Introduction and Motivation. As the georeferencing of position data in modern data bases, the availability of GNSS (GPS / GLONASS / GALILEO) related code- and phase-measurement DGNSS-correction data, which are provided in different ways by different GNSS positioning services (SA POS, ASCOS, SIGNET etc.) in and outside Europe leads to the replacement of the classical geodetic reference systems by GNSS-consistent ITRS-based reference systems. So the transformation of the old plan position data (N, E, H), related to the classical reference systems to the ITRS/ETRS89 datum (N_E_H)_ITRF becomes urgently necessary all over Europe (1) and the world respectively. A sophisticated and general solution of this transformation problem has to include a data base concept for the provision of the corresponding transformation parameters for GIS, GNSS navigation and surveying purposes. This is provided by the CoPaG-Concept. Further the capacity of a one-cm-positioning by GNSS services, such as e.g. SA POS® and ASCOS® in Germany, is also appropriate for a GNSS related heighting. The GNSS-based determination of sea-level (orthometric, normal) heights H requires the transformation of the ellipsoidal GNSS heights h_s to the respective physically defined height reference surface (HRS). A general concept for the evaluation of height reference surfaces (HRS) on the national and also on European level (E. HRS) is provided by DFHRS. Both the DFHRS and the CoPaG/DFLBF database standard are broadly accepted by the GIS(E1) and GNSS (E2) industry.

Albanian Reference Frames and Data used for CoPaG/DFLBF/DFHRS DB Computation

The state of Albania is situated between latitude 39°38’- 42°39’ North and longitude 19°16’-42°04’ East and extends over an area of 28,748 km2 (land 27,386 km2, water 1,350 km2). The terrain is mostly mountainous (highest point 2753m) and hills with small plains along coast. Albania is affected from natural hazards such as destructive earthquakes, tsunamis and draughts. The present national horizontal and geodetic reference network ALB87 is referring to Krassowski ellipsoid and UTM projection. Five common points were used to transform by a 7PT similarity transformation further 16 points (X,Y,Z) from ITRF96.1980 to ETRS89 (Nurec, B.: The New Albanian Network and GPS measurement campaigns. Veröffentlichungen der Bayerischen Kommission für die Internationale Erdmessung. Heft Nr.61.München,2000,238-241). So a total number of 21 points (N,E,H) related to ALB87 could be used to compute a first CoPaG/DFLBF_DB set for transformations ALB87 ↔ ETRS89 and a second set for transformations ALB87 ↔ ITRF96.1998. The vertical datum of Albania is referring to MSL Adriatic Sea. The DFHRS_DB was computed with respect to a ETRS89-georeferencing using a number of 17 identical points (B, L, h) and the EG87 observations. So Albania is ready for the installation of a GNSS positioning service ALBPOS such as e.g. SA POS®, ASCOS®.

CoPaG

The CoPaG concept is dealing with the precise and continuous transformation of plan positions (N,E,H), to the ITRS/ETRS89 datum (N,E,H). From the theoretical point of view a respective transformation can not resonance completely on height information (C1). The so-called CoPaG (Continuously Patched Georeferencing) concept however, has the advantage that the point height information is needed not only on a poor accuracy level in the target system. If precise height information is available in both systems, it can be introduced as third observation equation in system C1. Further basic considerations and a respective problem solution for the plan datum transition are due to the occurrence and the mathematical treatment of ‘weak forms’ (C3 left). These are long-waved deflections of the shape of classical networks, reaching a range of several meters in the nation-wide scale, e.g. for the size of Germany (C3, right). This requires the partition of the total network area into a set of different “patches” in a FEM similar to DFHRS (C2, C3, right). The introduction of patch conditions along the patch borders analogue to the DFHRS (D1) implies restrictions between the transformation parameters d of neighbouring patches (C3, right). Because of its mathematical strictness and general validity the CoPaG concept has a broad and far-reaching application profile in the context with the big amount of similar datum transition problems occurring world-wide in the upcoming GNSS-age. C2 shows the patch-layout for the computation of the <1 cm CoPaG_DB Albania (see accuracy contour-lines, C4). The inverse problem of transformation of GNSS positions (B,L,H), to national reference systems and grids (N,E,H) is solved by DFHRS_DB (www.geozilla.de).

DFHRS

The DFHRS (Digital-Finite-Element-Height-Reference-Surface) concept allows a GNSS height positioning by a direct online conversion of ellipsoidal heights h into standard heights H referring to the height reference surface (HRS). The DFHRS is computed and modelled as a continuous HRS with parameters p in arbitrary large areas by bivariate polynomials over a grid of Finite-Element meshes (FEM) (D1, D3). Geoid heights, vertical deflections, gravity anomalies and identical points are to be used as observations in a least squares computation to derive the DFHRS-parameters (D4). Any number of geoid models may be introduced simultaneously and geoid models may be parted into different “patches” with individual datum-parameters in order to reduce the effect of existing medium- and long-waved systematic errors. So the resulting DFHRS parameters p, setup as a DFHRS database, serve as input for the DFHRS (p,m,B,L,h) to transform by H=DFHRS(p,B,L,h) ellipsoidal GNSS heights h into standard heights H (D4, top). The DFHRS-correction consists of the FEM surface of the HRS (‘geoid-part’) as function of (B,L) and an additional “scale part” as function of h (D4, top). The present ‘high-end’ of a HRS representation and the DFHRS-correction DFHRS (p,m,B,L,h) respectively is the level of less than 1 cm, provided by so-called "<1 cm DHF RS_DB". These <1 cm DFH RS_DB are characterized by a mean reproduction quality of less than 1 cm (www.dfhbf.de). D3 left shows the meshing and patching design for the computation of the <10 cm DFHRS_DB Albania and D4 right shows the isolines of the final HRS result. An improvement to a three centimetre level could be achieved by introducing a number of further 20 height points (B, L, h).