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LKS-92 coordinates transformation to ITRF2000

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Abstract

LKS-92 is Latvian geodetic coordinate system used as an EUREF89 realization in Latvia. LKS-92 is official coordinate system for procuring of essential geospatial data. For aeronautical and other purposes ITRF2000 is used in publication of geospatial data. Research is done to obtain transformation parameters from LKS-92 realization epoch 1992.75 through LatPos to ITRF2000 epoch 2000.00. Valuation of two different coordinate adjustment strategies and accuracy of parameters is done. Results of research could be used for transformation from LKS-92 to ITRF2000 for all kind of geospatial data.

Keywords: LKS-92; transformation to ITRF2000 epoch2000.

1. Latvian geodetic coordinate system

Latvian geodetic coordinate system was established at 1992 by means of global positioning campaign EUREF.BAL'92. Global positioning measurements where done form 28th of August till 5th of September [1]. Four ground benchmarks were used as a frame in the territory of Latvia eventually dissipated within whole area. Benchmarks Arājs, Indra and Kangari previously were served as triangulation network stations, but ground benchmark in Rīga was specially established for satellite laser ranging in Botanical garden of University of Latvia. Station Rīga still serves as a collocation station of satellite laser ranging and global navigation satellite systems for monitoring movement of crustal plate in territory of Latvia and other scientific purposes. In EUREF symposium, which was held in 1993 at Budapest, by resolution No. 2 the EUREF Baltic States GPS campaign were found to be at the same level of quality as EUREF-89. EUREF endorses these results as an extension of the EUREF-89 solution. Baltic state GPS campaign was stand alone campaign and none of ITRS realizations were directly connected to it.

LKS-92 measurement epoch is 1992.75 and four stations where defined as zero order global positioning network (G0) for Latvia. First, second and third order of state network where established and connected to G0 by means of GNSS campaigns. Global positioning state network evenly covers all territory of Latvia. All global positioning networks are served for transformation purposes from Soviet Union time coordinate system connected to Pulkova observatory and Krasovsky ellipsoid of rotation to LKS-92 and GRS-80 ellipsoid of rotation.

The NKG 2003 GPS campaign was carried out in GPS week 1238 (September 28th to October 4th 2003) under the framework of the Nordic Geodetic Commission [2]. Results show problems for correct epoch transmission in ETRS89, differences between NKG 2003 and EUREF.BAL'92 are in order of few centimeters.

Nowadays all geospatial information is acquired for purpose of municipalities and state, and must be referenced in LKS-92. That mean all cadastral, topographical on a scale of 1:500 and cartographical information must be and is in LKS-92. Latvian state owns permanent positioning base station system LatPos mainly served for LKS-92 transmission from state network to geospatial data originator in field. LatPos provide real time kinematic and post processing data for all kind of purposes. At this time it is main instrument for surveyors to reference they data to LKS-92.

Geospatial data in Latvia are connected to twenty one year old epoch via four ground benchmarks. Aeronautical society after EU regulation 73/2010 decided that for aeronautical purpose coordinates in WGS-84 and ITRF2000 epoch 2000.00 are equal. In aeronautical integrated publication coordinates must be in ITRF2000, but origination of geospatial data can be in any coordinate system which has transformation parameters to ITRF2000.00.

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1.1. Sets of transformation data

Active part of LKS-92 realization is LatPos which is very extensively used in everyday survey. LatPos base station coordinates and service was validated against state's first and second order network in July of year 2012 as it is appointed in regulation issued by the Cabinet of Ministers "Geodetical reference system and topographical map system". From 3rd of August year 2012 new coordinates for LatPos are used, they differ from previously used in range of few cm for geodetical height component. Main purpose of validation was large number of base station location change from one building to other. GNSS measurements on zero order global positioning network for LatPos validation purpose where done at 10th of November in year 2011.

LatPos is state network and evenly overlays all territory of Latvia, it collects GNSS data 24 hours seven days a week, so 24 stations were chosen as data set for calculation of seven Helmert transformation parameters.

LatPos coordinates in LKS-92 were identical with the ones obtained after validation and used in everyday work. See Table 1.

Table 1. LatPos coordinates in LKS-92

LatPos station name	X (m)	Y (m)	Z (m)
ALUKSNE	3065247.663	1566667.648	5351678.738
BALVI	3084535.056	1589675.926	5333791.703
BAUSKA	3226814.995	1449250.181	5289639.377
DAGDA	3162078.490	1648394.735	5270703.309
DAUGAVPILS1	3209600.839	1601536.417	5256389.485
DOBELE1	3229567.825	1389764.137	5303835.643
IRBENE	3183614.933	1276707.563	5359315.042
JEKABPILS1	3174732.709	1539143.697	5295773.145
KULDIGA1	3231465.168	1302078.897	5324713.086
LIELVARDE	3179869.688	1471150.387	5311847.454
LIEPAJA1	3293067.583	1265205.966	5295955.789
LIMBAZI	3119682.909	1435782.692	5356755.075
LODE	3128070.630	1501820.952	5333995.923
MADONA	3136049.843	1544577.108	5317122.736
MAZSALACA	3081539.152	1440527.853	5377339.258
OJARS	3185444.629	1423322.990	5321411.201
PALSMANE	3092007.937	1520314.550	5349551.206
PREILI	3169094.094	1595616.277	5282560.865
REZEKNE1	3132106.551	1619598.819	5297236.988
SALDUS1	3246339.049	1344595.958	5305291.949
SIGULDA	3145951.751	1459815.116	5335020.958
TALSI	3193687.667	1328546.548	5340897.002
VALMIERA1	3099933.557	1472349.453	5358237.292

Second set of LatPos coordinates is in ITRF2000 epoch 2000.00 which were independently calculated by two organizations – University of Latvia, Institute of Geodesy and Geoinformation and Latvian Geospatial information agency. Obtaining two independent results and on common transformation parameters using set of average coordinates in ITRF2000 epoch 2000.00.

1.2. First approach for coordinate calculation

First approach strategy was to use five IGS stations around Latvia:
- Svetloe, Sankt-Petersburg, Russia;
- Golosiiv, Kiev, Ukraine;
- Jozefoslaw, Warsaw, Poland;
- Potsdam, Potsdam, Germany;
- Maartsbo, Maarstsbo, Sweden

Latvian Geospatial information agency use Bernese software version 5.2 for GNSS calculations. IGS station coordinates in IGb08 from epoch 2005.00 applying station velocities were converted to epoch 2011.9 which is epoch for LatPos GNSS measurements for validation. For GNSS vectors calculation took 15 days period before and after 10th of November in year 2011. IGS precise orbits and station coordinates were used from http://igscb.jpl.nasa.gov/ web page. For applying independent vectors in LatPos network every single day was calculated separate vectors scheme, which not cover all LatPos stations. After that separate 3 day solutions were combined in three-day solution and processed 10 times.

As a result, 10 three-day solutions for calculation period were achieved in totally independent vector scheme and for check made common data adjustment for one month solution. Differences between solutions see in Table 2.

Table 2. Differences between mean of ten solutions and month solution

LatPos station name	Differences X (m)	Differences Y (m)	Differences Z (m)
ALUKSNE	–0.000033	–0.000021	–0.000073
BALVI	–0.000042	–0.000024	–0.000056
BAUSKA	–0.000001	–0.000022	–0.000023
DAGDA	–0.000042	–0.000038	–0.000027
DAUGAVPILS1	–0.000040	–0.000028	–0.000029
DOBELE1	0.000071	0.000046	0.000163
IRBENE	–0.000087	–0.000019	–0.000027
JEKABPILS1	0.000241	0.000138	0.000370
KULDIGA1	–0.000388	–0.000057	–0.000274
LIELVARDE	–0.000119	–0.000052	–0.000085
LIEPAJA1	–0.000021	–0.000039	–0.000053
LIMBAZI	–0.000094	–0.000050	–0.000036
LODE	0.000028	0.000041	0.000057
MADONA	–0.000039	–0.000022	–0.000021
MAZSALACA	–0.000128	0.000104	–0.000083
OJARS	–0.000064	–0.000008	–0.000014
PALSMANE	–0.000022	–0.000017	–0.000069
PREILI	0.000009	0.000016	0.000014
REZEKNE1	0.000001	–0.000026	–0.000015
SALDUS1	–0.000051	0.000075	0.000035
SIGULDA	0.000012	0.000008	0.000113
TALSI	–0.000205	0.000021	–0.000026
VALMIERA1	0,000614	0.000376	0.000764

Common month solution was select for transformation from ITRF2008 epoch 2011.9 to ITRF2008 epoch 2000 using IGS station Riga velocity for all LatPos stations according to the guidelines in [3]. Transformation parameters from http://itrf.ensg.ign.fr/doc_ITRF/Transfo-ITRF2008_ITRFs.txt web page were used for transformation from ITRF2008 epoch 2000 to ITRF2000 epoch 2000 see Table 3.

Table 3. Transformation parameters from ITRF2008 to ITRF2000

Solution epoch	TX Tx mm/y	TY Ty mm/y	TZ Tz mm/y	D D ppb/y	RX Rx 0.001″/y	RY Ry 0.001″/y	RZ Rz 0.001″/y
ITRF2000 EPOCH 2000	–1.9	–1.7	–10.5	1.34	0.00	0.00	0.00
Rate	0.1	0.1	–1.8	0.08	0.00	0.00	0.00

1.3. Second approach for coordinate calculation

Second approach used nine IGS reference station set:
- Kuressaare, Estonia;
- Mendeleevo, Russian Federation;
- Redzikowo, Poland;
- Riga, Latvia;
- Tallinn, Estonia;
- Suwalki, Poland;
- Tõravere, Estonia;
- Visby, Sweden;
- Vilnius, Lithuania.

For the GNSS coordinate determination solution Bernese GPS software version V5.0 was used. IGS/EPN reference station coordinates and velocity vectors of IGS08 coordinate realisation system were used, IGS precise GNSS orbits, ionosphere and troposphere models, TEC data and ERP parameters were applied. Coordinate calculation was performed for the time period from day 299 to day 329, year 2011. For GNSS vector calculation OBS-MAX strategy was applied. The calculated daily solution results were reduced to the epoch 1989.00 and transformed to ETRS89 using Bernese GPS software. Average coordinate values from the ETRS89 daily solutions were obtained and then transformed to ITRF2000 and extrapolated to the epoch 2000.00 according to the guidelines in [3]. Transformation scheme is show in Table 4. [4] web page was used for the transformation to ITRF2000.

Table 4. Transformation scheme of second solution

System	Epoch	Solution type
IGS08	Year 2011, day 299 – day 329	Daily
IGS08	1989.00	Daily
ETRS89	1989.00	Average
ITRF2000	1989.00	Average
ITRF2000	2000.00	Average

1.4. Transformation parameters from LKS-92 to ITRF2000

Maximum difference between both approaches is 4 cm in Z value and it is acceptable for purpose of research. Average value of each LatPos station was used for calculation of transformation parameters from LKS-92 to ITRF2000 epoch 2000 according to [5]. ITRF2000 epoch 2000 is validly used as geospatial reference in aeronautical community for data publication. Accuracy of transformation parameters is in order of 5 mm. Transformation parameters see Table 5.

Table 5. Transformation parameters from LKS-92 to ITRF2000

Parameters	T_X (m)	T_Y (m)	T_Z (m)	D (m)	R_X (m)	R_Y (m)	R_Z (m)
	–0.64229104	0.11205432	0.201306011	$1.93378E^{-08}$	$-3.24476E-^{09}$	$5.35202E^{-08}$	-3.1384^{E-08}

2. Conclusion

Transformation parameters accuracy between LKS-92 and ITRF2000 epoch are at the millimeter level. Results of both approaches can be used for transformation of geospatial data to ITRF2000 epoch 2000 before publication for aeronautical purpose. Also current aeronautical data base with geospatial data in LKS-92 can be transformed.

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