National report of Ukraine

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Introduction

The following activities during last years should be mentioned:

- development of the permanent GNSS network,
- initiation of the State coordinate system UCS-2000 in the areas of municipal networks (cities),
- estimation of the strain rate tensor from GPS observations in the Eastern Europe,
- new regular (2’x3’) grid of the Bouguer anomalies for geodetic aims,
- preparations to the readjustment of the State vertical network,
- modeling the gravity field in the Ukraine area from gravity gradients of GOCE data,
- further densification of GPS-leveling data to a number of about 4000 GPS-leveling points for new quasigeoid solution,
- finalization of practical activity of the search of Struve Arc points in the Ukraine area.
1. Permanent (▲) and periodically observed (▲) GNSS-stations
2. Adopted criteria for UCS-2000:

1) it is eccentric, the center of UCS-2000 selected as the center of Krassowsky’s ellipsoid is defined under the standard condition of minimal deviation between reference ellipsoid and quasigeoid in the Ukraine area;

2) its orientation is given initially by the orientation of ITRF2000 at epoch 2005.0 (scale is identical to the ITRF2000 scale at the same epoch);

3) its realization is based on the Ukrainian permanent network and preferred stations of the State network of 1st order via common adjustment of GNSS observations and classic terrestrial data;

4) UCS-2000 should be close to the horizontal system S-42 (Pulkovo).

After practical realization of these requirements the new system keeps old maps of the scale 1:10000 or smaller given in the S-42 system. In addition the accurate connection between the reference system UCS-2000 and the coordinate systems ITRS/ITRF2005 and ETRS89 was derived.
Accuracy estimation of the position of geodetic stations given in UCS-2000

<table>
<thead>
<tr>
<th>Statistics</th>
<th>1(^{st}) order, 813 points</th>
<th>2(^{nd}) order, 5586 points</th>
<th>3(^{rd}) order, 10084 points</th>
<th>4(^{th}) order, 8174 points</th>
<th>Total: 24657 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.003</td>
<td>0.001</td>
</tr>
<tr>
<td>Max</td>
<td>0.026</td>
<td>0.112</td>
<td>0.099</td>
<td>0.143</td>
<td>0.143</td>
</tr>
<tr>
<td>Mean</td>
<td>0.003</td>
<td>0.020</td>
<td>0.032</td>
<td>0.032</td>
<td>0.028</td>
</tr>
</tbody>
</table>

Further densification of the Ukrainian State Geodetic Network (SGN):
1) new points (restoring old and installing new sites) were developed (650 points),
2) a special work for the transformation from UCS-2000 to different municipal (local) coordinate systems was started,
3) at present there are 18 municipal coordinate systems where parameters of the transformation must be derived,
4) among these local coordinate systems connected with various municipal areas (cities) new 12 geodetic networks were constructed.
Dilatation rate in the Eastern Europe (ETRS89)
3. Current status of the Ukrainian vertical reference system

- all leveling polygons of the 1st order leveling between Ukraine and neighboring countries were connected,
- new regular (2’x3’) grid of the Bouguer anomalies for calculation of geopotential numbers was constructed,
- creation of the database for the adjustment of leveling networks of 1st and 2nd orders via geopotential numbers,
- in the process of preparation to the readjustment of the State vertical network all necessary data of the leveling of 1st and 2nd orders between Ukraine and bordering countries were transmitted to Bundesamt für Kartographie und Geodäsie (BKG),
- building of the special geodynamic polygons in the areas of atomic power station,
New regular grid (2’x3’) of the Bouguer anomalies in the Ukraine and Moldova area
Distribution of GPS-leveling data

**LEGEND**
- 1st order leveling
- 2nd order leveling
- 3rd order leveling
- 4th order leveling
Vertical networks of 1\textsuperscript{st} (-) and 2\textsuperscript{nd} (-) orders

<table>
<thead>
<tr>
<th>Order</th>
<th>Number of lines</th>
<th>Length of lines, km</th>
<th>Number of polygons</th>
<th>Perimeter, km</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Max</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>29</td>
<td>70.7</td>
<td>1301.9</td>
<td>11975.0</td>
</tr>
<tr>
<td>II</td>
<td>62</td>
<td>37.5</td>
<td>383.9</td>
<td>11179.5</td>
</tr>
</tbody>
</table>
4. Current status of the Struve Arc points in the Ukraine area

Finally we can conclude:

• Among 63 points of Struve Arc in the Ukraine area only 15 point are saved,

• A large number of Struve Arc points – 26 stations were destroyed,

• A large number – 22 points were replaced in the Ukraine area by the centers of the State Geodetic Network points (SGN).
### Saved points of Struve Arc in the Ukraine area

<table>
<thead>
<tr>
<th>No</th>
<th>Struve No</th>
<th>Point Name</th>
<th>Result</th>
<th>No</th>
<th>Struve No</th>
<th>Point Name</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>213</td>
<td>Katerinowka</td>
<td>UNESCO</td>
<td>48</td>
<td>211</td>
<td>Bazalia</td>
<td>Found</td>
</tr>
<tr>
<td>37</td>
<td>215</td>
<td>Felschtin</td>
<td>UNESCO</td>
<td>49</td>
<td>216</td>
<td>Alexandrowka</td>
<td>Found</td>
</tr>
<tr>
<td>38</td>
<td>218</td>
<td>Baranowka</td>
<td>UNESCO</td>
<td>50</td>
<td>264</td>
<td>Izmail</td>
<td>Found</td>
</tr>
<tr>
<td>43</td>
<td>196</td>
<td>Golobi</td>
<td>Found</td>
<td>51</td>
<td>265</td>
<td>Staro-Nekrassowka</td>
<td>Found (cupola of bell tower of temple)</td>
</tr>
<tr>
<td>44</td>
<td>206</td>
<td>Matwejewzi</td>
<td>Found</td>
<td>52</td>
<td>52</td>
<td>KUS</td>
<td>Found</td>
</tr>
<tr>
<td>45</td>
<td>207</td>
<td>Mosty</td>
<td>Found</td>
<td>53</td>
<td>53</td>
<td>POG</td>
<td>Found</td>
</tr>
<tr>
<td>46</td>
<td>208</td>
<td>Ssiwki</td>
<td>Found</td>
<td>62</td>
<td>265</td>
<td>Sselyshe</td>
<td>Found</td>
</tr>
<tr>
<td>47</td>
<td>256</td>
<td>Pandaklia</td>
<td>Found</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Izmail – cupola of bell tower of the Orthodox temple of Saint Mikolay**

**Struve Arc center of the Golobi point filled by the lead**
Matwejewzi

Mosty
Conclusions

- Common adjustment of GNSS observations and classic terrestrial data have led to the State geodetic network UCS-2000 with accuracy from 1 to 3 cm.

- The UCS-2000 reference system has accurate parameters of transformation with the realizations of ITRS and ETRS systems and 12 municipal (local systems) around different cities.

- To make available the connection with the United European Leveling Network by means of geopotential numbers new regular (2’x3’) grid of the Bouguer anomalies for calculating geopotential numbers was constructed.

- Preparation to the readjustment of the State vertical network all necessary data of the leveling of 1st and 2nd orders between Ukraine and neighboring countries included also data transition to BKG.

- A special work for the construction of tailored model of the gravity field in the Ukraine area was started and includes as initial data gravity gradients of GOCE data.

- Further densification of GPS-leveling data in 2011 to a number of about 4000 GPS-leveling points allows new quasigeoid solution based on gravimetry, altimetry (Black Sea and Azov Sea areas), GOCE, and GPS-leveling data.

- Finally among 63 points of Struve Arc in the Ukraine area only 15 point are saved. A large number of Struve Arc sites – 26 points were destroyed and 22 points were replaced by centers of the State Geodetic Network points.
Thank you for your attention!
Gravity gradients distribution for the time-period of 1 day
Gravity gradients distribution for the time-period of 1 month

\[ \omega = \nabla^2 \mathbf{W} = \begin{bmatrix} \frac{\partial^2 W}{\partial x^2} & \frac{\partial^2 W}{\partial x \partial y} & \frac{\partial^2 W}{\partial x \partial z} \\ \frac{\partial^2 W}{\partial y \partial x} & \frac{\partial^2 W}{\partial y^2} & \frac{\partial^2 W}{\partial y \partial z} \\ \frac{\partial^2 W}{\partial z \partial x} & \frac{\partial^2 W}{\partial z \partial y} & \frac{\partial^2 W}{\partial z^2} \end{bmatrix} = \nabla_t + \mathbf{\omega} \]