Geodetic Infrastructure for GNSS Positioning Services (GIPS)

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The worldwide ongoing process of the establishment of high precise DGNSS-positioning services and respective GNSS-reference station networks, which are related to the globally GNSS-consistent ITRF and ITRF-derivatives (e.g. ETRF89), implies the replacement of the georeferencing in the old independent classical national reference frames by an ITRF-related one. Accordingly the new age of GNSS-positioning services - as interdisciplinary tool with a broad and growing spectrum of precise satellite positioning, navigation, mobile GIS and mobile IT applications - requires the establishment and maintenance of a geodetic infrastructure for GNSS positioning services (GIPS). The development mathematical models and software of a GIPS must be appropriate to fulfil the requirements of its implementation with respect to the existing and to future belongings, technical concepts and standardizations (e.g. RTCM).

The authors divide the geodetic infrastructure for GNSS-services (GIPS) into a transformation and a geomonitoring component. As concerns the transformation component, the old plan position data, which is related to a classical reference frame, has to be transformed to the ITRF-related horizontal geoferencing (B, L) provided by the GNSS-service. This forward-transformation (trafo-1) concerns the establishment of modern GNSS-related databases for the infrastructure for spatial information in Europe (INSPIRE) and worldwide (cadastre, GIS, navigation, urban planning, construction, transportation, meteorology, land management, precise agriculture, etc.). It is necessary for a future direct horizontal positioning by GNSS services. The backward transformation (trafo-2) of the ITRF–related GNSS-position to an old classical datum is needed, because the classical non-ITRF reference frames will still be relevant for at least one decade or more. The software COPAG solves the above 3D-datum transformation problems (trafo-1, trafo-2) by a finite element related mathematical modelling (FEM) and in a strict and general concept, including quality control. The computed high precise parameters are stored to transformation parameter data-bases. The ellipsoidal GNSS-heights always need a further processing, in order to transform h - by H=h-N - to the physical height H referring to the height reference surface (HRS) N. The software DFHBF solves that height transformation problem (trafo-3) and models again in a Finite Element (FEM) concept. Global geopotential models (GPM), existing HRS models, vertical deflections, terrestrial gravity g and identical points (h, H) can be used as observations for the computation of a HRS database by the DFHBF-software. The CoPaG (trafo-2) and DFHBF (trafo-3) databases can be used on all GNSS-controller types. Alternatively they can also be implemented as so-called reference transformations for setting up the recent world-standard of RTCM 3.1 transformation messages for the GNSS rover-clients using a RTCM transformation messages server. The new RTCM 3.1 transformation messages allow the GNSS service to provide their users with all necessary information for an RTK 2D positioning (trafo-2) and a GNSS-based heighting (trafo-3). So RTCM-compatibility is regarded as a general GIPS requirement.

The capacity of an absolute positioning by GNSS-positioning services requires, that possible changes of the coordinates of the GNSS reference stations in the amount of few millimetres are detected immediately. To solve that task, the GNSS-reference-station MONitoring by the KArlsruhe approach and software (MONIKA) has been developed. The MONIKA approach and software can, besides the coordinate control of GNSS-positioning services, also be applied for a use of the permanent GNSS-stations as a geosensor-network for geodynamical questions and research, as well for a setting up temporary GNSS-arrays as a disaster monitoring and early warning GNSS service , e.g. for land-slides, flood and construction areas.

The authors present the mathematical models, the software and the technical realization of the above GIPS components in a closed modular and general concept. Applications are shown with respect to the German SAPOS and the Moldavian GNSS service MOLDPOS.