.8 | 22.09 | 105 |
| | 1.8 | 298.89 | 5 |
| | 1.5 | 99.02 | 2 |
| NABG - *NABG* | 0.3 | 44.05 | 100 |
| | 0.3 | 113.11 | 0 |
| | 0.3 | 13.11 | 0 |
| 7392 - *VLBI1A20* | 1.5 | 83.12 | 4 |
| | 1.3 | 183.17 | 1 |
| | 0.8 | 95.18 | 96 |
| 7393 - *VLBI2A20* | 1.5 | 83.06 | 4 |
| | 1.3 | 183.11 | 1 |
| | 0.8 | 95.09 | 96 |

A complete covariance matrix was computed. Covariance submatrix for the main points of interest was extracted for the following ITRF solution computation. Finally, the covariance submatrixes were converted into SINEX format using the « geotosnx » tool provided by Z. Altamimi (LAREG, IGN). The resulting SINEX files are provided in Appendix A.

## 5.2 Results comparisons

The table below provides the differences in results between the two computations.

*Table 8 Coordinate differences from the 2019 and 2020 computations*

| Point | ΔX (mm) | ΔY (mm) | ΔZ (mm) |
|---|---|---|---|
| SVAC | 0.0 | 0.5 | 4.9 |
| NABG | 0.0 | 0.0 | 0.0 |
| 7392 | -0.5 | 0.5 | 0.6 |
| 7393 | -0.6 | -0.6 | 0.8 |

The differences in coordinates of the VLBI reference points 7392 and 7393 are as expected based on the instrument specifications. The 4.9 mm difference of the z-coordinate of the Doris antenna SVAC is most likely due to imprecise observations to the bottom of the antenna. This will be re-measured during the 2021 survey campaign.

## 5.3 Vectors

The following tables show vectors in Cartesian coordinate system (IGS14 ep.2018.00). The tenth of a millimetre is provided as an indication.

*Table 9 Vectors from the 2019 survey campaign*

| | ΔX (m) | ΔY (m) | ΔZ (m) |
|---|---|---|---|
| NABG → SVAC | 290.4706 | -283.4697 | -21.6026 |
| NABG → 7392 | 61.3759 | -28.7506 | 0.3109 |
| NABG → 7393 | -16.5874 | -59.4470 | 16.4540 |
| 7392 → 7393 | -77.9633 | -30.6964 | 16.1431 |
| SVAC → 7392 | -229.0947 | 254.7191 | 21.9135 |
| SVAC → 7393 | -307.0580 | 224.0227 | 38.0566 |

*Table 10 Vectors from the 2020 survey campaign*

| | ΔX (m) | ΔY (m) | ΔZ (m) |
|---|---|---|---|
| NABG → SVAC | 290.4706 | -283.4691 | -21.5977 |
| NABG → 7392 | 61.3754 | -28.7501 | 0.3115 |
| NABG → 7393 | -16.5880 | -59.4475 | 16.4548 |
| 7392 → 7393 | -77.9634 | -30.6974 | 16.1433 |
| SVAC → 7392 | -229.0952 | 254.7190 | 21.9092 |
| SVAC → 7393 | -307.0586 | 224.0216 | 38.0525 |

# 6 APPENDIX A SINEX files

10338_Kartverket_2019-244.SNX

```
%=SNX 1.00 IGN 21:075:00000 IGN 19:244:00000 19:244:00000 C 00012
*-------------------------------------------------------------------------------
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* File created by geotosnx software (Z.Altamimi)
* Original input file: .\calcul19-4.comp.cov
* Matrix Scalling Factor used:        1.0000000000
-FILE/COMMENT
*-------------------------------------------------------------------------------
+SITE/ID
*CODE PT __DOMES__ T _STATION DESCRIPTION__ APPROX_LON_ APPROX_LAT_ _APP_H_
 SVAC  A 10338S003   10338S003              11 50 29.6  78 56 27.8    65.1
 NABG  A 10338M008   10338M008              11 51 26.3  78 56 35.1    43.0
 7392  A 10338S001   10338S001              11 51 19.4  78 56 33.4    53.6
 7393  A 10338S002   10338S002              11 51 17.1  78 56 36.1    53.6
-SITE/ID
*-------------------------------------------------------------------------------
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-SOLUTION/EPOCHS
*-------------------------------------------------------------------------------
+SOLUTION/ESTIMATE
*INDEX TYPE__ CODE PT SOLN _REF_EPOCH__ UNIT S __ESTIMATED VALUE____ _STD_DEV___
     1 STAX   SVAC  A    1 19:244:00000 m    2 0.120129972991000E+07 0.34744E-03
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     3 STAZ   SVAC  A    1 19:244:00000 m    2 0.623800058548000E+07 0.54027E-03
     4 STAX   NABG  A    1 19:244:00000 m    2 0.120100925927000E+07 0.99939E-04
     5 STAY   NABG  A    1 19:244:00000 m    2 0.252158076793000E+06 0.99994E-04
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     9 STAZ   7392  A    1 19:244:00000 m    2 0.623802249901000E+07 0.25808E-03
    10 STAX   7393  A    1 19:244:00000 m    2 0.120099267187000E+07 0.17397E-03
    11 STAY   7393  A    1 19:244:00000 m    2 0.252098629841000E+06 0.21743E-03
    12 STAZ   7393  A    1 19:244:00000 m    2 0.623803864206000E+07 0.22634E-03
-SOLUTION/ESTIMATE
*-------------------------------------------------------------------------------
+SOLUTION/MATRIX_ESTIMATE L COVA
*PARA1 PARA2 ____PARA2+0__________ ____PARA2+1__________ ____PARA2+2__________
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     2     1 0.122359497562000E-07 0.123866488230000E-06
     3     1 0.298569784550000E-07 0.585270045179000E-08 0.291887921475000E-06
     4     1 0.100456623920000E-07 0.109477610380000E-09 -.898552435478000E-11
     4     4 0.998781551958000E-08
     5     1 -.207819022696000E-08 0.783952137712000E-08 0.484215892419000E-09
     5     4 -.332129633696000E-12 0.999874901460000E-08
     6     1 0.742048162128000E-10 0.661997868165000E-10 0.998235653314000E-08
     6     4 0.234403796311000E-11 0.113746178075000E-12 0.999954705525000E-08
     7     1 0.182315469811000E-07 0.331535048491000E-08 -.105064243985000E-09
     7     4 0.998981190049000E-08 -.212848728149000E-09 0.103969582647000E-10
     7     7 0.712443694678000E-07
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     8     7 -.451970545942000E-08 0.117594894545000E-06
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     9     4 0.110415078364000E-11 0.589324044749000E-10 0.999743987872000E-08
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```

```
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   11     7 -.207698851254000E-08 0.135722503627000E-07 -.246902569189000E-09
   11    10 -.131287489591000E-07 0.472754356966000E-07
   12     1 -.327482626020000E-09 -.102344850855000E-08 0.147937729561000E-07
   12     4 0.575874753107000E-12 0.792614847872000E-10 0.999669937342000E-08
   12     7 0.684667717707000E-09 -.102990442893000E-08 0.144424059964000E-07
   12    10 0.997754112327000E-08 -.988188452422000E-08 0.512278498266000E-07
-SOLUTION/MATRIX_ESTIMATE L COVA
%ENDSNX
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## 10338_Kartverket_2020-244.SNX

```
%=SNX 1.00 IGN 21:075:00000 IGN 20:244:00000 20:244:00000 C 00012
*-------------------------------------------------------------------------------
+FILE/COMMENT
* File created by geotosnx software (Z.Altamimi)
* Original input file: .\2020-3.comp.cov
* Matrix Scalling Factor used:         1.0000000000
-FILE/COMMENT
*-------------------------------------------------------------------------------
+SITE/ID
*CODE PT __DOMES__ T _STATION DESCRIPTION__ APPROX_LON_ APPROX_LAT_ _APP_H_
 SVAC  A 10338S003   10338S003              11 50 29.6  78 56 27.8    65.1
 NABG  A 10338M008   10338M008              11 51 26.3  78 56 35.1    43.0
 7392  A 10338S001   10338S001              11 51 19.4  78 56 33.4    53.6
 7393  A 10338S002   10338S002              11 51 17.1  78 56 36.1    53.6
-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   SVAC  A    1 20:244:00000 m    2 0.120129972987000E+07 0.66066E-03
     2 STAY   SVAC  A    1 20:244:00000 m    2 0.251874607672000E+06 0.57438E-03
     3 STAZ   SVAC  A    1 20:244:00000 m    2 0.623800059036000E+07 0.71720E-03
     4 STAX   NABG  A    1 20:244:00000 m    2 0.120100925927000E+07 0.99965E-04
     5 STAY   NABG  A    1 20:244:00000 m    2 0.252158076793000E+06 0.99997E-04
     6 STAZ   NABG  A    1 20:244:00000 m    2 0.623802218808000E+07 0.99999E-04
     7 STAX   7392  A    1 20:244:00000 m    2 0.120107063471000E+07 0.53621E-03
     8 STAY   7392  A    1 20:244:00000 m    2 0.252129326713000E+06 0.54878E-03
     9 STAZ   7392  A    1 20:244:00000 m    2 0.623802249957000E+07 0.30663E-03
    10 STAX   7393  A    1 20:244:00000 m    2 0.120099267127000E+07 0.53438E-03
    11 STAY   7393  A    1 20:244:00000 m    2 0.252098629266000E+06 0.56735E-03
    12 STAZ   7393  A    1 20:244:00000 m    2 0.623803864288000E+07 0.28873E-03
-SOLUTION/ESTIMATE
*-------------------------------------------------------------------------------
+SOLUTION/MATRIX_ESTIMATE L COVA
*PARA1 PARA2 ____PARA2+0__________ ____PARA2+1__________ ____PARA2+2__________
    1     1 0.436475407233000E-06
    2     1 0.262911997249000E-07 0.329915876011000E-06
    3     1 0.748588479561000E-08 0.651246516504000E-08 0.514371584243000E-06
    4     1 0.984691082085000E-08 0.473142206364000E-10 0.297204739771000E-10
    4     4 0.999305733575000E-08
    5     1 -.205416125885000E-08 0.784391500549000E-08 0.479243915807000E-09
    5     4 0.226036268597000E-13 0.999931393297000E-08
    6     1 0.111254055847000E-09 0.779123165310000E-10 0.997515348897000E-08
    6     4 0.132709440477000E-11 0.232096669899000E-13 0.999974522021000E-08
```

```
     7     1 0.268571120366000E-06 0.246556050321000E-08 -.448088172241000E-07
     7     4 0.982124832011000E-08 -.208751804346000E-09 0.424752740832000E-10
     7     7 0.287521486211000E-06
     8     1 -.375700481988000E-07 0.211894656993000E-06 -.717976489088000E-09
     8     4 0.230577168809000E-10 0.953543345514000E-08 0.142822506835000E-10
     8     7 -.114421862149000E-07 0.301158055490000E-06
     9     1 -.430708411136000E-07 -.794490074404000E-08 0.440348965288000E-07
     9     4 0.332505199293000E-10 0.586363602924000E-10 0.999130273070000E-08
     9     7 -.378226487970000E-07 -.698561920233000E-08 0.940191540350000E-07
    10     1 0.275800142304000E-06 0.417789423503000E-08 -.464173337107000E-07
    10     4 0.983274915376000E-08 -.436299498605000E-09 0.495321399895000E-10
    10     7 0.261183209164000E-06 -.530619484106000E-08 -.435122760959000E-07
    10    10 0.285562490533000E-06
    11     1 -.623823757424000E-07 0.210190582315000E-06 0.399006418017000E-08
    11     4 -.662947357945000E-11 0.101245231329000E-07 -.363297889030000E-11
    11     7 -.857213450947000E-08 0.263655621291000E-06 -.885143818313000E-08
    11    10 -.267162388029000E-07 0.321891213713000E-06
    12     1 -.429865286293000E-07 -.807880635084000E-08 0.428865055704000E-07
    12     4 0.315037292428000E-10 0.784840895177000E-10 0.999081449995000E-08
    12     7 -.428804883636000E-07 -.102548166811000E-07 0.413947227123000E-07
    12    10 -.335158874555000E-07 -.209706532587000E-07 0.833630820979000E-07
-SOLUTION/MATRIX_ESTIMATE L COVA
%ENDSNX
```

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