



**United Nations/Latvia Workshop on the
Applications of Global Navigation Satellite Systems
Riga, Latvia
14 – 18 May, 2012**



University of Sarajevo

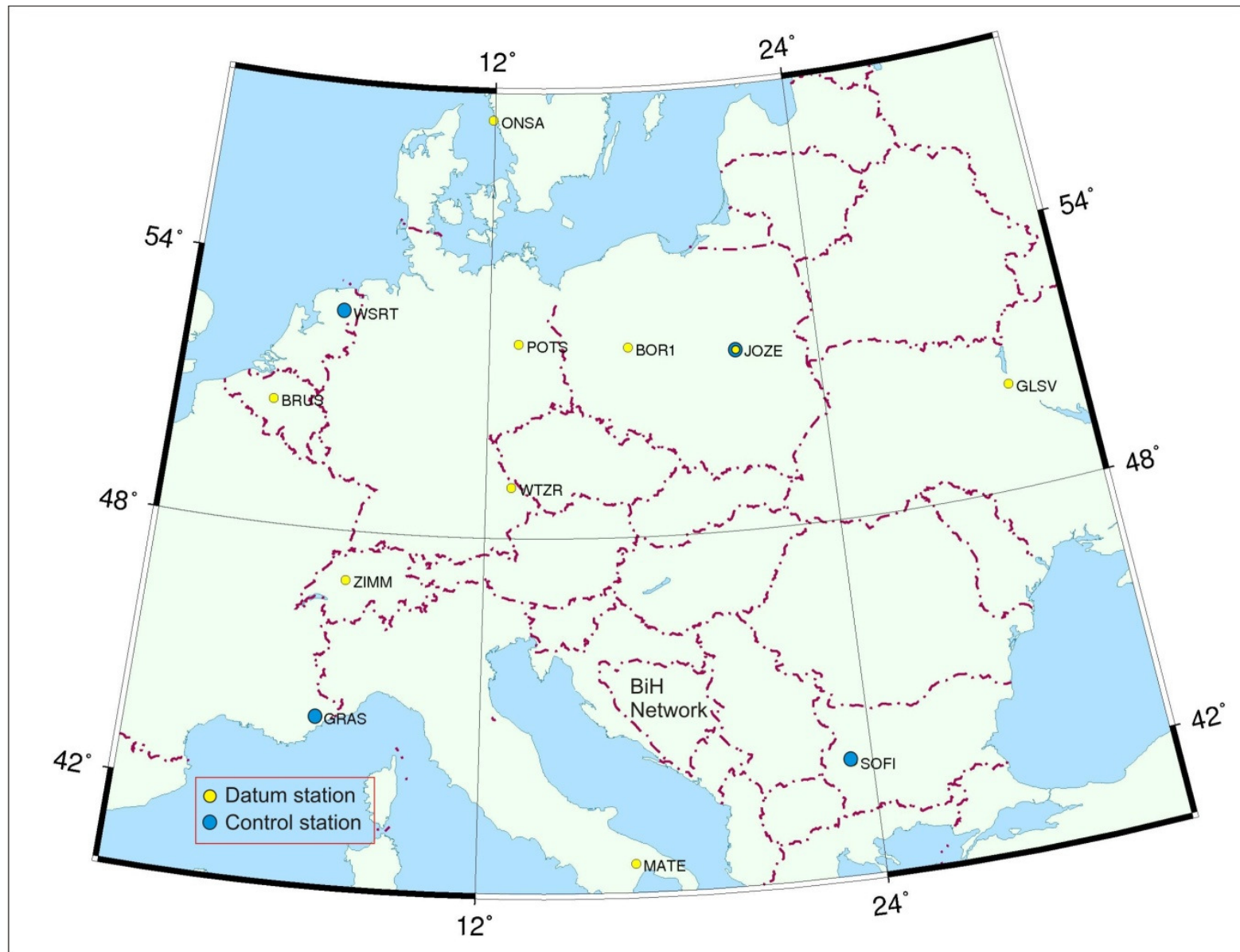
Faculty of Civil Engineering-Department of Geodesy

**BENEFIT OF THE REPROCESSED ORBITS IGS05 (IG1),
TO GEODETIC REFERENCE FRAME OF
BOSNIA AND HERZEGOVINA**

Medzida Mulic

Content

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UN/Latvia Workshop "Applications of GNSS"
 RIGA 14-18, May 2012



GPS campaigns

BIHREF2000



CEGRN05 u BiH



Observations in B&H GPS campaigns

BIHREF2000

261, 262, 263, 264, 265, 266, DoY 2000

Stanica	PUNO IME	DOY261	DOY262	DOY263	DOY264	DOY265	DOY266
SRJV	Sarajevo p.	*	*	*	*	*	*
STOL	Stolice	*	*	*	*	*	*
KUDB	Kudić brdo	*	*	*	*	*	*
LEOT	Leotar	*	*	*	*	*	*
LIVN	Livanjsko polje	*	*	*	*	*	*
BABJ	Babja glava	*	*	*			
BJEL	Blelašnica				*	*	*
BORO	Borovac	*	*	*			
BRAT	Bratila					*	*
BUBA	Bubanj	*	*				
BUTU	Buturovica					*	*
CUBR	Čubren	*	*	*			
DEKA	Dekala	*	*	*			
IGRI	Igrište	*	*	*			
KABA	Kabajkovac				*	*	*
LAZA	La zarevica				*	*	*
LISI	Lisina	*	*	*			
MIDE	Midena				*	*	*
OKRS	Okresanica	*	*	*			
OBLJ	Oblijaj	*	*	*			
PONI	Ponikve				*	*	*
RADU	Raduša	*	*	*			
RANC	Ranča				*	*	*
SAMO	Samotica				*	*	*
STRZ	Stražište	*	*	*			
SUMA	Šumatica				*	*	*
TVRT	Tvrkovac				*	*	*
VOST	Voštrovica	*	*	*			

CEGRN05 in BiH

171, 171, 173,174, 175, 176, 177 DoY 2005

Stanica	IME	DOY171	DOY172	DOY173	DOY174	DOY175	DOY176	DOY177
SRJV	Sarajevo	*	*	*	*	*	*	*
STOL	Stolice	*	*	*	*	*	*	
KUDB	Kudić B.	*	*	*	*	*	*	
LEOT	Leotar	*	*	*	*	*	*	
LIVN	Livanjsko P.	*	*	*	*	*	*	*
ALAB	Aladžinica B.		*	*	*	*		
BJEL	Blelašnica	*	*	*	*	*	*	*
BORO	Borovac	*	*	*				
KABA	Kabajkovac	*	*	*	*	*	*	
OSJC	Osječnica	*	*	*	*	*	*	*
PONI	Ponikve	*	*	*	*	*	*	
TURI	Turić	*	*	*	*	*	*	
VLAS	Vlašić	*	*	*	*	*	*	

Stations observed in both campaigns:
SRJV, KUDB, LEOT, LIVN,
BJEL, KABA, PONI, BABJ,

Processing of BIHREF2000

PROBLEMS:

- Only two 24 sessions of observations!
- Bad weather conditions: heavy raining !!
- Ionosphere?

Results published in 2005

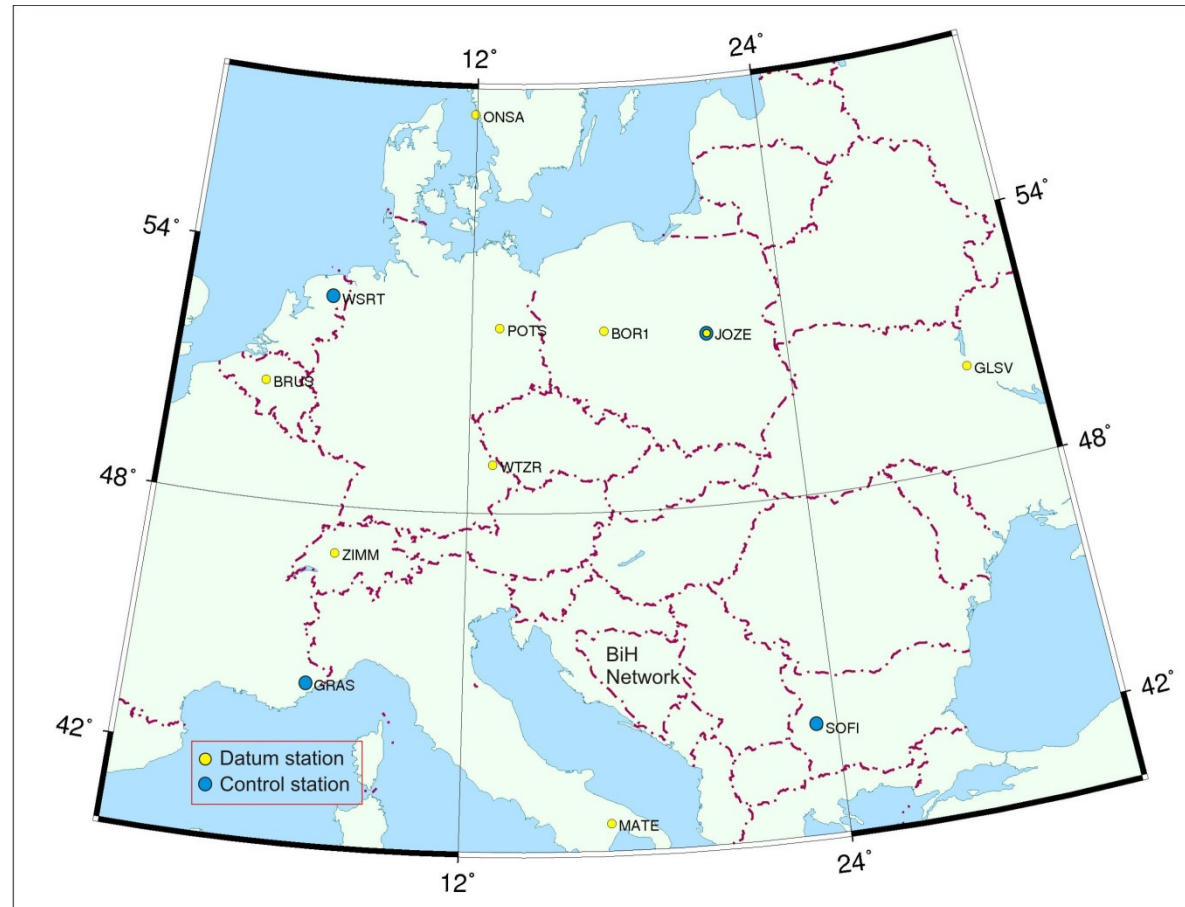
- Reference frames:
- ITRF97
- ITRF2000
- Generally-achieved 3D accuracy not satisfied requirements of 1 cm!

Availability of the IGS05 reprocessed orbit opens the door for the possibility to reprocess GPS data of the BIHREF2000/CEGRN05 with aim to improve accuracy of stations positions.

Selected IGS reference stations

Datum +
Control
stations:

BOR1,
BRUS,
GLSV,
JOZE,
MATE,
ONSA,
POTS,
WTZR,
ZIMM,
GRAS,
WSRT,
SOFI.



PROCESSING STRATEGY

Parameter	Processing model and algorithms
Cut of angle	10°
Sampling rate	30 s
Orbit	IGS05
Earth's rotation parameter	Per day
Ocean loading model	FES2000
Tidal effects	IERS Conventions 2000
Precision-Nutation model	IAU2000
Gravity Field	EGM96
Third-Body	JPL Planetary ephemeris DE200
Earth shadow model	Penumbra
Eccentricities of antennas	ARP eccentricities from RINEX files of data
PCV	Phase center variations of antennas from GPS week 1627
Pseudo distances	For detection of clocks of satellites and receivers for each epoch
Carrier phase data	For formation of double differences
Ambiguity solution	Quasi ionosphere-free model;
Signal delay in the troposphere	Computation of a priori delay in the troposphere using the model of Saastamoinen, and projection to the height of stations with the Neill mapping function. Linear estimation the wet part of the troposphere delay for each hour, gradients per 4 hours.
Daily free solutions	Ionosphere-free linear combination L3 applying a standard deviation for each component of coordinates of 1.0 m.
Datum of estimated station coordinates	Weighting of coordinates of 8 IGS stations (BOR1, BRUS, GLSV, MATE, ONSA, POTS, WTZR, and ZIMM) at the epoch of the individual campaign considering a standard deviation of 0.1 mm for each component of coordinates of selected datum stations.

Daily solutions

properties of the ambiguity solutions

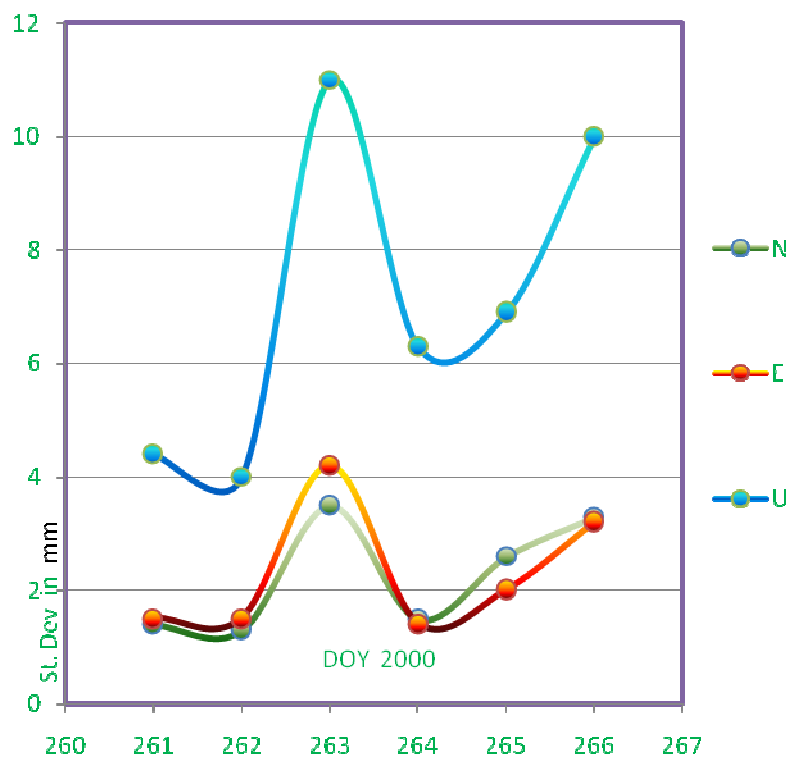


DoY	Numb.	Length	Amb.	Amb	RMS	Amb
	Baseline	(km)	(mm)		(mm)	(%)
BIHREF2000						
261	36	218.5	3926	1046	1.4	73.4
262	38	209.0	4346	1104	1.3	74.6
263	34	229.5	2288	482	1.1	78.9
264	35	225.3	3794	1134	1.4	70.1
265	37	213.5	4440	1462	1.5	67.1
266	37	213.5	2304	518	1.2	77.5
CEGRN2005						
171	39	214.0	3700	1148	1.3	69.0
172	39	214.0	5322	1786	1.3	66.4
173	39	214.0	4926	1508	1.3	69.4
174	39	214.0	5516	1880	1.3	65.9
175	39	214.0	4788	1582	1.3	67.0
176	37	224.3	3556	1074	1.3	69.8
177	26	289.2	2706	690	1.3	74.5

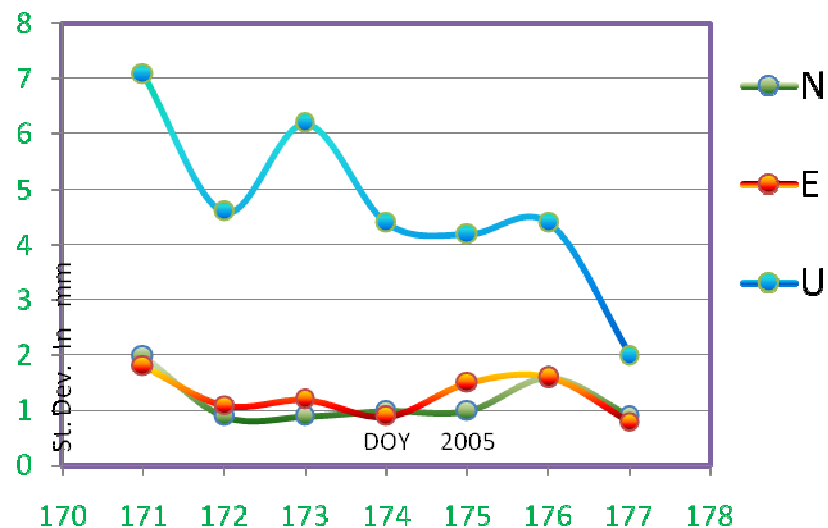
Daily free solutions

daily repeatability

BIHREF 2000



CEGRN05 in BiH



Quality of the reference and control stations

BIHREF2000

CERGOP

BIHRE Station	CEGRN2005	EPOCH: 2005-06-23 12:00:00		
	Station	N (mm)	E (mm)	U (mm)
BOR1				
BRUS	BOR1 12205M002	-0.1	-0.7	0.6
GLSV	BRUS 13101M004	0.7	2.8	0.2
MATE	GLSV 12356M001	-0.6	-3.2	-0.6
ONSA	JOZE 12204M001	3.3	-3.8	6.3
POTS	MATE 12734M008	1.9	-0.6	0.2
WTZR	ONSA 10402M004	-0.9	-0.3	-0.7
ZIMM	POTS 14106M003	0.2	0.0	-2.3
GRAS	WTZR 14201M010	0.4	1.3	1.2
JOZE	ZIMM 14001M004	0.3	0.8	-0.1
WSRT				



Error ellipses of the stations in B&H

8 DATUM STATIONS solution– (a priori st. dev. 0.1 mm)

Probability 95% (multiplied by factor 4)

BIHREF2000



CERGN05 in BiH



Velocities from the combined campaign

ep. 2003.100

horizontal velocities



Velocities of height component



Comparison of the **coordinates** of the combined campaign- epoch 2003,100

Comparison of the coordinates estimated from the combination of:

- All free daily solutions (6+7=13 day)
- Without 263 DOY 2000 and 171 DOY 2005
- **Differences are not significant!**

Stacija		N (mm)	E (mm)	U (mm)
301	BABJ 1045	0.1	0.0	1.2
302	BJEL 0268	-0.3	0.2	-1.0
303	BORI 12205M002	0.1	0.1	-0.2
306	BRUS 13101M004	-0.2	0.0	0.3
314	GLSV 12356M001	0.0	0.1	-0.1
315	GRAS 10002M006	-0.2	0.0	-0.6
320	JOZE 12204M001	-0.1	0.1	-0.2
321	KABA 0243	-0.1	0.0	-0.1
325	LEOT 0318	-0.1	-0.2	0.3
327	LIVN 0436	-0.2	-0.2	-0.8
328	MATE 12734M008	0.0	-0.1	-0.2
335	ONSA 10402M004	0.1	0.0	0.0
341	PONI 1074	-0.1	-0.1	-0.7
342	POTS 14106M003	0.1	0.0	0.2
347	SRJV 11801S001	-0.1	0.0	-0.6
355	WSRT 13506M005	0.1	-0.1	0.2
356	WTZR 14201M010	-0.1	0.0	0.0
357	ZIMM 14001M004	-0.2	0.0	-0.1
377	KUDB 0235	0.0	0.1	-0.3

Comparison of the velocities

estimated in the combined campaign ep. 2003,100

Comparison of the velocities from combination of daily solutions

- all free solutions (6+7=13 days)
- without **263** in year 2000 and **171** in year 2005 (5+6=11)

Differences are not significant!

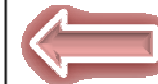
Station	Vx (m/year)	Vy (m/year)	Vz (m/year)
301 BABJ 1045	-0.0002	-0.0002	0.0000
302 BJEL 0268	0.0001	0.0000	0.0001
303 BOR1 12205M002	0.0001	0.0000	0.0001
306 BRUS 13101M004	-0.0001	-0.0001	-0.0001
314 GLSV 12356M001	0.0000	0.0000	0.0001
315 GRAS 10002M006	0.0001	0.0000	0.0002
320 JOZE 12204M001	-0.0001	-0.0001	0.0000
321 KABA 0243	0.0000	-0.0001	0.0001
325 LEOT 0318	-0.0002	0.0000	0.0001
327 LIVN 0436	0.0001	-0.0001	0.0002
328 MATE 12734M008	-0.0001	0.0000	0.0001
335 ONSA 10402M004	0.0000	0.0000	0.0000
341 PONI 1074	0.0001	0.0000	0.0003
342 POIS 14106M003	0.0000	-0.0001	0.0001
347 SRJV 11801S001	0.0000	0.0000	0.0000
355 WSRT 13506M005	0.0001	0.0000	0.0001
356 WTZR 14201M010	0.0000	0.0000	0.0000
357 ZIMM 14001M004	0.0000	0.0000	-0.0001
377 KUDB 0235	-0.0002	-0.0001	-0.0001

Comparison of the **coordinates** from combined campaign

Solution with 8 datum station minus solution with 9 datum stations

EPOHA: 2003-02-06 0:00:00

BABJ	1045	-0.6	0.7	-0.3
BJEL	0268	-0.5	0.7	-0.3
KABA	0243	-0.6	0.7	-0.6
LEOT	0318	-0.5	0.6	-0.3
LIVN	0436	-0.5	0.7	-0.3
PONI	1074	-0.5	0.6	-0.3
KUDB	0235	-0.6	0.7	-0.6
BOR1	12205M002	-0.4	0.7	-0.3
BRUS	13101M004	-0.2	0.6	-0.2
GLSV	12356M001	-0.6	0.8	-0.3
JOZE	12204M001	-1.0	1.3	-3.6
MATE	12734M008	-0.5	0.5	-0.1
ONSA	10402M004	-0.2	0.6	-0.3
POTS	14106M003	-0.3	0.7	-0.3
SRJV	11801S001	-0.5	0.8	-0.3
WTZR	14201M010	-0.3	0.7	-0.3
ZIMM	14001M004	-0.4	0.6	-0.2
GRAS	10002M006	-0.4	0.6	-0.4
WSRT	13506M005	-0.2	0.6	-0.7



Analyse of the accuracy of the **coordinates** of the control stations

Comparison of coordinates of control stations in IGS05 from combined solution and reference IGS05 coordinates translated to epoch 2003.100

Datum: IGS05		Epoch: 2003-02-26 0:00:00				
Station	latitude	longitudo	height(m)	N (cm)	E (cm)	U (cm)
GRAS	43.75474	6.92057	1319.31088	-0.39545	-0.70547	-0.69643
JOZE	52.09727	21.03154	141.43442	-0.40647	0.40092	-0.18774
WSRT	52.91461	6.60450	82.28070	-0.02133	-0.35795	-0.79855



Analyse of the accuracy of the **velocities** of the control stations



Comparation of the reference velocities IGS05 with velocities from combined solution when 8 or 9 datum stations.

Station	Reference vel. IGS05	Differences of velocities from combined s.		
			9 datum stations sol.	8 datum stations
GRAS 10002M006	Vx (m/god)	-0.0139	0.0000	-0.0001
	Vy (m/god)	0.0186	0.0011	0.0010
	Vz (m/god)	0.0116	0.0019	0.0019
JOZE 12204M001	Vx (m/god)	-0.0165	-0.0002	-0.0002
	Vy (m/god)	0.0159	-0.0012	-0.0014
	Vz (m/god)	0.0106	0.0000	0.0001
WSRT 13506M005	Vx (m/god)	-0.0145	-0.0007	0.0007
	Vy (m/god)	0.0159	0.0002	-0.0003
	Vz (m/god)	0.0103	-0.0005	-0.0005

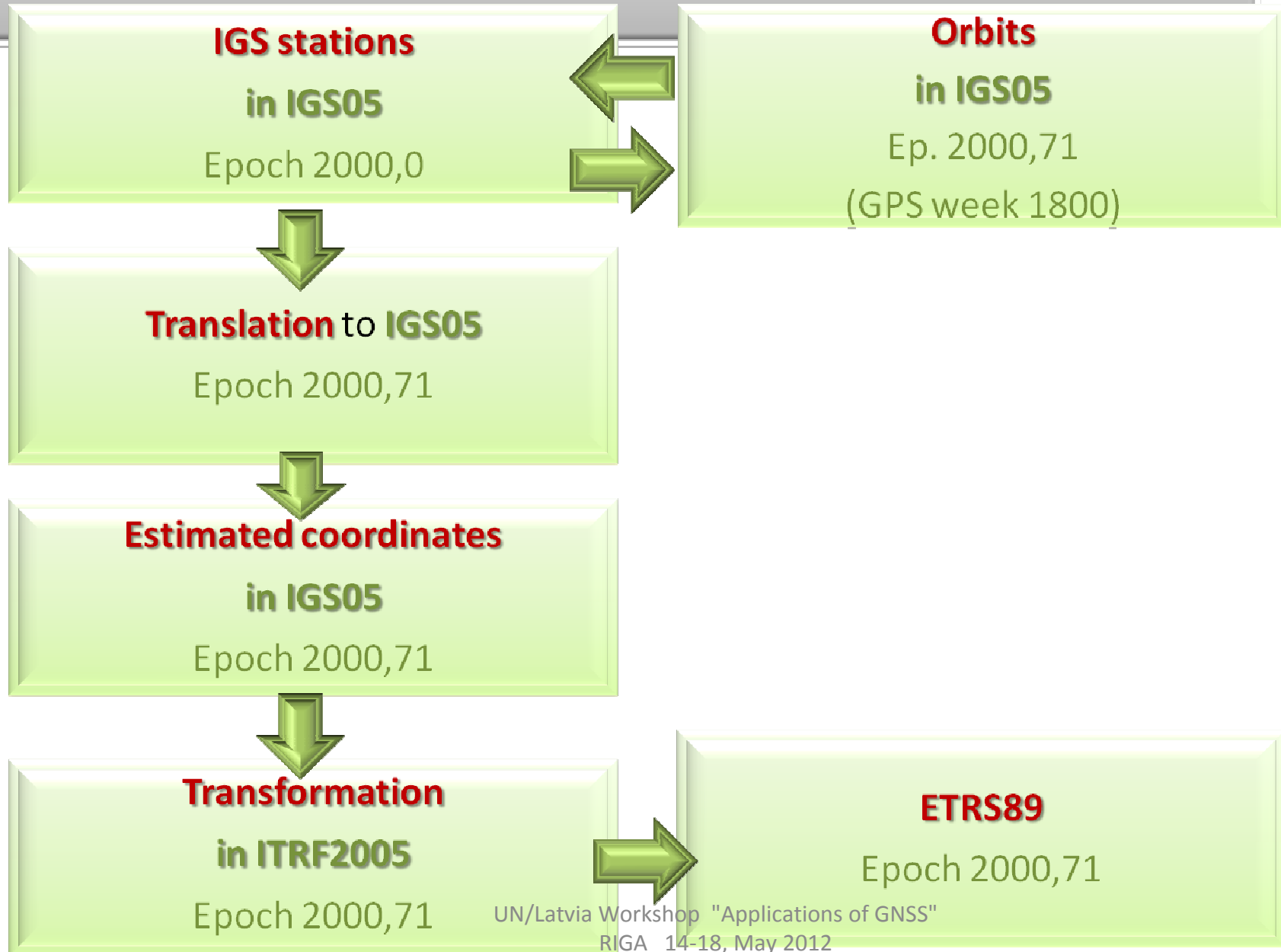
Velocities of GPS stations

RESULTS of the COMBINED CAMPAIGN:

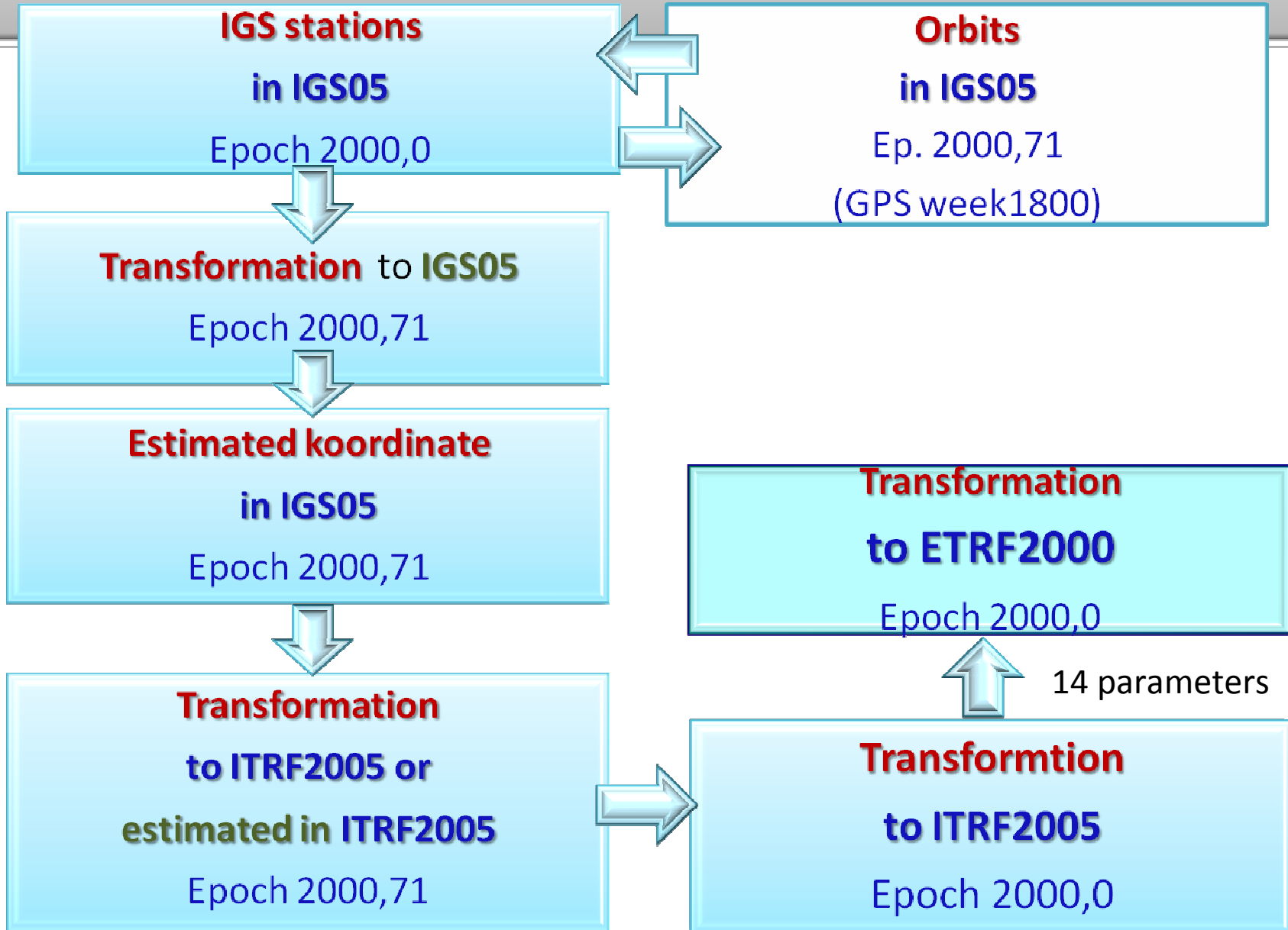
Estimated velocities at IGS05 from combined campaign solutions relative to 8 datum stations. Velocities from IGS stations GRAS and WSRT are, shown in bold, estimated to check the quality of velocity estimation.

STANICA	VX (m/god)	VY (m/god)	VZ (m/god)	
BABJ 1045	-0.0106	0.0163	0.0163	
BJEL 0268	-0.0205	0.0171	0.0114	
GRAS 10002M006	-0.0140	0.0196	0.0135	
JOZE 12204M001	-0.0167	0.0145	0.0107	
KABA 0243	-0.0212	0.0172	0.0107	
LEOT 0318	-0.0185	0.0174	0.0134	
LIVN 0436	-0.0136	0.0176	0.0097	
PONI 1074	-0.0203	0.0188	0.0125	
SRJV 11801S001	-0.0181	0.0154	0.0126	
WSRT 13506M005	-0.0152	0.0156	0.0098	
KUDB 0235	-0.0190	0.0173	0.0117	

Transformation from IGS05 to ETRS89



Transformation from IGS05 to ETRF2000



Quality of the **coordinates** in ETRF2000

8 stations in BiH observed in the **bouth** campaigns and their coordinate estimates tree times:

1. Combined solution
2. BIHREF2000
3. CEGRN05

Comparison of the coordinates in ETRF2000 ⁽¹⁾

Comparison of coordinates of **combined** campagne with solutions of **BIHREF2000** and **CEGRN05**, in ETRF2000, epoch 2000.0

STANICA	BIHREF2000			CEGRN05		
	N (mm)	E (mm)	U (mm)	N (mm)	E (mm)	U (mm)
BOR1 12205M002	0.3	-0.9	-1.3	-0.4	1.0	1.2
BRUS 13101M004	-0.2	-3.2	0.8	0.2	3.0	-1.0
GLSV 12356M001	-0.5	-2.4	-1.7	0.2	2.4	1.6
MATE 12734M008	10.4	0.6	0.8	-10.3	-0.8	-1.0
ONSA 10402M004	-1.3	-2.1	6.0	1.4	2.1	-5.9
POTS 14106M003	0.0	-1.4	-2.0	0.0	1.5	2.1
WTZR 14201M010	1.1	-0.2	1.3	-1.0	0.1	-1.3
ZIMM 14001M004	0.7	-0.8	3.1	-0.8	0.6	-3.2
BABJ 1045	-0.4	-9.5	15.4	-2.0	7.5	-16.6
BJEL 0268	5.6	-0.3	-8.1	-8.3	-2.0	6.6
KABA 0243	6.2	0.4	-10.1	-8.6	-2.9	9.2
LEOT 0318	6.0	-1.7	-2.1	-8.5	-0.4	0.8
LIVN 0436	-7.1	-4.2	1.0	5.2	1.8	-2.3
PONI 1074	6.1	3.2	-5.2	-8.9	-5.1	4.0
SRJV 11801S001	5.1	-5.9	-3.3	-7.7	3.7	1.4
KUDB 0235	5.3	-0.7	-5.6	-7.3	-1.5	4.7

Comparison of the coordinates in ETRF2000 (2)

Coordinates differences of the same stations in ETRF2000,
resulting from **BIHREF2000** and **CEGRN05**.

Datum ETRF2000 epoch 2000.0

Coordinates differences **CEGRN05 minus BIHREF2000**

Satnica	N (mm)	E (mm)	U (mm)
BOR1 12205M002	0.7	-2.0	-2.5
BRUS 13101M004	-0.4	-6.1	1.8
GLSV 12356M001	-0.7	-4.8	-3.3
JOZE 12204M001	-0.2	-1.3	6.6
MATE 12734M008	20.7	1.4	1.7
ONSA 10402M004	-2.7	-4.3	11.8
POTS 14106M003	0.0	-2.9	-4.1
WTZR 14201M010	2.1	-0.3	2.5
ZIMM 14001M004	1.5	-1.4	6.4
BABJ 1045	1.6	-17.0	32.0
BJEL 0268	13.9	1.8	-14.7
KABA 0243	14.8	3.4	-19.2
LEOT 0318	14.5	-1.3	-2.9
LIVN 0436	-12.3	-6.0	3.3
PONI 1074	14.9	8.3	-9.2
SRJV 11801S001	12.8	-9.6	-4.8
KUDB 0235	12.6	0.8	-10.2

Comparison of the velocities: IGS05 and NUVEL-1A

Station	NUVEL-1A			Estimated in IGS05		
	Vx (m/y)	Vy (m/y)	Vz (m/y)	Vx (m/y)	Vy (m/y)	Vz (m/y)
BABJ 1045	-0.0150	0.0182	0.0092	-0.0102	0.0166	0.0165
BJEL 0268	-0.0151	0.0181	0.0091	-0.0206	0.0173	0.0112
KABA 0243	-0.0149	0.0181	0.0091	-0.0212	0.0174	0.0106
KUDB 0235	-0.0146	0.0181	0.0092	-0.0190	0.0174	0.0117
LEOT 0318	-0.0150	0.0183	0.0092	-0.0183	0.0175	0.0134
LIVN 0436	-0.0147	0.0182	0.0092	-0.0136	0.0177	0.0097
PONI 1074	-0.0151	0.0182	0.0091	-0.0203	0.0189	0.0123
SRJV 11801S001	-0.0151	0.0181	0.0090	-0.0181	0.0155	0.0126
BOR1 12205M002	-0.0156	0.0167	0.0078	-0.0167	0.0157	0.0097
BRUS 13101M004	-0.0127	0.0175	0.0093	-0.0133	0.0157	0.0105
GLSV 12356M001	-0.0182	0.0159	0.0064	-0.0193	0.0142	0.0090
GRAS 10002M006	-0.0123	0.0188	0.0104	-0.0139	0.0197	0.0136
JOZE 12204M001	-0.0164	0.0165	0.0074	-0.0167	0.0147	0.0106
MATE 12734M008	-0.0143	0.0187	0.0097	-0.0178	0.0186	0.0156
ONSA 10402M004	-0.0150	0.0159	0.0074	-0.0131	0.0145	0.0109
POTS 14106M003	-0.0148	0.0169	0.0082	-0.0153	0.0161	0.0102
WSRT 13506M005	-0.0135	0.0170	0.0087	-0.0153	0.0158	0.0097
WTZR 14201M010	-0.0144	0.0176	0.0088	-0.0161	0.0169	0.0106
ZIMM 14001M004	-0.0129	0.0182	0.0098	-0.0129	0.0180	0.0129

CONCLUSIONS 1

Benefit of the availability of the reprocessed IGS05 orbits (IG1) used for re-processing of the B&H campaigns resulted in the improved accuracy of the realization of the geodetic reference network of Bosnia and Herzegovina. It could be generally said that the accuracy of the all three components of the positions were within the 10 mm and accuracy of the processed velocities for the identical stations were about 1mm/year.

CONCLUSIONS 2

Improvements in the accuracy of the coordinates BIHREF2000 GPS stations achieved through the use of the following processing strategies:

- Reference frame **IGS05**,
- Reprocessed **IGS05 orbits -IG1**,
 - which are introduced into official use in November 2006,
 - whose accuracy is improved by applying corrections for the absolute calibration of the antennas of the satellites and the receivers.
- Calculating **horizontal gradients** for minimizing the effects of delay signals passing through the troposphere.
 - this was particularly reflected to the improved accuracy of the height.
- Further improvement of accuracy achieved by combining with CEGRN05 data.

BIHPOS

BIH POSITIONING SERVICE

UN/Latvia Workshop "Applications of GNSS"
RIGA 14-18, May 2012

BIHPOS-BiH Postioning Service

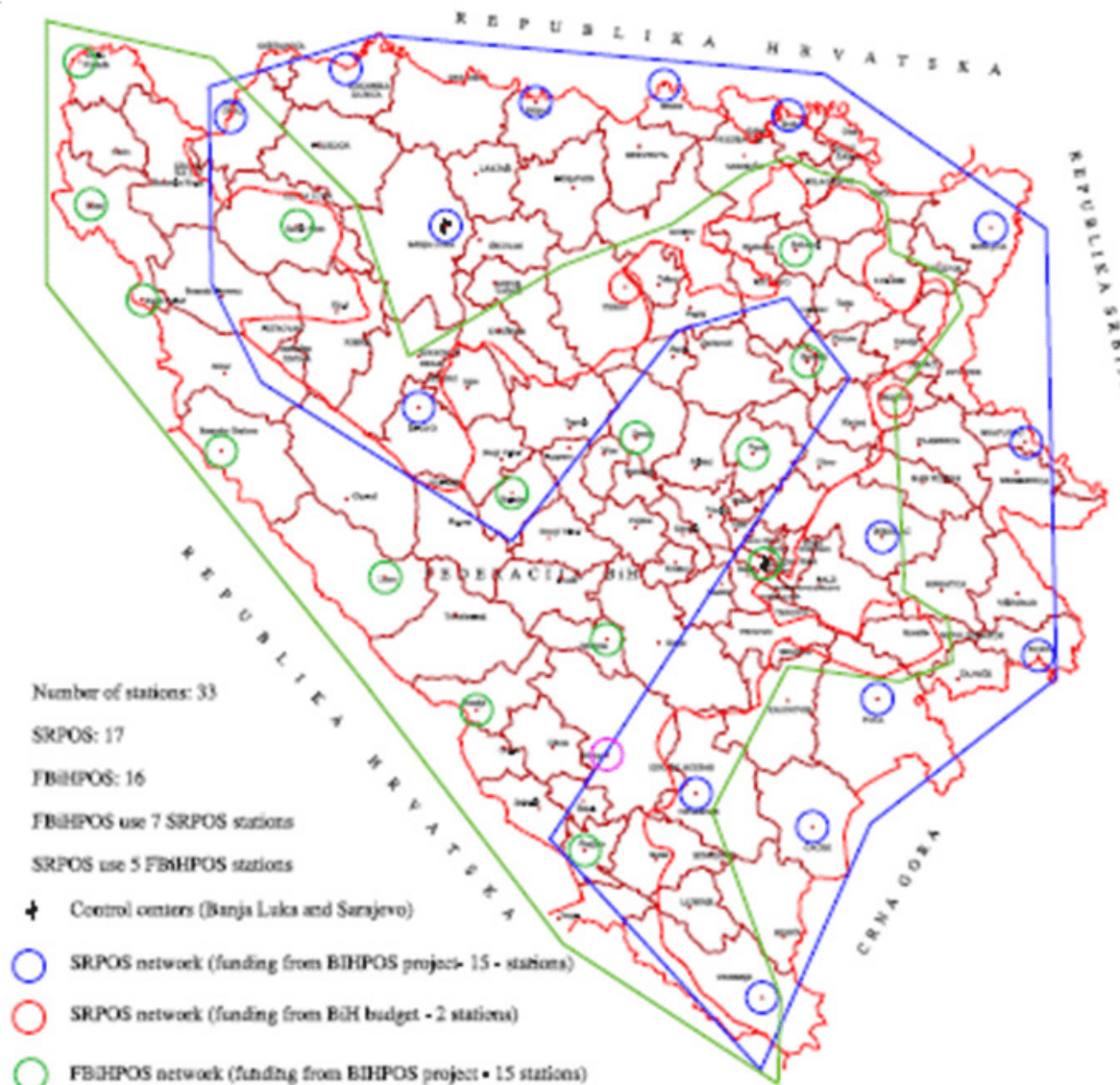
FBIHPOS +SRPOS

<http://www.fgu.com.ba>

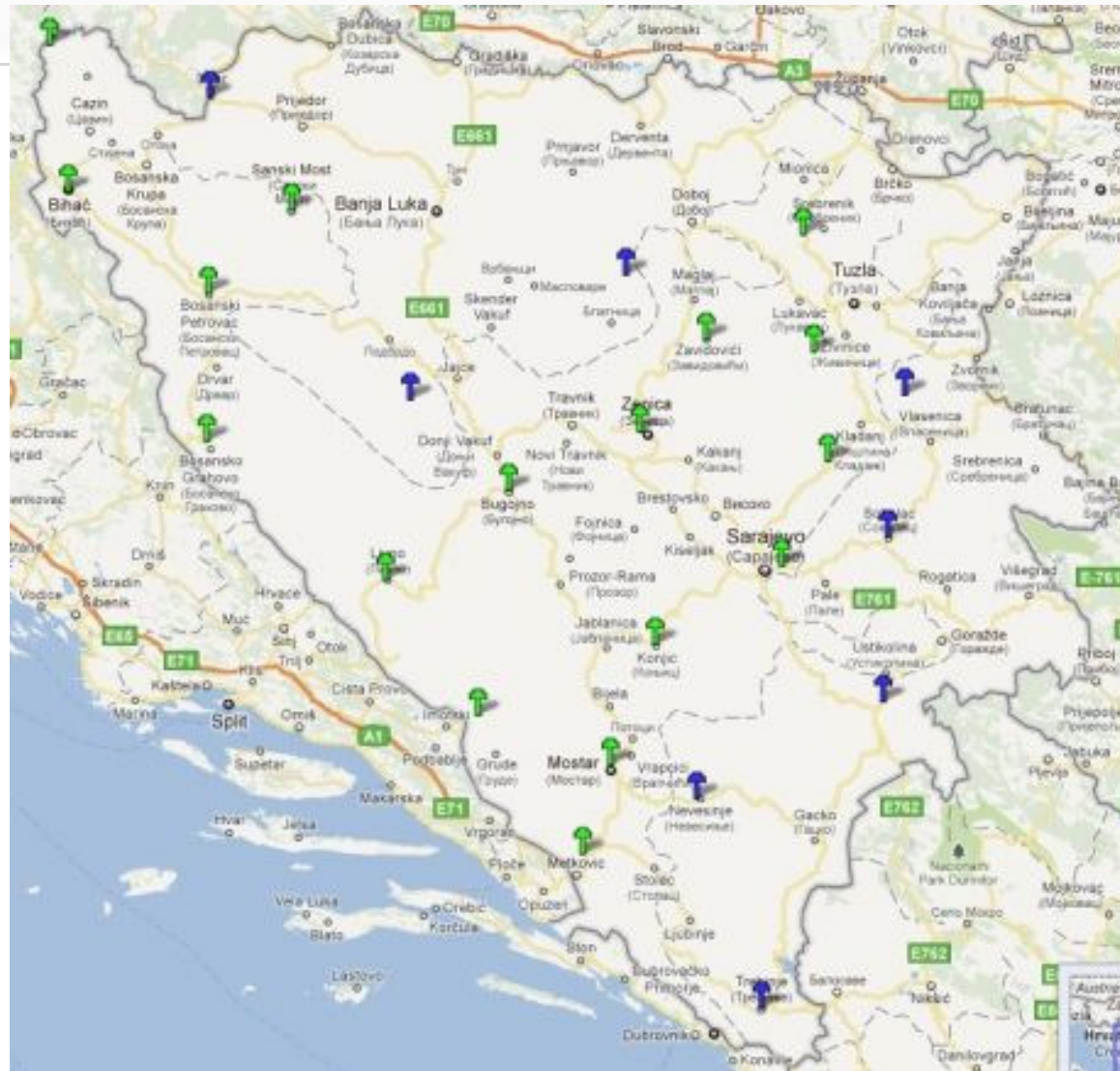
17+17 =34 stations



BIHPOS=FBIHPOS+SRPOS

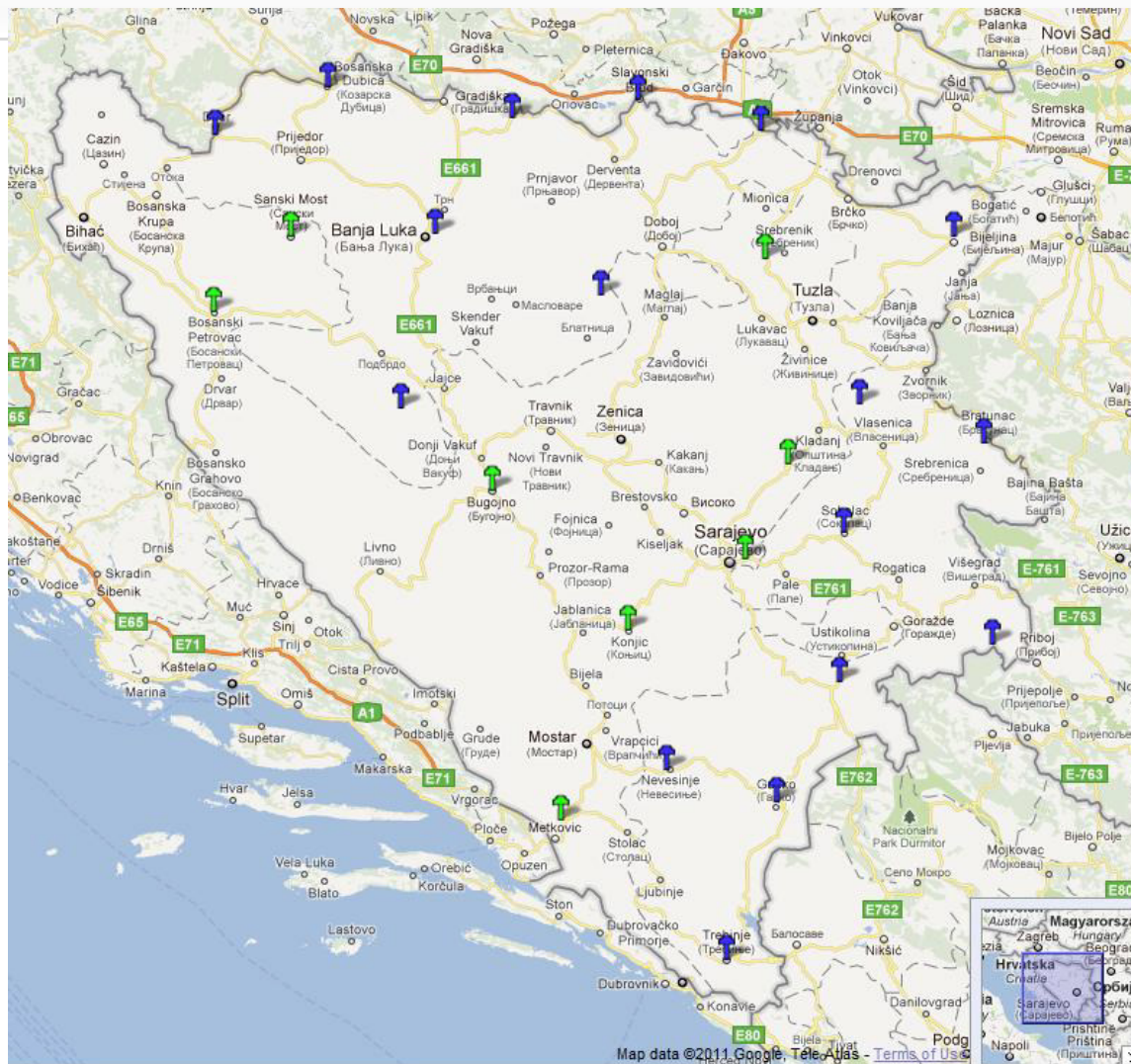


FBiHPOS



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GNSS" RIGA 14-18, May 2012

SRPOS



UN/Latvia Workshop "Applications of GNSS"
RIGA 14-18, May 2012

Leica Recivers +Spider software

- GPS
- GLONASS
- Galileo
- Compass

SERVICES

DSP	VPSP	GPSP
1-3 m	1-2 cm	1 cm

<http://www.fgu.com.ba/index.php?part=stranice>



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Thanks!



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