ANALYSIS OF REPEATED GPS OBSERVATIONS

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ABSTRACT
GPS data observed on the DOPNUL network were processed by the software SKI 2.3 (a product of the LEICA company) and by the software Trimble Geomatics Office (a product of the Trimble Navigation Ltd). The Dopnul stations were monitored in 2 sessions on 16 points of the network. The 1st session took place at spring 2001, it was observed twice 6 hours. The 2nd session took place at autumn 2001, it was also observed twice 6 hours. The results compared by means of (a) transformations parameters and (b) residuals from Helmert 6- and 7- element 3D transformations will be discussed.

KEYWORDS: GPS, DOPNUL network, SKI 2.3, Trimble Geomatics Office

1. INTRODUCTION

The task of my work was to process the GPS data by the software SKI 2.3 and by the software Trimble Geomatics Office. And review the accuracy of the results and comparison of the processed sessions.

The GPS data were observed on the part of the DOPNUL network. Which started to develop on the break of November and December 1991 when took place the GPS campaign under the name EUREF-CS/H 91, in the course of it was observed 6 points at that time newly built European reference network EUREF.

With these points were continued in the project CS-NULRAD-92, whose purpose was to establish the national three-dimensional reference network. The network of the zero order, how this network was named, has 19 points related to reference system EUREF-89, epoch 1989.0. Network was observed by the GPS techniques in the period from 19.5. to 4.6. 1992 in the area of, then named, ČSFR.

Campaign DOPNUL was executed in years 1993-94 and its main purpose was to densify the zero order network. The average length between the points of the network is 20 – 30 km. Altogether there are in the area of the Czech Republic 176 points of the network DOPNUL (including the points of the zero order network).

2. THE PROCESS OF MONITORING

The GPS observations were monitored in 2 sessions on 16 points of the DOPNUL network. The monitoring was done by firms Viageos s.r.o., which used the Trimble apparatuses (4000SSI, 7400MSI) and antennas TR GEOD L1/L2, and Geodezie Krkonoše s.r.o.., which used the Leica apparatuses (SR 299, SR399) and antennas LEICA INTERNAL. On the GOPE observatory was used the apparatus ASHTEC Z18 and antenna ASH 701946.22 SNOW.

The elevation mask was 10° and the lapse of time was 30´´.

1st session took place at spring 2001. It was observed from Friday April 20th, to Saturday April 21st, twice 6 hours (from 2001-04-20 20:00 to 2001-04-21 02:00 and from 2001-04-21 02:30 to 2001-04-21 08:30).

2nd session took place at autumn 2001. It was observed from Friday October 19th, to Saturday October 20th, twice 6 hours (from 2001-10-19 20:00 to 2001-10-20 02:00 and from 2001-10-20 02:30 to 2001-10-20 08:30).
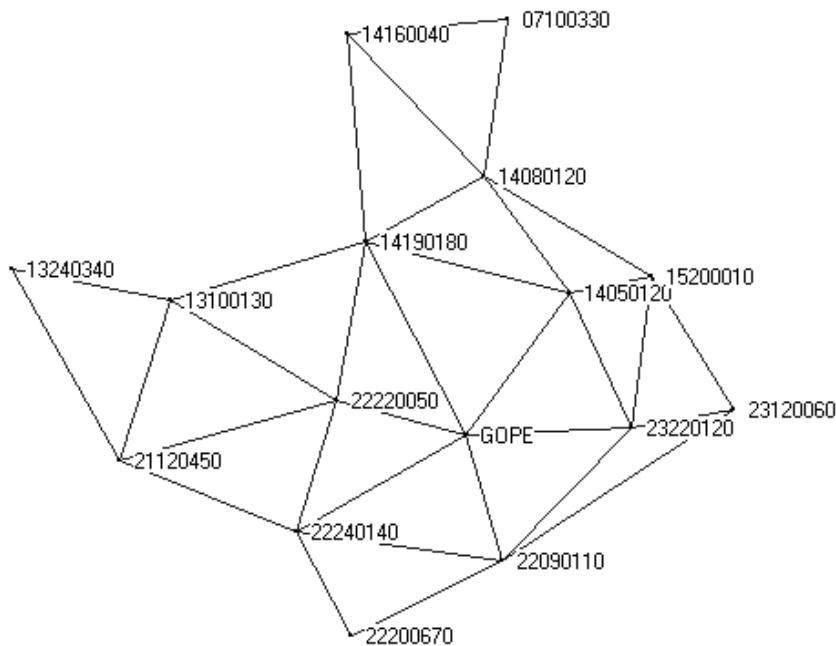
Fig. 1 The scheme of the GPS observations in the area of 12 000 km^2

3. THE PROCESSING OF THE GPS OBSERVATIONS

The GPS data were in the format RINEX. The software SKI 2.3 (a product of the LEICA company) and the software Trimble Geomatics Office (a product of the Trimble Navigation Ltd) was used for its processing.

3.1. THE SOFTWARE SKI 2.3

The GPS observations were first processed by the software SKI 2.3.. The final coordinates are in ETRF - 89 (European Terrestrial Reference Frame).

This software is intended for the GPS data and its major task is computation and apparition of the coordinates. We can set up the software according to our wish, import and export of the data in several different formats, plan the field works, selection of the data and parameters for the computation, show and arrange the results of the computation in graphic form and transform the coordinates into local systems.

The coordinates were than transformed to the system S - JTSK with the software *Etrf2kro*. The coordinates of the network DOPNUL were transformed to the S-JTSK too with the same software and they were both compared.

3.2. THE SOFTWARE TRIMBLE GEOMATICS OFFICE™

The GPS observations were further processed by the software Trimble Geomatics Office™. The final coordinates are in the system S-JTSK.

This software enables production of a projects, collection, storage, analysis, figure and recovery of the 3D information. There are two additional modules for processing the GPS baselines and for adjustment of the geodetic networks. We can control the GPS and conventional observing, correction of the incorrect data, GPS processing or adjustment of the networks. We can also manipulate with data cods of the elements, work with layers and styles.

The final coordinates from both software were reduced to the center of the area. In the next step were these coordinates compared with each other and with the coordinates of the network DOPNUL, by the means of transformations parameters and residuals from Helmert 6- and 7- element 3D transformations.

4. NUMERICAL RESULTS

The mentioned results are in meters.

It is evident, from the computed transformations parameters and residuals of Helmert transformation,

Table 1 The quadratic averages of the residuals between different sessions from the 6-element Helmert 3D transformation.

sessions	dx	dy	dh
SKI, spring - autumn	0.0046	0.0061	0.0121
SKI - DOPNUL, spring	0.0340	0.0240	0.0324
SKI - DOPNUL, autumn	0.0323	0.0246	0.0264
Trimble, spring - autumn	0.0057	0.0064	0.0131
Trimble - DOPNUL, spring	0.0453	0.0353	0.1242
Trimble - DOPNUL, autmn	0.0456	0.0340	0.1215
SKI - Trimble, spring	0.0328	0.0284	0.1323
SKI - Trimble, autumn	0.0335	0.0287	0.1204

Table 2 The quadratic averages of the residuals between different sessions from the 7-element Helmert 3D transformation.

sessions	dx	dy	dh
SKI. spring - autumn	0.0046	0.0061	0.0122
SKI - DOPNUL. spring	0.0339	0.0238	0.0327
SKI - DOPNUL. autumn	0.0322	0.0243	0.0264
Trimble. spring - autumn	0.0057	0.0064	0.0131
Trimble - DOPNUL. spring	0.0355	0.0280	0.1242
Trimble - DOPNUL. autmn	0.0353	0.0266	0.1215
SKI - Trimble. spring	0.0105	0.0146	0.1323
SKI - Trimble. autumn	0.0131	0.0143	0.1204

that scale factor almost did not change and the residuals do not differs much. The 6-element 3D transformation would be sufficient for the computation.

5. CONCLUSIONS

We can assume from the comparison of both sessions, that the points between observations of the SPRING and AUTUMN sessions did not change position, because neither one software did display any greater changes. Both software computed similar positions of the points. The heights from the software Trimble Geomatics Office™ are different because of the set-up of the tropospheric correction model.

REFERENCES

Cimbálník, M. and Mervart, L.: 1999, Cesty ČSR do Evropy, Vyšší geodezie 1, 150-157.
Trimble Geomatics Office – user guide.
SKI 2.3 (LEICA) - user guide.

APPENDIX

Processing of the GPS observations by SKI 2.3
The mentioned results are in meters.

Table 1 The transformations parameters between sessions SPRING and AUTUMN from the Helmert 6- and 7-element 3D transformation.

tx=	-0.00518749855754	tx=	-0.00518749815205
ty=	0.00412500481096	ty=	0.00412500595212
tz=	0.00118754994777	tz=	0.00162504762881
α=	-0.00000018772605	q=	1.00000000629773
β=	0.00000014587475	α=	-0.00000019494640
χ=	-0.0000000863005	β=	0.00000012180018
		χ=	-0.0000000866229

Table 2 The residuals between sessions SPRING and AUTUMN from the Helmert 6- and 7- element 3D transformation.

6-element 3D	transformaton				7-element 3D	transformaton			
station code	station name	dx	dy	dh	station code	station name	dx	dy	dh
13100130	Nad Charvátiny	0.0001	0.0005	-0.0025	13100130	Nad Charvátiny	-0.0001	0.0006	-0.0020
13240340	Senecká hora	0.0021	0.0034	0.0187	13240340	Senecká hora	0.0017	0.0034	0.0199
21120450	Chlumek	0.0054	-0.0065	0.0094	21120450	Chlumek	0.0051	-0.0066	0.0100
22070100	Pecný-věž	0.0053	-0.0040	-0.0027	22070100	Pecný-věž	0.0054	-0.0041	-0.0034
22090110	Zálesí	-0.0055	0.0100	0.0074	22090110	Zálesí	-0.0054	0.0098	0.0064
22200670	Na rovině	0.0026	-0.0082	-0.0244	22200670	Na rovině	0.0026	-0.0085	-0.0250
22220050	U Pytlíka	0.0003	0.0068	0.0104	22220050	U Pytlíka	0.0002	0.0067	0.0101
22240140	Ve vrších	-0.0015	-0.0003	-0.0096	22240140	Ve vrších	-0.0017	-0.0005	-0.0098
7100330	U silnice	0.0077	0.0060	-0.0052	7100330	U silnice	0.0078	0.0063	-0.0056
14050120	Sadská(pilíř)	-0.0089	0.0111	0.0091	14050120	Sadská(pilíř)	-0.0087	0.0111	0.0081
14080120	Horka	0.0029	-0.0040	-0.0174	14080120	Horka	0.0030	-0.0039	-0.0180
14160040	Na křižovatce	-0.0033	-0.0002	-0.0063	14160040	Na křižovatce	-0.0033	0.0001	-0.0062
14190180	Boleslavka	-0.0040	-0.0052	-0.0142	14190180	Boleslavka	-0.0040	-0.0051	-0.0144
15200010	Za Trouby	-0.0029	-0.0088	0.0175	15200010	Za Trouby	-0.0027	-0.0088	0.0162
23120060	U křížku	0.0053	-0.0037	0.0014	23120060	U křížku	0.0056	-0.0038	0.0066
23220120	Na hrobech	-0.0057	0.0032	0.0085	23220120	Na hrobech	-0.0055	0.0031	0.0071
the quadratic averages		0.0046	0.0061	0.0121	the quadratic averages		0.0046	0.0061	0.0122

Table 3 The transformations parameters between the session SPRING and the part of the DOPNUL network from the Helmert 6- and 7- element 3D transformation.

tx=	0.14412495687867	tx=	0.14412494317889
ty=	0.15437502184487	ty=	0.15437500606208
tz=	-0.02031263896083	tz=	-0.02075013454623
α=	0.00000091811778	q=	0.99999990121149
β=	0.00000001767484	α=	0.00000092533814
χ=	-0.00000028213137	β=	0.00000004174940
		χ=	-0.00000028209914

Table 4 The residuals between session SPRING and the part of the DOPNUL network from the Helmert 6- and 7- element 3D transformation.

6-element 3D	transformaton				7-element 3D	transformaton			
station code	station name	dx	dy	dh	station code	station name	dx	dy	dh
13100130	Nad Charvátiny	-0.0130	0.0028	0.0315	13100130	Nad Charvátiny	-0.0092	0.0021	0.0310
13240340	Senecká hora	0.0076	-0.0085	-0.0695	13240340	Senecká hora	0.0139	-0.0097	-0.0707
21120450	Chlumek	0.0082	-0.0056	-0.0160	21120450	Chlumek	0.0129	-0.0037	-0.0166
22070100	Pecný-věž	-0.1249	-0.0850	0.0352	22070100	Pecný-věž	-0.1258	-0.0835	0.0360
22090110	Zálesí	0.0108	0.0048	-0.0092	22090110	Zálesí	0.0093	0.0083	-0.0082
22200670	Na rovině	0.0102	0.0089	0.0175	22200670	Na rovině	0.0111	0.0135	0.0181
22220050	U Pytlíka	-0.0085	0.0073	0.0347	22220050	U Pytlíka	-0.0073	0.0083	0.0349
22240140	Ve vrších	-0.0055	0.0024	-0.0160	22240140	Ve vrších	-0.0037	0.0054	-0.0158
7100330	U silnice	-0.0007	0.0041	-0.0079	7100330	U silnice	-0.0023	-0.0010	-0.0075
14050120	Sadská(pilíř)	0.0266	-0.0170	-0.0195	14050120	Sadská(pilíř)	0.0241	-0.0177	-0.0185
14080120	Horka	0.0064	0.0151	0.0231	14080120	Horka	0.0052	0.0124	0.0236
14160040	Na křižovatce	0.0079	0.0069	0.0026	14160040	Na křižovatce	0.0089	0.0020	0.0024
14190180	Boleslavka	0.0224	0.0058	0.0665	14190180	Boleslavka	0.0231	0.0042	0.0667
15200010	Za Trouby	0.0179	0.0208	-0.0417	15200010	Za Trouby	0.0140	0.0197	-0.0404
23120060	U křížku	0.0139	0.0195	-0.0159	23120060	U křížku	0.0087	0.0206	-0.0211
23220120	Na hrobech	0.0208	0.0177	-0.0154	23220120	Na hrobech	0.0172	0.0191	-0.0140
the quadratic averages		0.0340	0.0240	0.0324	the quadratic averages		0.0339	0.0238	0.0327

Table 5 The transformations parameters between the session AUTUMN and the part of the DOPNUL network from the Helmert 6- and 7- element 3D transformation.

tx=	0.13893745713634	tx=	0.13893744430447
ty=	0.15850002628256	ty=	0.15850001164608
tz=	-0.01912509289198	tz=	-0.01912509111154
α=	0.00000073039171	q=	0.99999990750948
β=	0.00000016354959	α=	0.00000073039171
χ=	-0.00000029076153	β=	0.00000016354959
		χ=	-0.00000029076153

Table 6 The residuals between the session AUTUMN and the part of the DOPNUL network from the Helmert 6- and 7- element 3D transformation.

6-element 3D transformaton					7-element 3D transformaton				
station code	station name	dx	dy	dh	station code	station name	dx	dy	dh
13100130	Nad Charvátiny	-0.0129	0.0033	0.0290	13100130	Nad Charvátiny	-0.0093	0.0027	0.0290
13240340	Senecká hora	0.0097	-0.0052	-0.0508	13240340	Senecká hora	0.0156	-0.0063	-0.0508
21120450	Chlumek	0.0136	-0.0121	-0.0066	21120450	Chlumek	0.0179	-0.0103	-0.0066
22070100	Pecný-věž	-0.1196	-0.0890	0.0325	22070100	Pecný-věž	-0.1204	-0.0876	0.0326
22090110	Zálesí	0.0053	0.0148	-0.0018	22090110	Zálesí	0.0039	0.0181	-0.0018
22200670	Na rovině	0.0128	0.0007	-0.0069	22200670	Na rovině	0.0137	0.0051	-0.0069
22220050	U Pytlíka	-0.0082	0.0141	0.0451	22220050	U Pytlíka	-0.0071	0.0150	0.0451
22240140	Ve vrších	-0.0071	0.0022	-0.0256	22240140	Ve vrších	-0.0054	0.0050	-0.0255
7100330	U silnice	0.0070	0.0101	-0.0131	7100330	U silnice	0.0056	0.0053	-0.0131
14050120	Sadská(pilíř)	0.0177	-0.0059	-0.0104	14050120	Sadská(pilíř)	0.0153	-0.0066	-0.0105
14080120	Horka	0.0093	0.0110	0.0056	14080120	Horka	0.0082	0.0086	0.0056
14160040	Na křižovatce	0.0046	0.0067	-0.0037	14160040	Na křižovatce	0.0055	0.0021	-0.0037
14190180	Boleslavka	0.0184	0.0006	0.0523	14190180	Boleslavka	0.0190	-0.0009	0.0523
15200010	Za Trouby	0.0150	0.0120	-0.0242	15200010	Za Trouby	0.0113	0.0110	-0.0242
23120060	U křížku	0.0192	0.0158	-0.0144	23120060	U křížku	0.0143	0.0168	-0.0145
23220120	Na hrobech	0.0151	0.0209	-0.0070	23220120	Na hrobech	0.0118	0.0222	-0.0070
the quadratic averages		0.0323	0.0246	0.0264	the quadratic averages		0.0322	0.0243	0.0264

Processing of the GPS observations by Trimble Geomatics Office™

The mentioned results are in meters.

Table 7 The transformations parameters between sessions SPRING and AUTUMN from the Helmert 6- and 7-element 3D transformation.

tx=	0.00074996968621	tx=	0.00074997107890
ty=	0.00037502624812	ty=	0.00037502740247
tz=	0.00200000719313	tz=	0.00200000883826
α=	0.00000010468733	q=	1.00000001005430
β=	0.00000013898505	α=	0.00000010468733
χ=	-0.00000006598992	β=	0.00000013898505
		χ=	-0.00000006598992

Table 8 The residuals between sessions SPRING and AUTUMN from the Helmert 6- and 7- element 3D transformation.

6-element 3D	transformaton				7-element 3D	transformaton			
station code	station name	dx	dy	dh	station code	station name	dx	dy	dh
13100130	Nad Charvátiny	0.0038	0.0021	-0.0110	13100130	Nad Charvátiny	0.0034	0.0022	-0.0110
13240340	Senecká hora	-0.0005	0.0074	0.0099	13240340	Senecká hora	-0.0011	0.0075	0.0099
21120450	Chlumek	-0.0055	-0.0095	-0.0205	21120450	Chlumek	-0.0060	-0.0096	-0.0205
22070100	Pecný-věž	0.0003	0.0002	0.0008	22070100	Pecný-věž	0.0004	0.0001	0.0008
22090110	Zálesí	-0.0044	-0.0024	-0.0252	22090110	Zálesí	-0.0043	-0.0027	-0.0252
22200670	Na rovině	0.0124	0.0050	0.0277	22200670	Na rovině	0.0123	0.0045	0.0277
22220050	U Pytlíka	0.0049	0.0119	0.0014	22220050	U Pytlíka	0.0048	0.0118	0.0014
22240140	Ve vrších	0.0063	0.0024	0.0117	22240140	Ve vrších	0.0061	0.0021	0.0117
7100330	U silnice	-0.0092	0.0047	0.0028	7100330	U silnice	-0.0090	0.0052	0.0028
14050120	Sadská(pilíř)	-0.0013	0.0083	0.0118	14050120	Sadská(pilíř)	-0.0010	0.0084	0.0118
14080120	Horka	0.0025	-0.0026	0.0109	14080120	Horka	0.0026	-0.0023	0.0109
14160040	Na křižovatce	0.0010	-0.0040	-0.0086	14160040	Na křižovatce	0.0009	-0.0035	-0.0086
14190180	Boleslavka	-0.0068	-0.0008	0.0004	14190180	Boleslavka	-0.0069	-0.0007	0.0004
15200010	Za Trouby	-0.0065	-0.0068	0.0043	15200010	Za Trouby	-0.0061	-0.0067	0.0043
23120060	U křížku	0.0069	-0.0129	-0.0026	23120060	U křížku	0.0075	-0.0130	-0.0026
23220120	Na hrobech	-0.0038	-0.0030	-0.0136	23220120	Na hrobech	-0.0035	-0.0032	-0.0136
the quadratic averages		0.0057	0.0064	0.0131	the quadratic averages		0.0057	0.0064	0.0131

Table 9 The transformations parameters between the session SPRING and the part of the DOPNUL network from the Helmert 6- and 7- element 3D transformation.

tx=	0.13762503252245	tx=	0.13762515049370
ty=	0.11462493422986	ty=	0.11462503240182
tz=	0.16175001888772	tz=	0.16175015761590
α=	-0.00000128951701	q=	1.00000085833364
β=	-0.00000093570377	α=	-0.00000128951701
χ=	-0.00000103791506	β=	-0.00000093570377
		χ=	-0.00000103791506

Table 10 The residuals between session SPRING and the part of the DOPNUL network from the Helmert 6- and 7- element 3D transformation.

6-element 3D	transformaton				7-element 3D	transformaton			
station code	station name	dx	dy	dh	station code	station name	dx	dy	dh
13100130	Nad Charvátiny	0.0375	0.0076	-0.0953	13100130	Nad Charvátiny	0.0045	0.0133	-0.0953
13240340	Senecká hora	0.0912	0.0063	0.1320	13240340	Senecká hora	0.0364	0.0162	0.1319
21120450	Chlumek	0.0441	0.0301	0.0493	21120450	Chlumek	0.0041	0.0137	0.0492
22070100	Pecný-věž	-0.1343	-0.0749	0.1554	22070100	Pecný-věž	-0.1264	-0.0877	0.1552
22090110	Zálesí	0.0087	0.0230	0.0010	22090110	Zálesí	0.0216	-0.0071	0.0009
22200670	Na rovině	0.0033	0.0250	-0.2650	22200670	Na rovině	-0.0047	-0.0156	-0.2652
22220050	U Pytlíka	0.0051	0.0123	0.1181	22220050	U Pytlíka	-0.0049	0.0043	0.1181
22240140	Ve vrších	0.0080	0.0206	-0.0911	22240140	Ve vrších	-0.0076	-0.0055	-0.0912
7100330	U silnice	-0.0293	-0.0554	-0.1307	7100330	U silnice	-0.0158	-0.0110	-0.1307
14050120	Sadská(pilíř)	-0.0027	-0.0179	0.1453	14050120	Sadská(pilíř)	0.0195	-0.0111	0.1454
14080120	Horka	-0.0152	-0.0143	-0.1236	14080120	Horka	-0.0050	0.0086	-0.1235
14160040	Na křižovatce	0.0090	-0.0582	-0.1024	14160040	Na křižovatce	0.0004	-0.0156	-0.1023
14190180	Boleslavka	0.0269	-0.0140	0.1073	14190180	Boleslavka	0.0210	-0.0002	0.1074
15200010	Za Trouby	-0.0205	0.0227	0.0864	15200010	Za Trouby	0.0130	0.0318	0.0865
23120060	U křížku	-0.0233	0.0495	-0.0886	23120060	U křížku	0.0216	0.0402	-0.0885
23220120	Na hrobech	-0.0083	0.0376	0.1020	23220120	Na hrobech	0.0224	0.0257	0.1020
the quadratic averages		0.0453	0.0353	0.1242	the quadratic averages		0.0355	0.0280	0.1242

Table 11 The transformations parameters between the session AUTUMN and the part of the DOPNUL network from the Helmert 6- and 7- element 3D transformation.

tx=	0.13837500369075	tx=	0.13837512369309
ty=	0.11499995867744	ty=	0.11500005832499
tz=	0.16375002586268	tz=	0.16375016795272
α=	-0.00000118482932	q=	1.00000086838829
β=	-0.00000079671810	α=	-0.00000118482932
χ=	-0.00000110390498	β=	-0.00000079671810
		χ=	-0.00000110390498

Table 12 The residuals between session AUTUMN and the part of the DOPNUL network from the Helmert 6- and 7- element 3D transformation.

6-element 3D	transformaton				7-element 3D	transformaton			
station code	station name	dx	dy	dh	station code	station name	dx	dy	dh
13100130	Nad Charvátiny	0.0413	0.0097	-0.1063	13100130	Nad Charvátiny	0.0080	0.0155	-0.1063
13240340	Senecká hora	0.0907	0.0137	0.1419	13240340	Senecká hora	0.0352	0.0237	0.1418
21120450	Chlumek	0.0386	0.0206	0.0288	21120450	Chlumek	-0.0019	0.0041	0.0288
22070100	Pecný-věž	-0.1340	-0.0747	0.1562	22070100	Pecný-věž	-0.1261	-0.0877	0.1561
22090110	Zálesí	0.0043	0.0206	-0.0243	22090110	Zálesí	0.0173	-0.0098	-0.0243
22200670	Na rovině	0.0157	0.0300	-0.2374	22200670	Na rovině	0.0076	-0.0111	-0.2375
22220050	U Pytlíka	0.0100	0.0242	0.1194	22220050	U Pytlíka	-0.0002	0.0160	0.1194
22240140	Ve vrších	0.0142	0.0231	-0.0794	22240140	Ve vrších	-0.0015	-0.0034	-0.0795
7100330	U silnice	-0.0385	-0.0507	-0.1280	7100330	U silnice	-0.0248	-0.0058	-0.1279
14050120	Sadská(pilíř)	-0.0040	-0.0096	0.1571	14050120	Sadská(pilíř)	0.0184	-0.0027	0.1572
14080120	Horka	-0.0127	-0.0169	-0.1127	14080120	Horka	-0.0024	0.0062	-0.1126
14160040	Na křižovatce	0.0100	-0.0622	-0.1110	14160040	Na křižovatce	0.0013	-0.0191	-0.1109
14190180	Boleslavka	0.0201	-0.0148	0.1077	14190180	Boleslavka	0.0141	-0.0009	0.1078
15200010	Za Trouby	-0.0269	0.0159	0.0907	15200010	Za Trouby	0.0070	0.0251	0.0908
23120060	U křížku	-0.0164	0.0366	-0.0912	23120060	U křížku	0.0291	0.0272	-0.0911
23220120	Na hrobech	-0.0122	0.0345	0.0884	23220120	Na hrobech	0.0189	0.0226	0.0884
the quadratic averages		0.0456	0.0340	0.1215	the quadratic averages		0.0353	0.0266	0.1215

The comparison of amid software

The comparison of the results processed by both software by the means of transformations parameters and residuals from Helmert 6- and 7- element 3D transformations.

Table 13 The transformations parameters between the session SPRING, processed by SKI 2.3 and by Trimble Geomatics Office™ from the Helmert 6- and 7- element 3D transformation.

tx=	-0.00649993235324	tx=	-0.00649980079697
ty=	-0.03975025293628	ty=	-0.03975014346156
tz=	0.18206262146866	tz=	0.18206277616967
α=	-0.00000220763684	q=	1.00000095716015
β=	-0.00000095337739	α=	-0.00000220763684
χ=	-0.00000075578390	β=	-0.00000095337739
		χ=	-0.00000075578390

Table 14 The residuals between session SPRING, processed by SKI 2.3 and by Trimble Geomatics Office™ from the Helmert 6- and 7- element 3D transformation.

6-element 3D	transformaton				7-element 3D	transformaton			
station code	station name	dx	dy	dh	station code	station name	dx	dy	dh
13100130	Nad Charvátiny	0.0505	0.0048	-0.1268	13100130	Nad Charvátiny	0.0137	0.0112	-0.1269
13240340	Senecká hora	0.0836	0.0148	0.2015	13240340	Senecká hora	0.0224	0.0259	0.2013
21120450	Chlumek	0.0358	0.0357	0.0653	21120450	Chlumek	-0.0088	0.0174	0.0653
22070100	Pecný-věž	-0.0094	0.0101	0.1202	22070100	Pecný-věž	-0.0006	-0.0042	0.1200
22090110	Zálesí	-0.0021	0.0182	0.0102	22090110	Zálesí	0.0123	-0.0153	0.0102
22200670	Na rovině	-0.0069	0.0161	-0.2826	22200670	Na rovině	-0.0158	-0.0291	-0.2827
22220050	U Pytlíka	0.0136	0.0050	0.0834	22220050	U Pytlíka	0.0024	-0.0040	0.0834
22240140	Ve vrších	0.0135	0.0182	-0.0751	22240140	Ve vrších	-0.0039	-0.0110	-0.0752
7100330	U silnice	-0.0286	-0.0595	-0.1228	7100330	U silnice	-0.0136	-0.0099	-0.1228
14050120	Sadská(pilíř)	-0.0294	-0.0010	0.1648	14050120	Sadská(pilíř)	-0.0046	0.0066	0.1649
14080120	Horka	-0.0216	-0.0294	-0.1466	14080120	Horka	-0.0101	-0.0039	-0.1466
14160040	Na křižovatce	0.0011	-0.0651	-0.1050	14160040	Na křižovatce	-0.0084	-0.0176	-0.1049
14190180	Boleslavka	0.0045	-0.0197	0.0408	14190180	Boleslavka	-0.0021	-0.0044	0.0409
15200010	Za Trouby	-0.0384	0.0019	0.1281	15200010	Za Trouby	-0.0010	0.0120	0.1283
23120060	U křížku	-0.0372	0.0299	-0.0727	23120060	U křížku	0.0129	0.0196	-0.0726
23220120	Na hrobech	-0.0291	0.0198	0.1174	23220120	Na hrobech	0.0052	0.0067	0.1174
the quadratic averages		0.0328	0.0284	0.1323	the quadratic averages		0.0105	0.0146	0.1323

Table 15 The transformations parameters between the session AUTUMN, processed by SKI 2.3 and by Trimble Geomatics Office™ from the Helmert 6- and 7- element 3D transformation.

tx=	-0.00056243618481	tx=	-0.00056230340010
ty=	-0.04350020101226	ty=	-0.04350009075029
tz=	0.18287508707504	tz=	0.18287524429875
α=	-0.00000191522297	q=	1.00000096087831
β=	-0.00000096026632	α=	-0.00000191522297
χ=	-0.00000081314351	β=	-0.00000096026632
		χ=	-0.00000081314351

Table 16 The residuals between the session AUTUMN, processed by SKI 2.3 and by Trimble Geomatics Office™ from the Helmert 6- and 7- element 3D transformation.

6-element 3D	transformaton				7-element 3D	transformaton			
station code	station name	dx	dy	dh	station code	station name	dx	dy	dh
13100130	Nad Charvátiny	0.0541	0.0064	-0.1353	13100130	Nad Charvátiny	0.0173	0.0127	-0.1353
13240340	Senecká hora	0.0810	0.0188	0.1927	13240340	Senecká hora	0.0196	0.0300	0.1926
21120450	Chlumek	0.0250	0.0327	0.0354	21120450	Chlumek	-0.0198	0.0144	0.0353
22070100	Pecný-věž	-0.0145	0.0143	0.1237	22070100	Pecný-věž	-0.0057	-0.0001	0.1235
22090110	Zálesí	-0.0010	0.0058	-0.0224	22090110	Zálesí	0.0134	-0.0279	-0.0225
22200670	Na rovině	0.0028	0.0293	-0.2305	22200670	Na rovině	-0.0061	-0.0161	-0.2307
22220050	U Pytlíka	0.0182	0.0101	0.0744	22220050	U Pytlíka	0.0070	0.0011	0.0744
22240140	Ve vrších	0.0213	0.0209	-0.0539	22240140	Ve vrších	0.0038	-0.0084	-0.0540
7100330	U silnice	-0.0455	-0.0608	-0.1149	7100330	U silnice	-0.0304	-0.0111	-0.1148
14050120	Sadská(pilíř)	-0.0218	-0.0037	0.1675	14050120	Sadská(pilíř)	0.0031	0.0039	0.1676
14080120	Horka	-0.0220	-0.0279	-0.1183	14080120	Horka	-0.0106	-0.0023	-0.1182
14160040	Na křižovatce	0.0053	-0.0688	-0.1073	14160040	Na křižovatce	-0.0043	-0.0212	-0.1072
14190180	Boleslavka	0.0017	-0.0153	0.0554	14190180	Boleslavka	-0.0050	0.0000	0.0555
15200010	Za Trouby	-0.0419	0.0039	0.1149	15200010	Za Trouby	-0.0044	0.0141	0.1151
23120060	U křížku	-0.0355	0.0207	-0.0767	23120060	U křížku	0.0147	0.0104	-0.0766
23220120	Na hrobech	-0.0273	0.0136	0.0954	23220120	Na hrobech	0.0072	0.0004	0.0953
the quadratic averages		0.0335	0.0287	0.1204	the quadratic averages		0.0131	0.0143	0.1204