

To: IVS Analysis Centers
From: John Gipson
Re: Handling of Pressure loading in SINEX files
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Summary

For ITRF2020, in contrast to previous ITRF submissions, the IVS submission will include the effect of pressure loading. However since the other Space Geodetic Techniques (still!!) do not include the effect of pressure loading we need to modify the SINEX files so that this effect can be removed. This memo describes the new format and gives some examples. I use the IVS session 08AUG12XA as an example.

Including Calibration Effects in SINEX files

Suppose that are normal equations in the absence of pressure loading are given by:

$$N A = B$$

Call this solution 1.

The SINEX files contain information about the normal equations in the following blocks:

```
SOLUTION/NORMAL_MATRIX
Contains the normal matrix (N)
+SOLUTION/NORMAL_MATRIX
* Ind1  Ind2  Normal_matrix(ind1,ind2)
   1     1    2.14881619916730D+05
   2     1   -3.33204770145647D+05
   2     2    7.90092287175439D+05
   3     1    1.38924585365877D+04
. . .
 185    181  -2.62597634024145D+02
 185    182  -2.12078907489431D+03
 185    183  -9.50431506571872D+02
 185    184   4.50281783479461D+01
 185    185   2.93943824734567D+03
-SOLUTION/NORMAL_MATRIX
```

```
SOLUTION/NORMAL_VECTOR
Contains the normal vector (B from solution 1)
+SOLUTION/NORMAL_VECTOR
* Ind1  Normal Vector(ind1)
   1   -6.94314953331862D+01
   2   -1.13179001332931D+03
   3   -8.77674856901132D+01
   4    1.00165242832536D+03
. . .
 180  -1.50146267576976D+01
 181   5.02657125724688D+01
 182   1.02900535318495D+03
 183  -1.90816152785918D+03
 184   5.04330069101942D+01
 185  -7.30051744127663D+02
-SOLUTION/NORMAL_VECTOR
```

Consider solution 2 where we include the effect of some calibration. In our case this is pressure loading, but it could be anything. The normal equations become:

$$N A' = B + \text{delta}_B$$

where delta_B incorporates the effect of the calibration. The NORMAL_MATRIX block will stay the same, but the NORMAL_VECTOR block will change.

```
SOLUTION/NORMAL_VECTOR
Contains the normal vector ( now B + delta B)
+SOLUTION/NORMAL_VECTOR
* Ind1 Normal_vector(ind1)
  1 -3.22097748201563D+01
  2 -1.17063318862571D+03
  3  1.82265772858212D+01
  4  1.01701758938775D+03
. . .
 180  4.73738747897776D+00
 181  5.02801845321932D+01
 182  5.86141838420410D+02
 183 -1.94078331791664D+03
 184  4.60554224162214D+01
 185 -7.31313294566296D+02
-SOLUTION/NORMAL_VECTOR
```

In order to be able to remove the effect of calibration we introduce the new block:

```
SOLUTION/NORMAL_CALIBRATION <ARG>
Contains the calibration vector ( delta B)
+SOLUTION/NORMAL_CALIBRATION LOADING_EFFECT
* Ind1 Vector(ind1)
  1  3.72221606441848D+01
  2 -3.88438697865430D+01
  3  1.05993659130668D+02
  4  1.53663526167582D+01
. . .
 180  1.97521740982423D+01
 181  1.44484759638269D-02
 182 -4.42867102546352D+02
 183 -3.26225248420175D+01
 184 -4.37776855125543D+00
 185 -1.26159723058760D+00
-SOLUTION/NORMAL_CALIBRATION
```

Note the argument LOADING_EFFECT which tells what kind of calibration it is. The relation between the blocks of the different solutions is:

$$\text{NORMAL_VECTOR}(\text{solution } 1) = \text{NORMAL_VECTOR}(\text{solution } 2) - \text{NORMAL_CALIBRATION}(\text{solution } 2).$$

SINEX also gives you the option to include the covariance information and the estimated parameters in addition to, or instead of, the normal matrix. In this case the additional block which describes the effect of the

calibration is: SOLUTION/CALIBRATION_ESTIMATE. This also takes an argument. The relationship between the different blocks is similar to above:

```
NORMAL_ESTIMATE(solution 1) =  
    NORMAL_ESTIMATE(solution 2) - CALIBRATION_ESTIMATE (solution 2).
```

Aside for Solve Users

Leonid Petrov wrote the code that produces the SINEX output for solve. To distinguish between the original normal equations, and the normal equations where the nuisance parameters had been squeezed out, Leonid called the later the DECOMPOSED_NORMAL_MATRIX and DECOMPOSED_NORMAL_VECTOR. The DECOMPOSED blocks are what are actually in the Solve SINEX files.

In keeping with precedent, I call the NORMAL_CALIBRATION vector after the nuisance parameters have been squeezed out DECOMPOSED_NORMAL_CALIBRATION.