ROYAL OBSERVATORY OF BELGIUM

The EPN CB Coordinate Transformation Tool

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EUREF Tutorial
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San Sebastian, Spain

EPN CB: www.epncb.oma.be

ROYAL OBSERVATORY OF BELGIUM

EUREF Permanent GNSS Network

ROYAL OBSERVATORY OF BELGIUM

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- Position time series
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Welcome !

EUREF Permanent GNSS N

The European Terrestrial Reference System 89 (ETR
coordinate system throughout Europe. Supported b
EU, this reference system forms the backbone for all geographic and geodynamic projects on the European territory both on a national as on an international level.

The ETRS89 is maintained by the IAG sub-commission EUREF and it is accessed through the EUREF Permanent GNSS Network (EPN), a science-driven network of

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Last Updated/New Pages

2016-04-14 : Official ITRF2014 coordinates/velocities issued by the IERS added to the individual

ETRF/ITRF Transformation

ROYAL OBSERVATORY OF BELGIUM

The following tool allows to transform coordinates (position and velocity) from any ETRFxx to any ITRFyy (or ITRFyy to ETRFxx). In case input and output coordinates are requested at different epochs, then station velocities are mandatory.

Input

Frame : ETRF89

Epoch : 2000 . 00

```
# Lines starting by # are treated as comments
# Fields (in decimal format) should be separated by at least one space
#
# --> Example without velocity - StationName(no space character) X[m] Y[m] Z[m] :
StationName 4027894.006 307045.600 4919474.910
#
# --> Example with velocity - StationName(no space character) X[m] Y[m] Z[m] VX[m/yr] VY[m/yr] VZ[m/yr] :
StationName 4027894.006 307045.600 4919474.910 0.01 0.2 0.03
```

Output

Frame : ETRF89

Epoch : 2000 . 00

Home / Products & Serv

ETRF/ITRF

ETRS89

ETRF89, ETRF90, ETRF91, ETRF92, ETRF93, ETRF94, ETRF96, ETRF97, ETRF2000

ITRS

ITRF88, ITRF89, ITRF90, ITRF91, ITRF92, ITRF93, ITRF94, ITRF96, ITRF97, ITRF2000, ITRF2005, ITRF2008, ITRF2014

The following tool allows ... Fxx to any ITRFyy (or ITRFyy to ETRFxx). In ca... epochs, then station velocities are mandatory.

Input

Frame : ETRF89

Epoch : 2000 . 00

1980 → 2018

```
# Lines starting by # are treated as comments
# Fields (in decimal format) should be separated by at least one space
#
# --> Example without velocity - StationName(no space character) X[m] Y[m] Z[m] :
StationName 4027894.006 307045.600 4919474.910
#
# --> Example with velocity - StationName(no space character) X[m] Y[m] Z[m] VX[m/yr] VY[m/yr] VZ[m/yr] :
StationName 4027894.006 307045.600 4919474.910 0.01 0.2 0.03
```

Output

Frame : ETRF89

Epoch : 2000 . 00

ROYAL OBSERVATORY OF BELGIUM

ETRF/ITRF Transformation

ROYAL OBSERVATORY OF BELGIUM

The following tool allows to transform coordinates (position and velocity) from any ETRFxx to any ITRFyy (or ITRFyy to ETRFxx). In case input and output coordinates are requested at different epochs, then station velocities are mandatory.

Input

Frame : ETRF89

Epoch : 2000 . 00

```
# Lines starting by # are treated as comments
# Fields (in decimal format) should be separated by at least one space
#
# --> Example without velocity - StationName(no space character) X[m] Y[m] Z[m] :
StationName 4027894.006 307045.600 4919474.910
#
# --> Example with velocity - StationName(no space character) X[m] Y[m] Z[m] VX[m/yr] VY[m/yr] VZ[m/yr] :
StationName 4027894.006 307045.600 4919474.910 0.01 0.2 0.03
```

Output

Frame : ETRF89

Epoch : 2000 . 00

ETRF/ITRF Transformation

ROYAL OBSERVATORY OF BELGIUM

The following tool allows to transform coordinates (position and velocity) from any ETRFxx to any ITRFyy (or ITRFyy to ETRFxx). In case input and output coordinates are requested at different epochs, then station velocities are mandatory.

Input

Frame : ETRF89

Epoch : 2000 . 00

```
# Lines starting by # are treated as comments
# Fields (in decimal format) should be separated by at least one space
#
# --> Example without velocity - StationName(no space character) X[m] Y[m] Z[m] :
StationName 4027894.006 307045.600 4919474.910
#
# --> Example with velocity - StationName(no space character) X[m] Y[m] Z[m] VX[m/yr] VY[m/yr] VZ[m/yr] :
StationName 4027894.006 307045.600 4919474.910 0.01 0.2 0.03
```

Output

Frame : ETRF89

Epoch : 2000 . 00

Examples

1)	CRD:	ITRF2005 (2007,0)	→	ITRF91 (2007,0)
2)	CRD:	ITRF2005 (2007,0)	→	ITRF91 (1999,0)
3)	CRD+VEL:	ITRF2005 (2007,0)	→	ITRF91 (1999,0)
4)	CRD:	ITRF2000 (2012,0)	→	ETRF2000 (2012,0)
5)	CRD:	ITRF2014 (2012,0)	→	ETRF2000 (2012,0)
6)	CRD+VEL:	ITRF2014 (2012,0)	→	ETRF2000 (2001,0)
7)	CRD:	ETRF2000 (2008,0)	→	ETRF96 (2008,0)
8)	CRD+VEL:	ETRF2000 (2008,0)	→	ETRF96 (2001,0)

ROYAL OBSERVATORY OF BELGIUM

EX1: ITRF2005 (2007,0) → ITRF91 (2007,0)

ROYAL OBSERVATORY OF BELGIUM

Input

Frame : ITRF2005

Epoch : 2007 . 00

```
TTTTTTT 4027894.006 307045.600 4919474.910
```

Output

Frame : ITRF91

Epoch : 2007 . 00

Options

☑ show intermediate steps

Change epoch format: Decimal Year: YYYY.DDD

Transform

EX1: ITRF2005 (2007,0) → ITRF91 (2007,0)

ROYAL OBSERVATORY OF BELGIUM

Output

Frame : ITRF91

Epoch : 2007 . 00

```
TTTTTTT 4027894.04440  307045.62090 4919474.86130
```

Options

☑ show intermediate steps

Change epoch format: Decimal Year: YYYY.DDD

Transform

The table below shows the different transformation steps that were performed to go from the input coordinates to the requested output coordinates.

Intermediate steps

MarkerName	Frame	Epoch	X	Y	Z	V_X	V_Y	V_Z
TTTTTTT	ITRF2005	2007.0	4027894.0060	307045.6000	4919474.9100			
TTTTTTT	ITRF2000	2007.0	4027894.0086	307045.6002	4919474.8963			
TTTTTTT	ITRF91	2007.0	4027894.0444	307045.6209	4919474.8613			

CRD: ITRFyy(t) → ITRFzz(t)

ITRFyy(t) → ITRFzz(t)

$$X_{ITRFzz}(t) = X_{ITRFyy}(t) + T(t) + D(t).X_{ITRFyy}(t) + R(t).X_{ITRFyy}(t)$$

Translation vector $T(t) = \begin{bmatrix} T_1(t) \\ T_2(t) \\ T_3(t) \end{bmatrix}$

Scale $D(t)$

Rotation matrix $R(t) = \begin{bmatrix} 0 & -R_3(t) & R_2(t) \\ R_3(t) & 0 & -R_1(t) \\ -R_2(t) & R_1(t) & 0 \end{bmatrix}$

http://itrf.ign.fr/rel_trs.php

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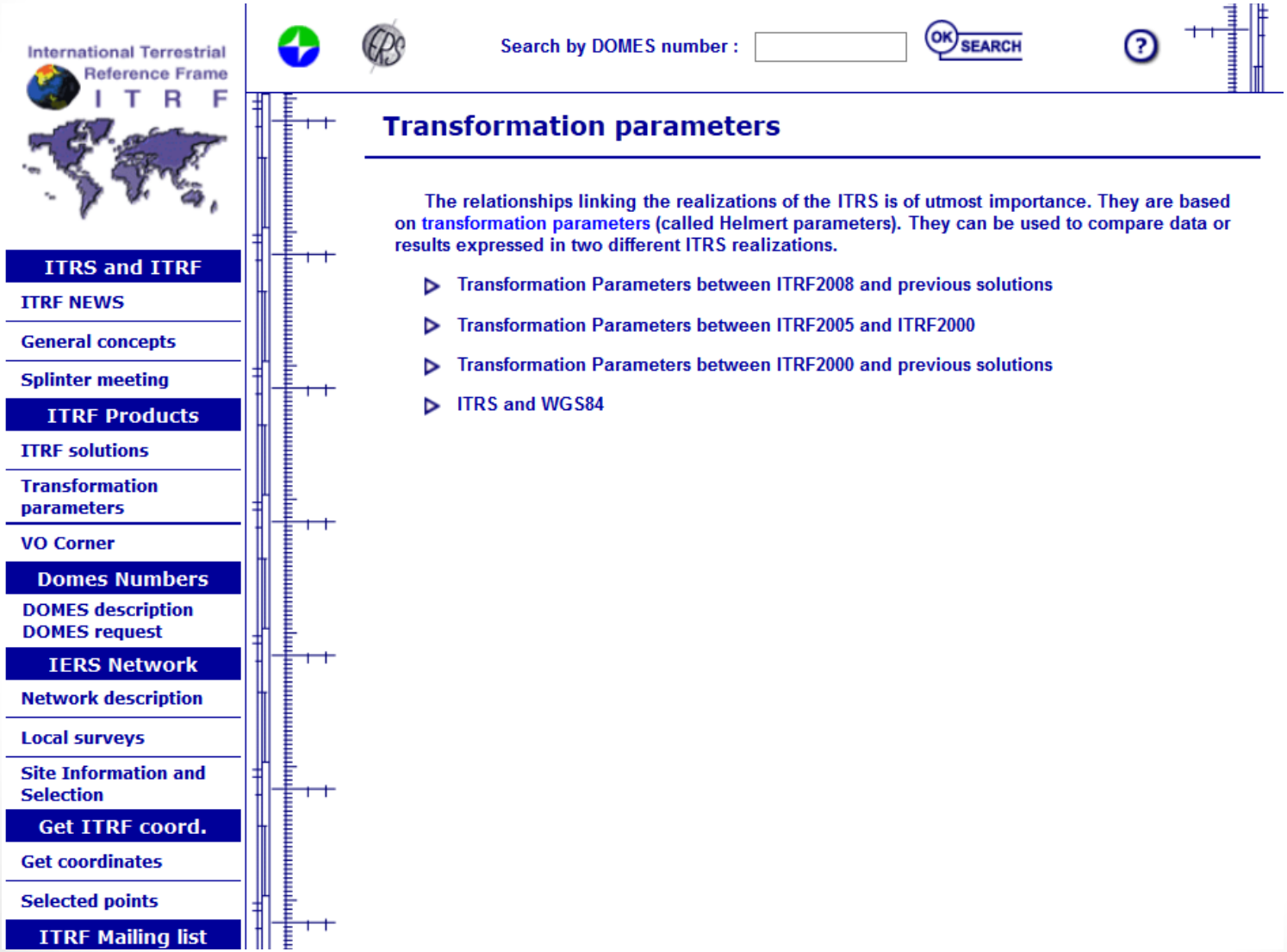
http://itrf.ign.fr/trans_para.php



ITRF web site

From-To	ITRF88	ITRF89	ITRF90	ITRF91	ITRF92	ITRF93	ITRF94	ITRF96	ITRF97	ITRF2000	ITRF2005	ITRF2008	ITRF2014
ITRF88	X									X		X	
ITRF89		X								X		X	
ITRF90			X							X		X	
ITRF91				X						X		X	
ITRF92					X					X		X	
ITRF93						X				X		X	
ITRF94							X			X		X	
ITRF96								X		X		X	
ITRF97									X	X		X	
ITRF2000	X	X	X	X	X	X	X	X	X	X	X	X	
ITRF2005										X	X	X	
ITRF2008	X	X	X	X	X	X	X	X	X	X	X	X	X
ITRF2014												X	X

Example ITRF2005 → ITRF91 :

ITRF2005 → ITRF2000

ITRF2000 → ITRF91

ROYAL OBSERVATORY OF BELGIUM

ITRF web site

From-To	ITRF88	ITRF89	ITRF90	ITRF91	ITRF92	ITRF93	ITRF94	ITRF96	ITRF97	ITRF2000	ITRF2005	ITRF2008	ITRF2014
ITRF88	X									X		X	
ITRF89		X								X		X	
ITRF90			X							X		X	
ITRF91				X						X		X	
ITRF92					X					X		X	
ITRF93						X				X		X	
ITRF94							X			X		X	
ITRF96								X		X		X	
ITRF97									X	X		X	
ITRF2000	X	X	X	X	X	X	X	X	X	X	X	X	
ITRF2005										X	X	X	
ITRF2008	X	X	X	X	X	X	X	X	X	X	X	X	X
ITRF2014												X	X

Example ITRF2005 → ITRF91 :

ITRF2005 → ITRF2000

ITRF2000 → ITRF91

ROYAL OBSERVATORY OF BELGIUM

ITRF web site

Transformation Parameters between ITRF2005 and ITRF2000

14 transformation parameters between ITRF2005 and ITRF2000 have been estimated and listed in Table 1, using 70 stations listed in Table 2 and located at sites shown on Figure 2.

	T1 mm	T2 mm	T3 mm	D 10-9	R1 mas	R2 mas	R3 mas
	0.1	-0.8	-5.8	0.40	0.000	0.000	0.000
+/-	0.3	0.3	0.3	0.05	0.012	0.012	0.012
Rates	-0.2	0.1	-1.8	0.08	0.000	0.000	0.000
+/-	0.3	0.3	0.3	0.05	0.012	0.012	0.012

Table 1: Transformation parameters at epoch 2000.0 and their rates from ITRF2005 to ITRF2000 (ITRF2000 *minus* ITRF2005)

mm → m
X 1000

$x10^{-9}$

mas → radians
$x \frac{0,001}{3600} . \frac{\pi}{180}$

1) conversion from milliarc second to arc second: x 0,001
2) conversion from arc second to degrees : /3600
3) conversion from degrees to radians : x 2π/360

ROYAL OBSERVATORY OF BELGIUM

ITRF2005→ ITRF2000 web site

Transformation Parameters between ITRF2005 and ITRF2000

14 transformation parameters between ITRF2005 and ITRF2000 have been estimated and listed in Table 1, using 70 stations listed in Table 2 and located at sites shown on Figure 2.

	T1 mm	T2 mm	T3 mm	D 10-9	R1 mas	R2 mas	R3 mas
	0.1	-0.8	-5.8	0.40	0.000	0.000	0.000
+/-	0.3	0.3	0.3	0.05	0.012	0.012	0.012
Rates	-0.2	0.1	-1.8	0.08	0.000	0.000	0.000
+/-	0.3	0.3	0.3	0.05	0.012	0.012	0.012

Table 1: Transformation parameters at epoch 2000.0 and their rates from ITRF2005 to ITRF2000 (ITRF2000 *minus* ITRF2005)

Use rates to express each parameter at the requested epoch (t=2007,0):

$$P(2007,0) = P(2000,0) + \dot{P}(2007,0 - 2000,0)$$

ROYAL OBSERVATORY OF BELGIUM

ITRF web site

From-To	ITRF88	ITRF89	ITRF90	ITRF91	ITRF92	ITRF93	ITRF94	ITRF96	ITRF97	ITRF2000	ITRF2005	ITRF2008	ITRF2014
ITRF88	X									X		X	
ITRF89		X								X		X	
ITRF90			X							X		X	
ITRF91				X						X		X	
ITRF92					X					X		X	
ITRF93						X				X		X	
ITRF94							X			X		X	
ITRF96								X		X		X	
ITRF97									X	X		X	
ITRF2000	X	X	X	X	X	X	X	X	X	X	X	X	
ITRF2005										X	X	X	
ITRF2008	X	X	X	X	X	X	X	X	X	X	X	X	X
ITRF2014												X	X

Example ITRF2005 → ITRF91 :

ITRF2005 → ITRF2000

ITRF2000 → ITRF91

ITRF2000→ ITRF91 web site

TRANSFORMATION PARAMETERS AND THEIR RATES FROM ITRF2000 TO PREVIOUS FRAMES
(See Note Below)

SOLN	T1 cm	T2 cm	T3 cm	D ppb	R1 .001"	R2 .001"	R3 .001"	EPOCH	Ref. IERS Tech. Note #
------>	T1 cm/y	T2 cm/y	T3 cm/y	D ppb/y	R1 .001"/y	R2 .001"/y	R3 .001"/y		
ITRF97	0.67	0.61	-1.85	1.55	0.00	0.00	0.00	199	
rates	0.00	-0.06	-0.14	0.01	0.00	0.00	0.02		
ITRF96	0.67	0.61	-1.85	1.55	0.00	0.00	0.00		
rates	0.00	-0.06	-0.14	0.01	0.00	0.00	0.02		
ITRF94	0.67	0.61	-1.85	1.55	0.00	0.00	0.00	19	
rates	0.00	-0.06	-0.14	0.01	0.00	0.00	0.02		
ITRF93	1.27	0.65	-2.09	1.95	-0.39	0.80	-1.14	1988	
rates	-0.29	-0.02	-0.06	0.01	-0.11	-0.19	0.07		
ITRF92	1.47	1.35	-1.39	0.75	0.00	0.00	-0.18	1988.0	
rates	0.00	-0.06	-0.14	0.01	0.00	0.00	0.02		
ITRF91	2.67	2.75	-1.99	2.15	0.00	0.00	-0.18	1988.0	
rates	0.00	-0.06	-0.14	0.01	0.00	0.00	0.02		
ITRF90	2.47	2.35	-3.59	2.45	0.00	0.00	-0.18	1988.0	9
rates	0.00	-0.06	-0.14	0.01	0.00	0.00	0.02		
ITRF89	2.97	4.75	-7.39	5.85	0.00	0.00	-0.18	1988.0	6
rates	0.00	-0.06	-0.14	0.01	0.00	0.00	0.02		
ITRF88	2.47	1.15	-9.79	8.95	0.10	0.00	-0.18	1988.0	IERS An. Rep. for 1988
rates	0.00	-0.06	-0.14	0.01	0.00	0.00	0.02		

Careful with units:
Convert to SI

Careful with reference epoch of parameters:
Express parameter at requested epoch using the rate

Note : These parameters are derived from those already published in the IERS Technical Notes indicated in the table above. The transformation parameters should be used with the standard model (1) given below and are valid at the indicated epoch.

: XS : : X : : T1 : : D -R3 R2 : : X :

ROYAL OBSERVATORY OF BELGIUM

Output

Frame : ITRF91

Epoch : 2007 . 00

```
TTTTTTT 4027894.04440  307045.62090 4919474.86130
```

Options

☑ show intermediate steps

Change epoch format: Decimal Year: YYYY.DDD

Transform

The table below shows the different transformation steps that were performed to go from the input coordinates to the requested output coordinates.

Intermediate steps

MarkerName	Frame	Epoch	X	Y	Z
TTTTTTT	ITRF2005	2007.0	4027894.0060	307045.6000	4919474.9100
TTTTTTT	ITRF2000	2007.0	4027894.0086	307045.6002	4919474.8963
TTTTTTT	ITRF91	2007.0	4027894.0444	307045.6209	4919474.8613

Examples

1)	CRD:	ITRF2005 (2007,0)	→	ITRF91 (2007,0)
2)	CRD:	ITRF2005 (2007,0)	→	ITRF91 (1999,0)
3)	CRD+VEL:	ITRF2005 (2007,0)	→	ITRF91 (1999,0)
4)	CRD:	ITRF2000 (2012,0)	→	ETRF2000 (2012,0)
5)	CRD:	ITRF2014 (2012,0)	→	ETRF2000 (2012,0)
6)	CRD+VEL:	ITRF2014 (2012,0)	→	ETRF2000 (2001,0)
7)	CRD:	ETRF2000 (2008,0)	→	ETRF96 (2008,0)
8)	CRD+VEL:	ETRF2000 (2008,0)	→	ETRF96 (2001,0)

ROYAL OBSERVATORY OF BELGIUM

EX2: ITRF2005 (2007,0) → ITRF91 (1999,0)

ROYAL OBSERVATORY OF BELGIUM

Input

Frame : ITRF2005

Epoch : 2007 . 00

```
ITIIIII 4027894.006 307045.600 4919474.910
```

Output

Frame : ITRF91

Epoch : 1999 . 00

EX2: ITRF2005 (2007,0) → ITRF91 (1999,0)

ROYAL OBSERVATORY OF BELGIUM

Input

Frame : ITRF2005

Epoch : 2007 . 00

```
ITTTTTT 4027894.006 307045.600 4919474.910
```

Incorrect number of fields at line 2 (different input and output epochs requires velocity information)

Output

Frame : ITRF91

Epoch : 1999 . 00

Examples

1)	CRD:	ITRF2005 (2007,0)	→	ITRF91 (2007,0)
~~2)~~	~~CRD:~~	~~ITRF2005 (2007,0)~~	~~→~~	~~ITRF91 (1999,0)~~
3)	CRD+VEL:	ITRF2005 (2007,0)	→	ITRF91 (1999,0)
4)	CRD:	ITRF2000 (2012,0)	→	ETRF2000 (2012,0)
5)	CRD:	ITRF2014 (2012,0)	→	ETRF2000 (2012,0)
6)	CRD+VEL:	ITRF2014 (2012,0)	→	ETRF2000 (2001,0)
7)	CRD:	ETRF2000 (2008,0)	→	ETRF96 (2008,0)
8)	CRD+VEL:	ETRF2000 (2008,0)	→	ETRF96 (2001,0)

ROYAL OBSERVATORY OF BELGIUM

CRD+VEL: ITRFyy(t) → ITRFzz(t)

ROYAL OBSERVATORY OF BELGIUM

ITRFyy(t) → ITRFzz(t)

Position:

$$X_{ITRFzz}(t) = X_{ITRFyy}(t) + T(t) + D(t).X_{ITRFyy}(t) + R(t).X_{ITRFyy}(t)$$

Velocity:

$$V_{ITRFzz} = V_{ITRFyy} + \dot{T} + \dot{D}.X_{ITRFyy} + \dot{R}.X_{ITRFyy}$$

http://itrf.ign.fr/rel_trs.php

EX3: ITRF2005 (2007,0) → ITRF91 (1999,0)

ROYAL OBSERVATORY OF BELGIUM

Input

Frame : ITRF2005

Epoch : 2007 . 00

```
EXAMPLE3 4027894.006 307045.600 4919474.910 0.01 0.2 0.03
```

Velocity is mandatory

Output

Frame : ITRF91

Epoch : 1999 . 00

Options

☐ show intermediate steps

Change epoch format: Decimal Year: YYYY.DDD

Transform

EX3: ITRF2005 (2007,0) → ITRF91 (1999,0)

ROYAL OBSERVATORY OF BELGIUM

Output

Frame : ITRF91

Epoch : 1999 . 00

```
TTTTTTT 4027893.96330  307044.02160 4919474.64340  0.01013  0.19992  0.02724
```

Options

☑ show intermediate steps Change epoch format: Decimal Year: YYYY.DDD

In step 1-3, positions and velocities are transformed ITRFyy(t)→ITRFzz(t).
In step 4, the velocities are used to express the positions at the correct epoch.

$$X(t_2) = X(t_1) + \quad V.\ (t_2 - t_1)$$

Intermediate steps

MarkerName	Frame	Epoch	X	Y	Z	V_X	V_Y	V_Z
TTTTTTT	ITRF2005	2007.0	4027894.0060	307045.6000	4919474.9100	0.010000	0.200000	0.030000
TTTTTTT	ITRF2000	2007.0	4027894.0086	307045.6002	4919474.8963	0.010122	0.200125	0.028594
TTTTTTT	ITRF91	2007.0	4027894.0444	307045.6209	4919474.8613	0.010133	0.199918	0.027243
TTTTTTT	ITRF91	1999.0	4027893.9633	307044.0216	4919474.6434	0.010133	0.199918	0.027243

Reverse Coordinate Transformation

$X_1 \rightarrow X_2$

$V_1 \rightarrow V_2$

with

T, D, R

$\dot{T}, \dot{D}, \dot{R}$

$X_2 \rightarrow X_1$?

$V_2 \rightarrow V_1$?

with

$-T, -D, -R$

$-\dot{T}, -\dot{D}, -\dot{R}$

ROYAL OBSERVATORY OF BELGIUM

Examples

1)	CRD:	ITRF2005 (2007,0)	→	ITRF91 (2007,0)
~~2)~~	~~CRD:~~	~~ITRF2005 (2007,0)~~	~~→~~	~~ITRF91 (1999,0)~~
3)	CRD+VEL:	ITRF2005 (2007,0)	→	ITRF91 (1999,0)
4)	CRD:	ITRF2000 (2012,0)	→	ETRF2000 (2012,0)
5)	CRD:	ITRF2014 (2012,0)	→	ETRF2000 (2012,0)
6)	CRD+VEL:	ITRF2014 (2012,0)	→	ETRF2000 (2001,0)
7)	CRD:	ETRF2000 (2008,0)	→	ETRF96 (2008,0)
8)	CRD+VEL:	ETRF2000 (2008,0)	→	ETRF96 (2001,0)

ROYAL OBSERVATORY OF BELGIUM

ITRFyy (t) → ETRFyy (t)

Memo Boucher & Altamimi:
http://etrs89.ensg.ign.fr/memo-V8.pdf

Position :

$$X_{ETRFyy}(t) = X_{ITRFyy}(t) + T_{yy} + \dot{R}_{yy}.X_{ITRFyy}(t).(t - 1989)$$

Velocity :

$$V_{ETRFyy} = V_{ITRFyy} + \dot{R}_{yy}.X_{ITRFyy}(t)$$

T_{yy} → Table 3 of Appendix 3 (case A) *(unit: cm → m)*

$$\dot{R}_{yy} = \begin{bmatrix} 0 & -\dot{R}_3 & \dot{R}_2 \\ \dot{R}_3 & 0 & -\dot{R}_1 \\ -\dot{R}_2 & \dot{R}_1 & 0 \end{bmatrix}$$ → Table 4 of Appendix 3

(unit: mas/yr → rad/yr)

ROYAL OBSERVATORY OF BELGIUM

Table 3: Estimation of T_{YY}

YY		T1 cm	T2 cm	T3 cm
89		0	0	0
90	A	1.9	2.8	-2.3
	B	2.6	2.5	-2.6
	±	0.7	0.7	0.7
91	A	2.1	2.5	-3.7
	B	2.3	2.1	-3.1
	±	0.7	0.7	0.7
92	A	3.8	4.0	-3.7
	B	4.3	3.4	-3.2
	±	0.8	0.8	0.8
93	A	1.9	5.3	-2.1
	B	1.0	5.9	-1.4
	±	0.5	0.5	0.6
94	A	4.1	4.1	-4.9
	B	2.9	4.3	-3.6
	±	0.4	0.5	0.5
96	A	4.1	4.1	-4.9
	B	3.9	4.1	-3.9
	±	0.4	0.4	0.4
97	A	4.1	4.1	-4.9
	B	3.4	4.4	-4.3
	±	0.4	0.4	0.4
00	A	5.4	5.1	-4.8
	B	4.2	5.1	-4.6
	±	0.4	0.4	0.4
05*	A	5.6	4.8	-3.7
	B	3.6	4.2	-4.1
	±	0.4	0.4	4

Table 3 : (cont'd)

* See TWG rec… §4

Constant parameters
(no reference epoch)

Careful with units:
Convert to SI

Table 4: Estimation of $\dot{R}_{YY}$

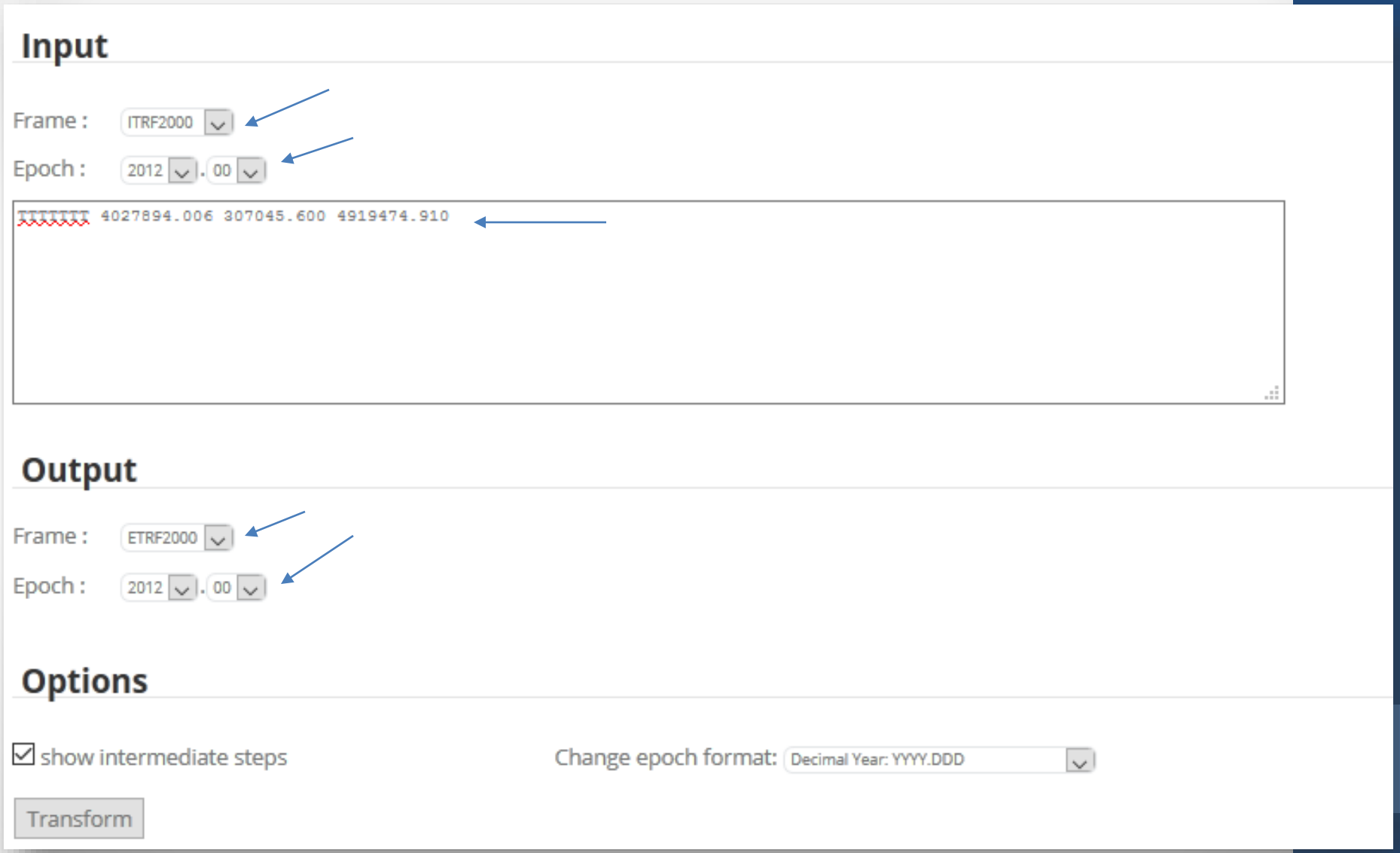
YY	$\dot{R}1$ mas/y	$\dot{R}2$ mas/y	$\dot{R}3$ mas/y
89	0.11	0.57	-0.71
90	0.11	0.57	-0.71
91	0.21	0.52	-0.68
92	0.21	0.52	-0.68
93	0.32	0.78	-0.67
94	0.20	0.50	-0.65
96	0.20	0.50	-0.65
97	0.20	0.50	-0.65
00	0.081	0.490	-0.792
	±0.021	±0.008	±0.026
05*	0.054	0.518	-0.781
	±0.009	±0.006	±0.011

* See TWG recommendation §4

ROYAL OBSERVATORY OF BELGIUM

EX4: ITRF2000 (2012,0) → ETRF2000 (2012,0)

ROYAL OBSERVATORY OF BELGIUM



EX4: ITRF2000 (2012,0) → ETRF2000 (2012,0)

ROYAL OBSERVATORY OF BELGIUM

Output

Frame : ETRF2000

Epoch : 2012 . 00

```
TTTTTTT 4027894.35590  307045.25080 4919474.64470
```

Options

☑ show intermediate steps

Change epoch format: Decimal Year: YYYY.DDD

Transform

The table below shows the different transformation steps that were performed to go from the input coordinates to the requested output coordinates.

Intermediate steps

MarkerName	Frame	Epoch	X	Y	Z	V_X	V_Y	V_Z
TTTTTTT	ITRF2000	2012.0	4027894.0060	307045.6000	4919474.9100			
TTTTTTT	ETRF2000	2012.0	4027894.3559	307045.2508	4919474.6447			

Examples

1)	CRD:	ITRF2005 (2007,0)	→	ITRF91 (2007,0)
~~2)~~	~~CRD:~~	~~ITRF2005 (2007,0)~~	~~→~~	~~ITRF91 (1999,0)~~
3)	CRD+VEL:	ITRF2005 (2007,0)	→	ITRF91 (1999,0)
4)	CRD:	ITRF2000 (2012,0)	→	ETRF2000 (2012,0)
5)	CRD:	ITRF2014 (2012,0)	→	ETRF2000 (2012,0)
6)	CRD+VEL:	ITRF2014 (2012,0)	→	ETRF2000 (2001,0)
7)	CRD:	ETRF2000 (2008,0)	→	ETRF96 (2008,0)
8)	CRD+VEL:	ETRF2000 (2008,0)	→	ETRF96 (2001,0)

ROYAL OBSERVATORY OF BELGIUM

EX5: ITRF2014 (2012,0) → ETRF2000 (2012,0)

We know

- ITRFyy(t) → ITRFzz(t)
- ITRFzz(t) → ETRFzz(t)

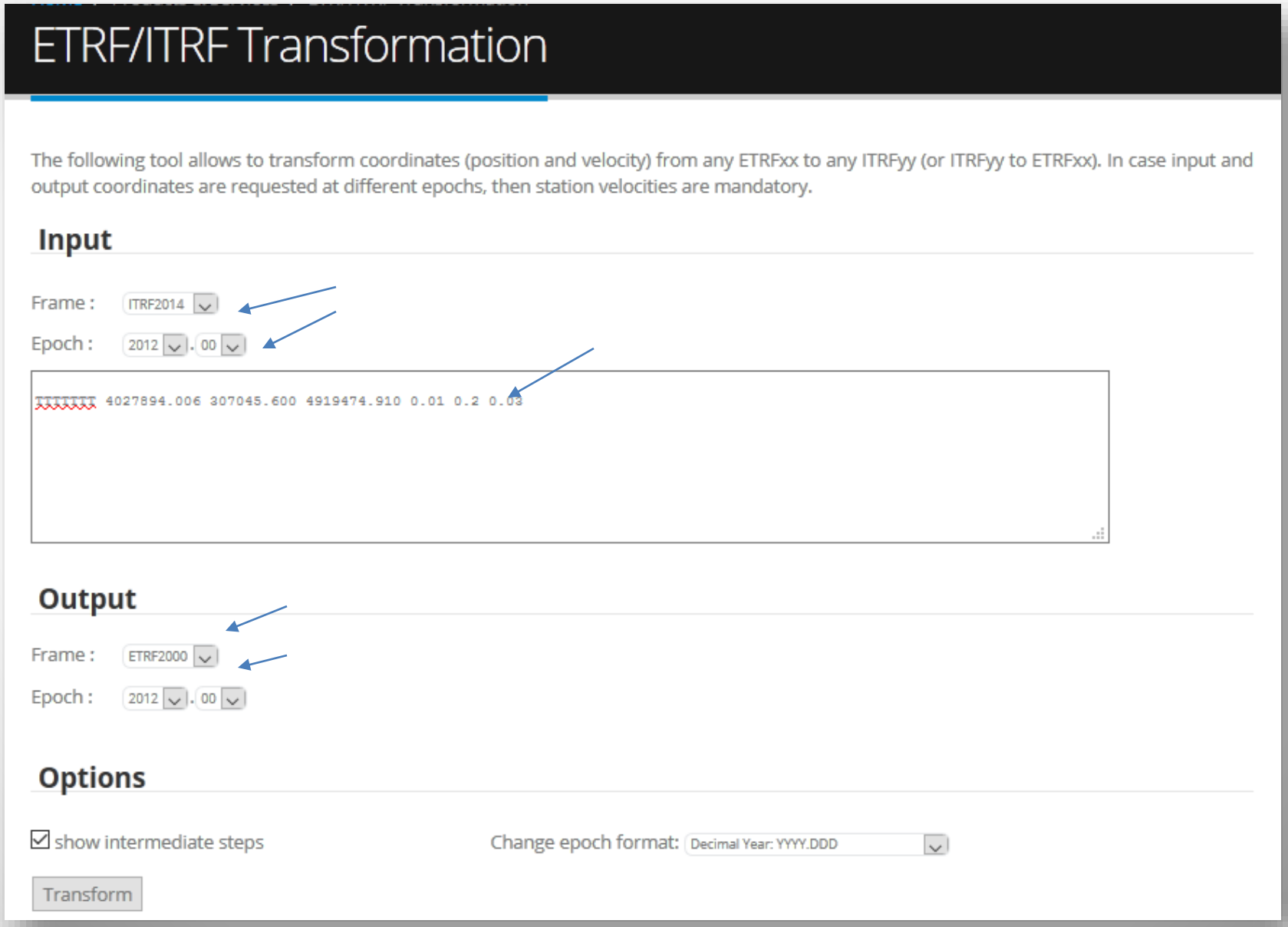
Step 1) ITRF2014(t) → ITRF2000(t)

can have sub-steps

Step 2) ITRF2000(t) → ETRF2000(t)

ROYAL OBSERVATORY OF BELGIUM

EX5: ITRF2014 (2012,0) → ETRF2000 (2012,0)



ROYAL OBSERVATORY OF BELGIUM

EX5: ITRF2014 (2012,0) → ETRF2000 (2012,0)

ROYAL OBSERVATORY OF BELGIUM

Output

Frame : ETRF2000

Epoch : 2012 . 00

```
TTTTTTT 4027894.36620  307045.25300 4919474.62630  0.02341  0.18274  0.01919
```

Velocities are optional!

Options

☑ show intermediate steps

Change epoch format: Decimal Year: YYYY.DDD

Transform

The table below shows the different transformation steps that were performed to go from the input coordinates to the requested output coordinates.

Intermediate steps

MarkerName	Frame	Epoch	X	Y	Z	V_X	V_Y	V_Z
TTTTTTT	ITRF2014	2012.0	4027894.0060	307045.6000	4919474.9100	0.010000	0.200000	0.030000
TTTTTTT	ITRF2008	2012.0	4027894.0078	307045.6019	4919474.9124	0.010121	0.200009	0.030048
TTTTTTT	ITRF2005	2012.0	4027894.0131	307045.6013	4919474.9123	0.010421	0.200009	0.030048
TTTTTTT	ITRF2000	2012.0	4027894.0163	307045.6021	4919474.8916	0.010543	0.200134	0.028641
TTTTTTT	ETRF2000	2012.0	4027894.3662	307045.2530	4919474.6263	0.023409	0.182736	0.019193

ITRF web site

From-To	ITRF88	ITRF89	ITRF90	ITRF91	ITRF92	ITRF93	ITRF94	ITRF96	ITRF97	ITRF2000	ITRF2005	ITRF2008	ITRF2014
ITRF88	X									X		X	
ITRF89		X								X		X	
ITRF90			X							X		X	
ITRF91				X						X		X	
ITRF92					X					X		X	
ITRF93						X				X		X	
ITRF94							X			X		X	
ITRF96								X		X		X	
ITRF97									X	X		X	
ITRF2000	X	X	X	X	X	X	X	X	X	X	X	X	
ITRF2005										X	X	X	
ITRF2008	X	X	X	X	X	X	X	X	X	X	X	X	X
ITRF2014												X	X

Example ITRF2014 → ITRF2000 :

ITRF2014 → ITRF2008
ITRF2008 → ITRF2005
ITRF2005 → ITRF2000

ROYAL OBSERVATORY OF BELGIUM

ITRF web site

From-To	ITRF88	ITRF89	ITRF90	ITRF91	ITRF92	ITRF93	ITRF94	ITRF96	ITRF97	ITRF2000	ITRF2005	ITRF2008	ITRF2014
ITRF88	X									X		X	
ITRF89		X								X		X	
ITRF90			X							X		X	
ITRF91				X						X		X	
ITRF92					X					X		X	
ITRF93						X				X		X	
ITRF94							X			X		X	
ITRF96								X		X		X	
ITRF97									X	X		X	
ITRF2000	X	X	X	X	X	X	X	X	X	X	X	X	
ITRF2005										X	X	X	
ITRF2008	X	X	X	X	X	X	X	X	X	X	X	X	X
ITRF2014												X	X

Example ITRF2014 → ITRF2000 :

ITRF2014 → ITRF2008
ITRF2008 → ITRF2005
ITRF2005 → ITRF2000

ROYAL OBSERVATORY OF BELGIUM

Examples

1)	CRD:	ITRF2005 (2007,0)	→	ITRF91 (2007,0)
~~2)~~	~~CRD:~~	~~ITRF2005 (2007,0)~~	~~→~~	~~ITRF91 (1999,0)~~
3)	CRD+VEL:	ITRF2005 (2007,0)	→	ITRF91 (1999,0)
4)	CRD:	ITRF2000 (2012,0)	→	ETRF2000 (2012,0)
5)	CRD:	ITRF2014 (2012,0)	→	ETRF2000 (2012,0)
6)	CRD+VEL:	ITRF2014 (2012,0)	→	ETRF2000 (2001,0)
7)	CRD:	ETRF2000 (2008,0)	→	ETRF96 (2008,0)
8)	CRD+VEL:	ETRF2000 (2008,0)	→	ETRF96 (2001,0)

ROYAL OBSERVATORY OF BELGIUM

EX6: ITRF2014 (2012,0) → ETRF2000 (2001,0)

We know

A. ITRF**yy**(t_1) → ITRF**zz**(t_1)

B. **I**TRFyy(t_1) → **E**TRFyy(t_1)

C. ETRFyy(t_1) → ETRFyy(t_2) *requires site velocity*

Step 1) ITRF**2014**(2012,0) → ITRF**2000**(2012,0) A.

can have sub-steps

Step 2) **I**TRF2000(2012,0) → **E**TRF2000(2012,0) B.

Step 3) ETRF2000(**2012,0**) → ETRF2000(**2001,0**) C.

ROYAL OBSERVATORY OF BELGIUM

EX6: ITRF2014 (2012,0) → ETRF2000 (2001,0)

The following tool allows to transform coordinates (position and velocity) from any ETRFxx to any ITRFyy (or ITRFyy to ETRFxx). requested at different epochs, then station velocities are mandatory.

Input

Frame : ITRF2014

Epoch : 2012 . 00

```
???????  4027894.006  307045.600  4919474.910  0.01  0.2  0.03
```

Velocity is mandatory

Output

Frame : ETRF2000

Epoch : 2001 . 00

Options

☑ show intermediate steps

Change epoch format: Decimal Year: YYYY.DDD

Transform

ROYAL OBSERVATORY OF BELGIUM

EX6: ITRF2014 (2012,0) → ETRF2000 (2001,0)

ROYAL OBSERVATORY OF BELGIUM

Output

Frame : ETRF2000

Epoch : 2001 . 00

```
TTTTTTT 4027894.10870  307043.24290 4919474.41520  0.02341  0.18274  0.01919
```

Options

☑ show intermediate steps Change epoch format: Decimal Year: YYYY.DDD

Transform

The table below shows the different transformation steps that were performed to go from the input coordinates to the requested output coordinates.

Intermediate steps

MarkerName	Frame	Epoch	X	Y	Z	V_X	V_Y	V_Z
TTTTTTT	ITRF2014	2012.0	4027894.0060	307045.6000	4919474.9100	0.010000	0.200000	0.030000
TTTTTTT	ITRF2008	2012.0	4027894.0078	307045.6019	4919474.9124	0.010121	0.200009	0.030048
TTTTTTT	ITRF2005	2012.0	4027894.0131	307045.6013	4919474.9123	0.010421	0.200009	0.030048
TTTTTTT	ITRF2000	2012.0	4027894.0163	307045.6021	4919474.8916	0.010543	0.200134	0.028641
TTTTTTT	ETRF2000	2012.0	4027894.3662	307045.2530	4919474.6263	0.023409	0.182736	0.019193
TTTTTTT	ETRF2000	2001.0	4027894.1087	307043.2429	4919474.4152	0.023409	0.182736	0.019193

Examples

1)	CRD:	ITRF2005 (2007,0)	→	ITRF91 (2007,0)
~~2)~~	~~CRD:~~	~~ITRF2005 (2007,0)~~	~~→~~	~~ITRF91 (1999,0)~~
3)	CRD+VEL:	ITRF2005 (2007,0)	→	ITRF91 (1999,0)
4)	CRD:	ITRF2000 (2012,0)	→	ETRF2000 (2012,0)
5)	CRD:	ITRF2014 (2012,0)	→	ETRF2000 (2012,0)
6)	CRD+VEL:	ITRF2014 (2012,0)	→	ETRF2000 (2001,0)
7)	CRD:	ETRF2000 (2008,0)	→	ETRF96 (2008,0)
8)	CRD+VEL:	ETRF2000 (2008,0)	→	ETRF96 (2001,0)

ROYAL OBSERVATORY OF BELGIUM

EX7: ETRF2000(2008,0) → ETRF96(2008,0)

We know

A. ITRFyy(t_1) → ITRFzz(t_1)

B. ITRFyy(t_1) → ETRFyy(t_1)

C. ETRFyy(t_1) → ETRFyy(t_2) *requires site velocity*

Step 1) ETRF2000(2008,0) → ITRF2000(2008,0) B. (reverse)

Step 2) ITRF2000(2008,0) → ITRF96(2008,0) A.

Step 3) ITRF96(2008,0) → ETRF96 (2008,0) B.

ROYAL OBSERVATORY OF BELGIUM

EX7: ETRF2000(2008,0) → ETRF96(2008,0)

ROYAL OBSERVATORY OF BELGIUM

The following tool allows to transform coordinates (position and velocity) from any ETRFxx to any ITRFyy (or ITRFyy to ETRFxx). In case input an output coordinates are requested at different epochs, then station velocities are mandatory.

Input

Frame : ETRF2000

Epoch : 2008 . 00

```
EXAMPLE7 4027894.006 307045.600 4919474.910
```

Output

Frame : ETRF96

Epoch : 2008 . 00

Options

☑ show intermediate steps

Change epoch format: Decimal Year: YYYY.DDD

Transform

EX7: ETRF2000(2008,0) → ETRF96(2008,0)

ROYAL OBSERVATORY OF BELGIUM

Output

Frame : ETRF96

Epoch : 2008 . 00

```
EXAMPLE7 4027894.00660  307045.59310 4919474.88290
```

Options

☑ show intermediate steps

Change epoch format: Decimal Year: YYYY.DDD

Transform

The table below shows the different transformation steps that were performed to go from the input coordinates to the requested output coordinates.

Intermediate steps

MarkerName	Frame	Epoch	X	Y	Z	V_X	V_Y	V_Z
EXAMPLE7	ETRF2000	2008.0	4027894.0060	307045.6000	4919474.9100			
EXAMPLE7	ITRF2000	2008.0	4027893.7076	307045.8796	4919475.1375			
EXAMPLE7	ITRF96	2008.0	4027893.7206	307045.8839	4919475.1118			
EXAMPLE7	ETRF96	2008.0	4027894.0066	307045.5931	4919474.8829			

Examples

1)	CRD:	ITRF2005 (2007,0)	→	ITRF91 (2007,0)
~~2)~~	~~CRD:~~	~~ITRF2005 (2007,0)~~	~~→~~	~~ITRF91 (1999,0)~~
3)	CRD+VEL:	ITRF2005 (2007,0)	→	ITRF91 (1999,0)
4)	CRD:	ITRF2000 (2012,0)	→	ETRF2000 (2012,0)
5)	CRD:	ITRF2014 (2012,0)	→	ETRF2000 (2012,0)
6)	CRD+VEL:	ITRF2014 (2012,0)	→	ETRF2000 (2001,0)
7)	CRD:	ETRF2000 (2008,0)	→	ETRF96 (2008,0)
8)	CRD+VEL:	ETRF2000 (2008,0)	→	ETRF96 (2001,0)

ROYAL OBSERVATORY OF BELGIUM

EX8: ETRF2000(2008,0) → ETRF96(2001,0)

We know

A. ITRFyy(t_1) → ITRFzz(t_1)

B. ITRFyy(t_1) → ETRFyy(t_1)

C. ETRFyy(t_1) → ETRFyy(t_2) *requires site velocity*

Step 1) ETRF2000(2008,0) → ITRF2000(2008,0) B. (reverse)

Step 2) ITRF2000(2008,0) → ITRF96(2008,0) A.

Step 3) ITRF96(2008,0) → ETRF96(2008,0) B.

Step 4) ETRF96 (2008,0) → ETRF96(2001,0) C.

ROYAL OBSERVATORY OF BELGIUM

EX8: ETRF2000(2008,0) → ETRF96(2001,0)

ROYAL OBSERVATORY OF BELGIUM

The following tool allows to transform coordinates (position and velocity) from any ETRFxx to any ITRFyy (or ITRFyy to ETRFxx). In case input and output coordinates are requested at different epochs, then station velocities are mandatory.

Input

Frame : ETRF2000

Epoch : 2008 . 00

```
EXAMPLE8 4027894.006 307045.600 4919474.910 0.01 0.2 0.03
```

Velocity is mandatory

Output

Frame : ETRF96

Epoch : 2001 . 00

Options

☑ show intermediate steps

Change epoch format: Decimal Year: YYYY.DDD

Transform

EX8: ETRF2000(2008,0) → ETRF96(2001,0)

Output

Frame : ETRF96

Epoch : 2001 . 00

```
EXAMPLE8 4027893.93630  307044.19500 4919474.68250  0.01004  0.19973  0.02863
```

Velocity is mandatory

Options

☑ show intermediate steps

Change epoch format: Decimal Year: YYYY.DDD

Transform

The table below shows the different transformation steps that were performed to go from the input coordinates to the requested outpu coordinates.

Intermediate steps

MarkerName	Frame	Epoch	X	Y	Z	V_X	V_Y	V_Z
EXAMPLE8	ETRF2000	2008.0	4027894.0060	307045.6000	4919474.9100	0.010000	0.200000	0.030000
EXAMPLE8	ITRF2000	2008.0	4027893.7076	307045.8796	4919475.1375	-0.002866	0.217398	0.039448
EXAMPLE8	ITRF96	2008.0	4027893.7206	307045.8839	4919475.1118	-0.002855	0.217192	0.038097
EXAMPLE8	ETRF96	2008.0	4027894.0066	307045.5931	4919474.8829	0.010038	0.199728	0.028631
EXAMPLE8	ETRF96	2001.0	4027893.9363	307044.1950	4919474.6825	0.010038	0.199728	0.028631

ROYAL OBSERVATORY OF BELGIUM

Final Remarks

We just use 3 basic formula:

- **ITRFyy(t) → ITRFzz(t)** ***between diff. ITRF, same epoch***

$$X_{ITRFzz} = X_{ITRFyy} + T(t) + D(t).X_{ITRFyy} + R(t).X_{ITRFyy}$$
$$V_{ITRFzz} = V_{ITRFyy} + \dot{T} + \dot{D}.X_{ITRFyy} + \dot{R}.X_{ITRFyy}$$

- **ITRFyy (t_1) → ITRFyy (t_2)** ***change epoch, same frame***
  ETRFyy(t_1) → ETRFyy(t_2)

$$X(t_2) = X(t_1) + V.\ (t_2 - t_1)$$

- **ITRFyy(t) → ETRFyy(t)** ***between ITRFyy and ETRFyy***

$$X_{ETRFyy}(t) = X_{ITRFyy}(t) + T_{yy} + \dot{R}_{yy}.X_{ITRFyy}(t).(t - 1989)$$
$$V_{ETRFyy} = V_{ITRFyy} + \dot{R}_{yy}.X_{ITRFyy}(t)$$

ROYAL OBSERVATORY OF BELGIUM

Final Remarks

Do not forget… for those of you who want to do some testing

- Transformation parameters are time dependent → convert to epoch of the transformation
- Check units of transformation parameters → convert to SI

http://epncb.oma.be/_productsservices/coord_trans/

References

- The ITRF web site

  http://itrf.ensg.ign.fr/

- The Memo

  http://etrs89.ensg.ign.fr/memo-V8.pdf

Questions ?

ROYAL OBSERVATORY OF BELGIUM