The implementation of new official geodetic datum and map projections in the Republic of Croatia

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Decree on establishing new official geodetic datum and map projections

The reasons for introducing the new geodetic reference system

- inadequate accuracy and significant errors in the existing datum
- the existing solutions have been adopted and adjusted to former states among which Croatia was only one constituent part,
- removal of the existing obstacles in the efficient use of modern measurement and GIS technologies, whereby the state, economy and citizens were offered an unambiguous, rational and simple reference system and framework to be implemented,
- introduce the official geodetic datum and plane map projections based on modern achievements in science and harmonized with the European recommendations and trends,
- in the part referring to spatial data, to create preconditions for the further development of geodetic and all other geo-related professions

HORIZONTAL DATUM – HTRS96

- ETRS89
  - GRS80 ellipsoid
    \[ a = 6378137,00 \text{ m} \]
    \[ \mu = 1/298,257222101 \]
  - Basic referent GNSS network of the 0 i 1th order – 78 sites

- Croatian Terrestrial Referent System – HTRS96

- Basic referent GNSS network of the 2nd order (10x10 km)
  - 1023 sites
VERTICAL DATUM - HVRS71

- Geoid surface determined at five tide gauges along the Adriatic coast (Dubrovnik, Split, Bakar, Rovinj i Koper) for epoch 1971.5
- Basic levelling network - permanent points - benchmarks of II. levelling of high accuracy - II. NVT
- Croatian Vertical Reference System sustav for epoch 1971.5 - HVRS71

GRAVIMETRIC DATUM – HGRS03

- International Gravity Standardisation Network 1971 – IGSN71
- Reference surface
  - GRS80 ellipsoid
  - GM = 398600.5 x 10^5 m^3 s^-2
  - Angular velocity of the Earth rotation
    \( \omega = 7.292115 \times 10^{-5} \text{ rad s}^{-1} \)
- Basic gravimetric network
  - Absolute gravimetric network - 6 sites
  - Gravimetric network of 1. order – 36 sites
- Croatian Gravimetric Referent System – HGRS03
MAP PROJECTION – HTRS96/TM

- Transverse aspect of Mercator's projection
  - Mean meridian 16° 30'
  - 0.9999 linear scale
  - State survey and cadastre
  - GRS80 ellipsoid
  - HTRS96/TM

- Normal aspect of Lambert's conformal conical projection –
  - Standard parallels 43°05'44''35''
  - Conformal cartography
  - GRS80 ellipsoid
  - HTRS96/TM

PROGRAM OF INTRODUCING THE OFFICIAL GEODETIC DATUMS

- Introduce new datums into practical use on the entire territory, into all official records and databases, as well as all works conducted by State Geodetic Administration (SGA).
- Ensure the new geodetic reference system for the establishment of the National Spatial Data Infrastructure (NSDI).
- Create the necessary preconditions and ensure support for the introduction into all official spatial records and databases of the State Administration bodies, and ensure its implementation in the economy and civil sector.
- Develop the legislation and implementation of the regulations, standards and specifications necessary for the implementation of the Program.
- Develop (establish) the system of education and training that will ensure the Program implementation.
Current realisation
GNSS permanent network

**CRoatian POsitioning System**
- launched on December 8, 2008
- in one year fully integrated in croatian geodetic society
- three types of services which are charged
- on April 11th, 2010, 254 users are registered
- average use of VPPS (RTK) service is 350,000 minutes per month

Current realisation
Basic geodetic works

- **Renewal of the basic reference GNSS network**
  - physical condition is bad
  - to prevent further deterioration
  - 41 (79) points have been renewed
- **Renewal of the basic vertical network**
  - network configuration was adjusted to the former state
  - lack of gravimetric survey
  - field review of the condition of benchmarks, high percentage of benchmark deterioration
  - systematic renewal is needed and planned for next five years program
Current realisation
Gravimetric network

- the micro-gravimetric networks were established for all absolute points (6);
- re-observation of absolute points is planned for 2010;
- 26 new gravimetric points of 1st order were established on islands which has been completed and contains 59 points;
- 2nd order which the establishment of 260 gravimetric was started, out of which approximately 20% has been completed and the network completion is planned for the end of 2012;
- Croatian Geodetic Institute is in charge of performing all gravimetric tasks.

Current realisation
Development of geoid model

- for a simple and accurate transfer from ellipsoidal heights into orthometric heights;
- calculation of the new geoid surface was included:
  - 60 reference points obtained (more than 10000)
  - geoid undulations (for 485 points)
  - grid undulations obtained from the satellite and airborne gravity data (485)
- a global geopotential model EGM96;
- highly reliable geoid surface with high internal accuracy +/- 0.03 m;
- highly external evaluation of accuracy +/- 0.04 m, obtained from 59 control points.
Current realisation
Development of transformation model

- T7D was developed in order for simple and equal-for-all-users procedure of the data transformation
- based on the uniform GRID transformation T7D includes:
  - datum shift (a 7-parameter transformation)
  - predicted values of distortion calculated from 6200 control points
- T7D ensures positional and vertical accuracy of transformation from ±0.06 m (in both directions)
- Integration T7D transformation model with the Trimble Generation application into the CROPOS system
- more simplify and accelerate the performance of field measurements through CROPOS.
- Transformation model of heights – HTMVOB includes datum and distortion components calculated in regular 45'' x 30'' raster from 8448 identical benchmarks
- external accuracy of the model ±0.01 m obtained on 1509 control points
- HTMVOB incorporated in the T7D computer software

Current realisation
Topographic survey and state maps

- new division into topographic map sheets and detailed cadastre map sheets (National Grid) was developed
- dimensions of the map sheet and detailed cadastre map sheet are the same for all scales and amounts to 80 x 40 cm
Current realisation
State topography

- Topographic map in the scale 1:25000 – TK25
  - The project started 1996, 594 sheets, full completion is planned for 2010
  - In old reference system and in accordance with the current division into sheets,
  - transformation into the system of new map projection.
- Digital orthophoto map DOPS in HTRS96/TM
  - Total number of sheets – 9756, 6089 sheets completed in HTRS96/TM (60%)
  - remaining sheets (40%) produced in the 2006 – 2007 period, will transformed HTRS96/TM

Current realisation
Real property cadastre

- Cadastral map vectorization
  - basic precondition for the transformation of cadastral maps, started in 2006
  - 3900 cadastral municipalities with the total of more than 54,000 cadastral map sheets
  - The cadastral survey have been conducted using various surveying methods and in different time periods
    - cadastral maps from the times of Austro-Hungarian Monarchy developed using the method of graphic survey (ca. 76%)
    - cadastral maps developed in the period from 1950 onwards in the projection system of Gauss-Krüger projection (Bessel ellipsoid)
  - for vectorization process the technical specifications and procedures have been developed
  - for maintenance of vector cadastral maps program application Vectoria have been developed
  - database of digital cadastral map has been established whose completion is planned for the end of 2010
Current realisation
Real property cadastre

Cadastral map homogenization

- The state of cadastral maps produced in the old Austro-Hungarian graphic survey underlines
  - very poor quality of geometry,
  - lack of homogeneity,
  - lack of accuracy
  - is not adequate for recording highly accurate data determined by modern surveying methods (CROP/OS)

- The homogenization process was developed, proper insertion of cadastral maps into HTRS96/TM under which the existing lack of homogeneity is being removed and the geometry and accuracy are being improved.

Transformation of cadastral maps in HTRS96/TM

- New systematic cadastral surveys have so far covered 7% of the state territory
- for the remaining part of the country (more than 90%), the existing cadastral survey will continue to be available
- The maintenance of cadastral maps at this moment is conducted in the reference systems used so far
- with the establishment of CROP/OS it is possible to conduct all types of geodetic tasks in HTRS96/TM
- consequence is that good-quality and highly accurate data directly determined by the survey is transformed into the old reference systems and in that way their accuracy and homogeneity is significantly reduced

- it is necessary to transform the existing cadastral maps into the HTRS96/TM, two transformation procedures:
  - for the plans developed in Gauss-Krüger projection of medium zones (approx. 20%) – for the plan developed using the method of graphical survey (approx. 70%), and which include the entire-decided homogenization procedure
- Basic preconditions for a successful transformation of cadastral maps:
  - cadastral map, vectorization (completed in 2010)
  - uniform transformation model – 170 (in use)
  - detailed procedure steps and technical specifications in order to have uniform procedures
Current realisation
Providing information and training

Organization of regional CROPOS workshops and the 1st CROPOS Conference
- four informative regional CROPOS workshops (November 2008) with more than 800 participants
- CROPOS Manual, distributed to the users at the moment they register, and it can be downloaded from the CROPOS web site - www.cropos.hr
- Organization of the 1st CROPOS conference Zagreb, June 8 – 9, 2009, exchange of domestic and international experience related to the work and use of permanent GNSS networks, more than 300 users, experts, scientists and professionals

Development of normative and technical regulations and training
- The new Rules and Regulations in the area of basic geodetic works on the manner of conducting basic geodetic works (Official Gazette no. 87/2009) support the new geodetic reference system together with the new acceptable and efficient methods of their conducting.
- “Technical Specifications for the procedure for calculations and divisions into official map sheets and detailed cadastral map sheets in the map projection of the Republic of Croatia – HT95/69” were put in official use.

Conclusion

- New geodetic datum and their realization have been determined for the Republic of Croatia. The Geodetic Administration invested great efforts in order to ensure adequate funds and other capacities necessary to conduct the Program tasks, in the framework of executing annual programs. In that, SGA has the support from all partners in the Program implementation, primarily the Faculty of Geodesy of the University of Zagreb and the Croatian Geodetic Institute.
- Until the end of 2008, through the Program implementation all preconditions were entirely established for the implementation in daily practice which is the end goal of the Program. In order to ensure that it is necessary to continue with the program approach, on the basis of achieved results, and in that way systematically manage the implementation process.
- From the previous five-year period, we can all conclude that the implementation of the new geodetic reference system is a highly demanding, complex and long-lasting process and as such presents a great challenge. Equally, it is an opportunity for our entire geodetic and cadastral system to prove itself and to present to the Croatian society a modern geodetic and reference system which will be able to meet the users’ requests.