The EPN Infrastructure: Status, Monitoring and Plans

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1 INTRODUCTION

The EUREF Permanent Network (EPN) is a network of continuously operating GNSS reference stations maintained on a voluntary basis by the EUREF members. The primary purpose of the EPN is to provide access to the European Terrestrial Reference System (ETRS89) by making publicly available the tracking data as well as the precise coordinates of all the EPN stations.

Today, the EPN network consists of 243 continuously operating GPS or GPS+GLONASS reference stations. The 21 new EPN stations that joined the EPN since June 2009 are shown in Figure 1. As can be seen from Table 1, ten of them stream data in real-time and 16 of them are equipped with GPS/GLONASS receivers. This brings the percentage of the EPN stations providing GPS+GLONASS data to 48% (Figure 2**).**

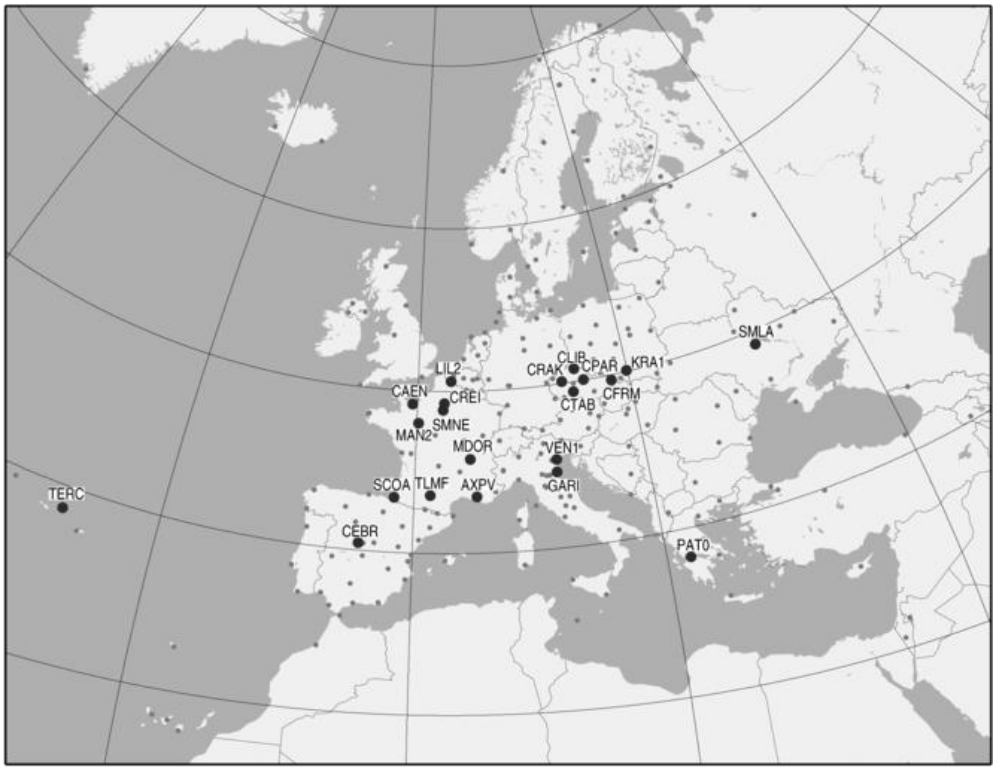

Figure 1 – EUREF permanent GNSS tracking network (status June 2010); big dots: the stations added to the network since June 2009.

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4-CHAR ID	LOCATION	FUNCTION		CALIB	FROM
AXPV	Aix En Provence, France		GLO	Type	28/03/2010
CAEN	Caen, France		GLO	Type	28/03/2010
CEBR	Cebreros, Spain	RT	GLO	Type	11/04/2010
CFRM	Frydek Mistek, Czech Republic	RT		Type	21/03/2010
CLIB	Liberec, Czech Republic	RT		Type	21/03/2010
CPAR	Pardubice, Czech Republic	RT		Type	21/03/2010
CRAK	Rakovnik, Czech Republic	RT		Type	21/03/2010
CREI	Creil, France		GLO	Type	28/03/2010
CTAB	Tabor, Czech Republic	RT		Type	21/03/2010
GARI	Porto Garibaldi, Italy		GLO	Type	08/11/2009
KRA1	Krakow, Poland	RT	GLO	Type	21/03/2010
LIL2	Lille, France		GLO	Type	28/03/2010
MAN2	Le Mans, France		GLO	Type	28/03/2010
MDOR	Saint-Didier-au-Mont-d'Or , France		GLO	Type	28/03/2010
PAT0	Patras, Greece		GLO	Type	14/06/2009
SCOA	Ciboure, France	RT	GLO	Type	28/03/2010
SMLA	Smila, Ukraine		GLO	Type	01/11/2009
SMNE	Saint-Mande, France		GLO	Type	28/03/2010
TERC	Angra do Heroismo, Portugal	RT	GLO	Type	03/01/2010
TLMF	Toulouse, France		GLO	Type	28/03/2010
VEN1	Venezia, Italy	RT	GLO	Type	13/12/2009

Table 1- Tracking stations added to the EPN since June 2009, RT: stations streaming real-time data, GLO: stations equipped with GPS+GLONASS receivers, Type: antenna/radome with absolute type calibrations; Indiv: antenna/radome with individual absolute calibrations.

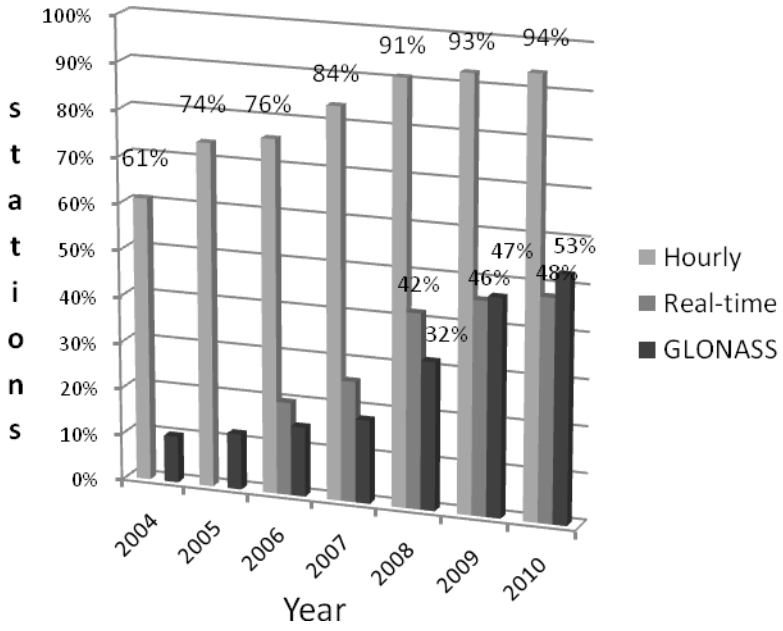

Figure 2 – Evolution of the percentage of EPN stations providing hourly, real-time and GLONASS data.

Calibration	*Dec. 2006 (% of stations)*	*June 2010 (% of stations)*
Individual absolute	5	14
Type absolute	64	70
From (relative) field measurements	14	7
No (radome not calibrated)	17	9

Table 2 – Evolution of the type of calibrations available for the EPN stations.

Table 2 shows that the number of EPN stations without absolute calibrations is slowly decreasing, while Table 3 shows that 30 of the 42 new antennas/radomes (new stations or replacements at existing stations) introduced in the EPN since June 2009 are already capable to track multiple GNSS.

GPS		*GPS/GLONASS*		*GPS/GLONASS/GALILEO*	
Name	*No*	*Name*	*No*	*Name*	*No*
AOA/M_T	1	LEIAT504GG	11	LEIAR25	4
ASH700936E	1	NOV702GG	1	LEIAR25.R3	2
ASH701945B_M	1			TPSCR.3G	2
LEIAT504	5			TRM59800.00	1
TRM29659.00	**4**			TRM55971.00	9
Total	***12***	***Total***	***12***	***Total***	***18***

Table 3 - Antennas introduced in the EPN since June 2009 with an indication of the GNSS satellite systems they have been designed for.

2 UPDATE OF EPN STATION GUIDELINES

The EUREF Technical Working Group issued a new release of the "Guidelines for EPN Stations and Operational Centers" on March 8, 2010. The on-line version of the guidelines is available from http://epncb.oma.be/_documentation/guidelines/guidelines_station_operationalcentre.pdf . Below, some of the main items in the updated guidelines are highlighted.

2.1 Data Flow and Format

With the release of the new guidelines, it is now mandatory for all EPN stations to submit hourly RINEX data. This requirement will be strictly applied for new stations, while already existing stations which are not yet providing hourly data will be encouraged to do so. In addition, all hourly and daily data delivery should be done with a maximal delay of 10 min. Finally, GPS+GLONASS stations streaming real-time data are encouraged to also stream GLONASS data. All real-time stations are recommended to stream the ephemeris of the satellite systems they are observing.

2.2 Introduction of New EPN Stations

The procedure to add new stations to the EPN has also slightly been changed. A station that wishes to be integrated in the EPN should still submit a commitment letter to the EPN Central Bureau, but from now on the full EPN Coordination Group (consisting of the EPN network coordinator, analysis coordinator, data flow coordinator and chairmen of EPN projects) will judge about the potential merit of the station to the EPN based on this commitment letter. An example commitment letter is available from http://epncb.oma.be/_organisation/guidelines/commitment.doc. The station will only be accepted as a proposed EPN station if the Coordination Group decides that the station has an added-value to the

EPN. From that moment on, the station can start submitting data to the data centres and the data quality and data flow will be checked. Once the station is responding to the requirements, it will be integrated in the EPN.

2.3 Long-term Network Stability

In order to reduce the number of station coordinate discontinuities, the new guidelines aim on one hand to reduce the number of uncalibrated antenna/radome sets and on the other hand to reduce the number of antenna replacements. For that purpose the following guidelines have been issued:

- Antennas with radomes not directly connected to the antenna are not accepted anymore
- Antenna changes are only allowed in case of a failure of the existing antenna or a major equipment upgrade.

In addition, when replacing an antenna, it is recommended to install a multi-GNSS antenna (even if the receiver is not yet multi-GNSS). In this way, future antenna changes (when also upgrading the receiver equipment) can be reduced to a minimum.

2.4 Satellite Tracking

IGS analysis centres as well as other research groups use the data from the EPN stations to compute the ephemerides of all GNSS satellites. These ephemerides are also computed for satellites that are set **unhealthy** in their navigation message. Consequently, EPN stations are requested to carefully set the tracking options of their receiver in such a way that the tracking of unhealthy satellites is activated. Presently, the majority of the EPN station does not track unhealthy satellites (see Figure 3).

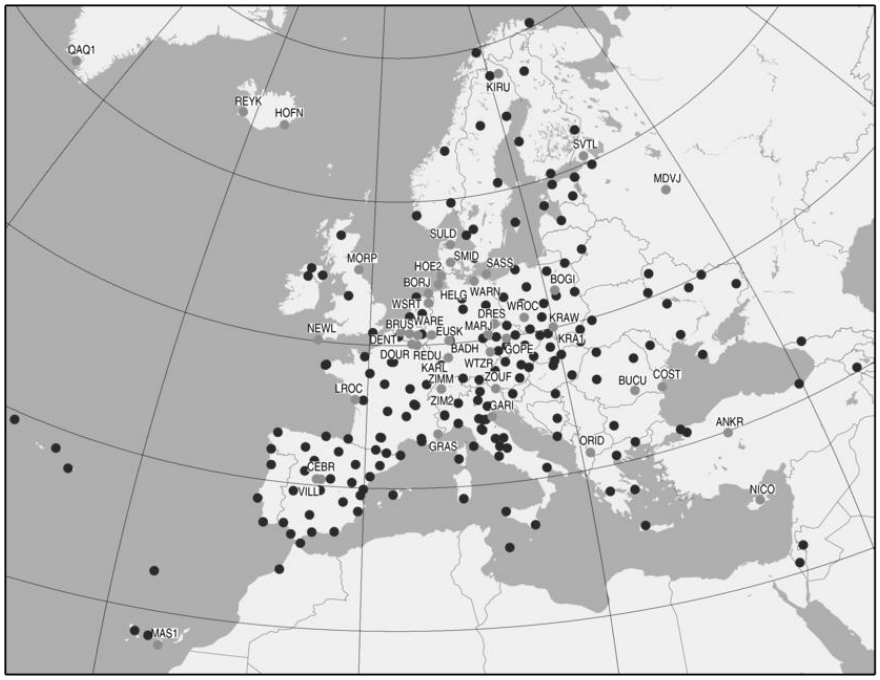

Figure 3 – EPN tracking network; stations indicated in dark (with label) do not track unhealthy satellites (status June 1, 2010).

From the perspective of operational EPN tracking, the P2 data is required. At the time of writing, 7 GPS satellites (the block IIR-M satellites) are emitting a second code on L2, namely the civil code, noted as **C2** in RINEX 2.xx. Note that in the RINEX 2.xx format, the respective carrier phase observable, L2, corresponds to whichever code signal is tracked by the receiver (C2 or P2). Current GPS receivers do not follow a uniform policy on the relative phases of the C2 and P2 signals. This means that there can be a quarter cycle difference between the L2 phase reconstructed from P2

(L2P(Y)) and L2 reconstructed from C2 (L2C). The use of mixed phases is problematic, especially in double-differenced solutions.
Therefore station operators are asked to ensure that their stations always report P2 observations and C2-tracking receivers should be disabled to track C2. Even while the C2 data are needed for several research interests, as long as there is no agreement amongst manufacturers concerning the correction of the quarter cycle issue, it is better not to track C2.
In an attempt to regularise the situation, the International GNSS Service (IGS) has sent an email to all manufacturers asking them to align the phases of L2P and L2C.
As can be seen in Figure 4, at the moment quite a few of EPN stations are still tracking C2.

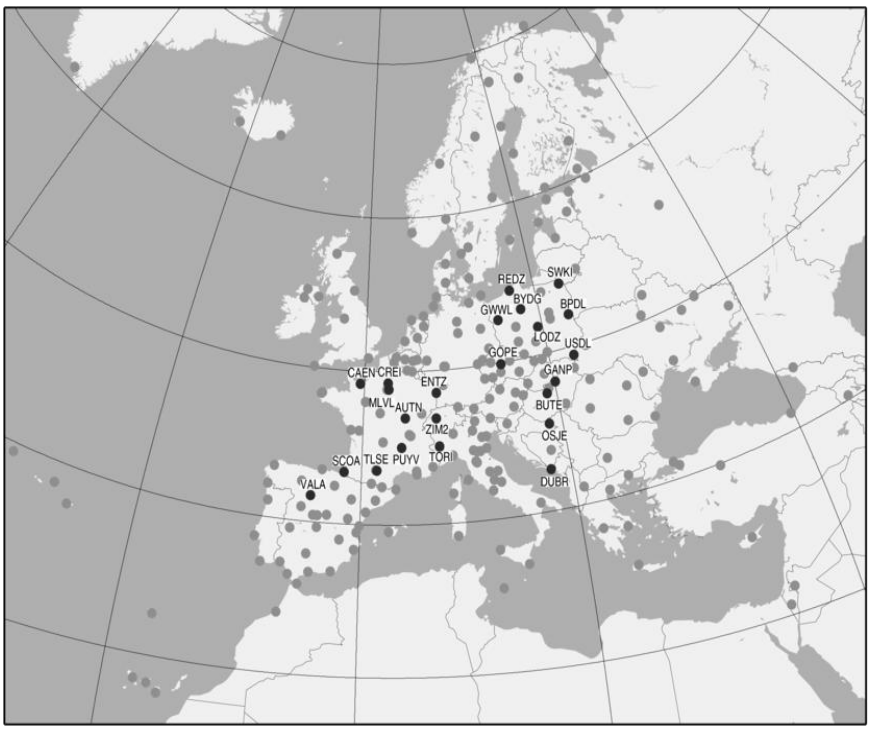

Figure 4 - EPN tracking network; stations indicated in dark (with label) track C2 (status June 1, 2010).

All EPN stations should track both L1 and L2 observables, but in addition, if the equipment allows it, it is recommended to also track new satellites signals, such as for example the **L5** signal. At the time of writing, June 1, 2010, one GPS satellite is emitting the L5 signal (first block II-F launched on May 27, 2010). This satellite is presently still set unhealthy in the satellite navigation message. GNSS research centres which are developing GNSS analysis software are in urgent need of these new L5 observables in order to test their software developments. For that purpose, a maximum number of EPN stations needs to track the L5 observable.

3 New at the Central Bureau

Several new web pages have been developed at the EPN Central Bureau:

- A description of the formats in use in the EPN http://epncb.oma.be/_documentation/formats/
- An interactive site map, http://epncb.oma.be/_trackingnetwork/stationmaps.php, see Figure 5, allowing the user generate on request maps of EPN station with a specific receiver and antenna manufacturer, observed satellites system(s), data flow, etc...

- An interactive site list, http://epncb.oma.be/_networkdata/stationmaps.php , see Figure 6, allowing the user to obtain metric on site performance and installations.
- On-line ETRS89/ITRS coordinate transformation tool, http://epncb.oma.be/_productsservices/coord_trans/ , allowing to transform positions (or positions and velocities) from any ETRS89 frame to any ITRS frame and vice versa.

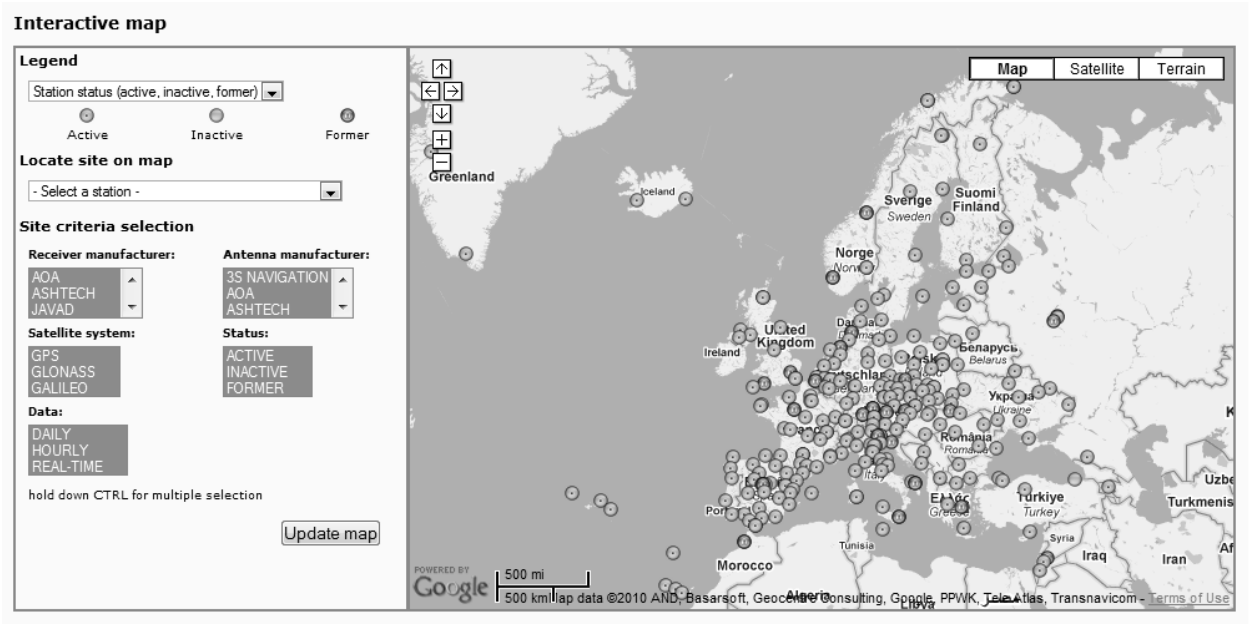

Figure 5 - New interactive site map available from the EPN CB.

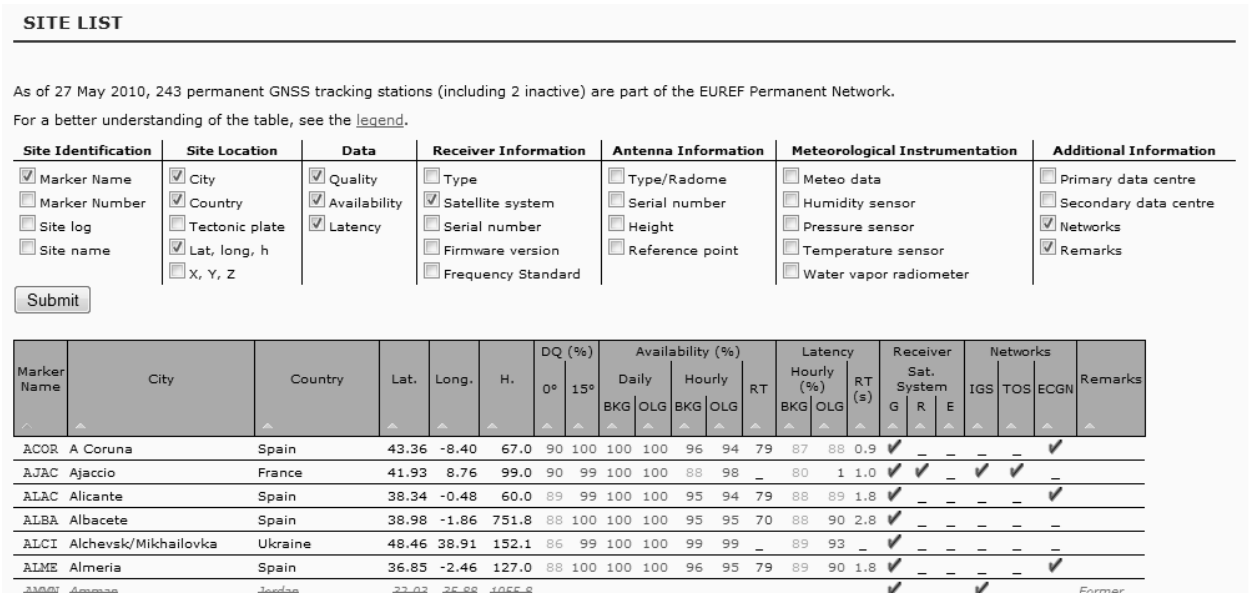

Figure 6 - New interactive site list available from the EPN CB.

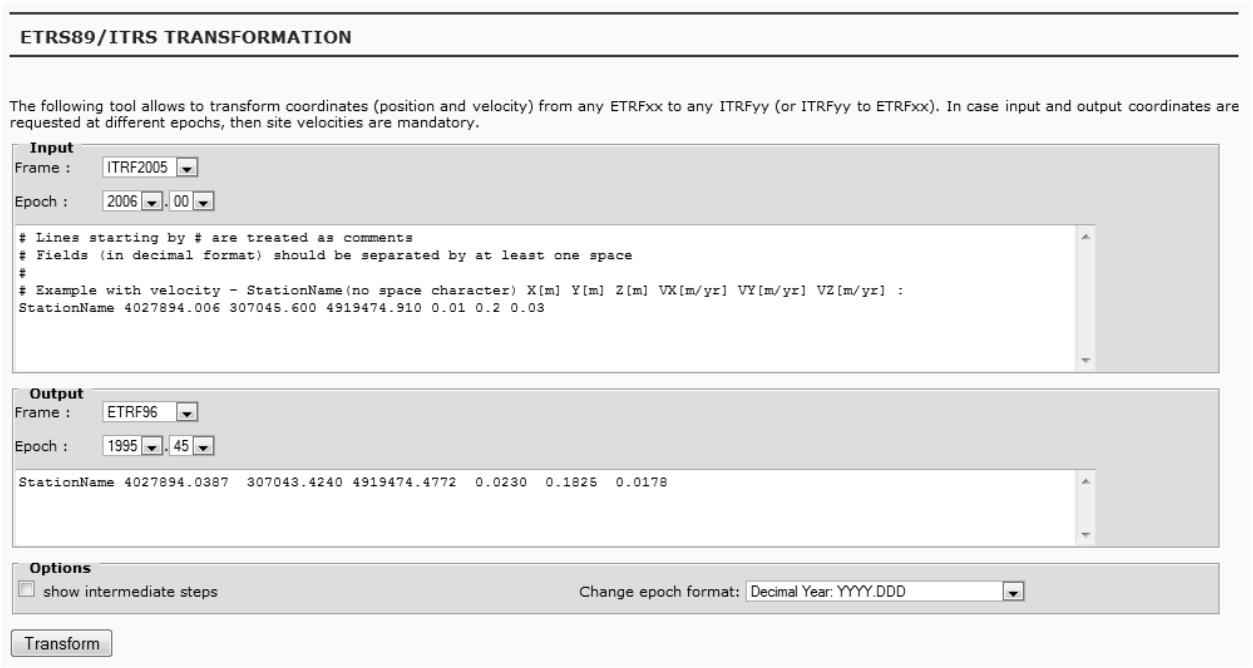

Figure 7 – On-line ETRS89/ITRS coordinate transformation tool.

4 SUMMARY

Since last year, 21 new EPN stations joined the EPN bringing the total number of EPN stations to 243. The EPN tracking network is becoming a real multi-GNSS tracking network with a total of 53% of the EPN stations tracking GPS and GLONASS signals. In addition, also the large majority of the new antenna/radome pairs introduced in the EPN over the last year is capable of tracking multiple GNSS. However, the changing GNSS landscape also imposes a careful monitoring of the signal tracking.
Also the number of EPN stations equipped with antenna/radome pairs with absolute calibrations is growing, demonstrating the importance of strategic guidelines aiming at upgrading the EPN. Stations should pay attention to tracking the unhealthy satellites, and if possible, activate L5 tracking.
Recent upgrades to the EPN Central Bureau monitoring system include an interactive site map, an interactive site list, and an on-line ETRS89/ITRS coordinate transformation tool. Planned upgrades of the EPN CB comprise an on-line site picture management system and a complete change of the data quality check programs responding to the needs imposed by the new satellites signals.

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