Historical Military Mapping of Czech Lands

Positional Accuracy of Old Maps

Maps of Czech lands derived from eighteenth and nineteenth-century military surveys are unique cartographic artefacts containing much useful, interesting and valuable information. The content and accuracy of these maps has come under investigation in the project ‘Georeferencing and Cartographic Analysis of Historical Military Mappings’. The authors here focus on positional accuracy.

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Czech lands once belonged to the former Austro-Hungarian Empire. The first systematic military survey was begun during the reign of Empress Maria-Theresia and finished by the reign of her son Joseph I. Mapping was conducted in Czech territories from 1764 to 1767, in Moravia from 1764 to 1768 and in Silesia between 1763 and 1764. Between 1780 and 1783 some map sheets were rectified and improved. Mapping at scale 1:28,800 was carried out by military cartographers/officers without any geodetic control and with the minimum of measurements, using the 'is leis' method, spacing and the simplest measuring devices. Enlargements of the Müller map of Bohemia from 1720 (original scale 1:132,000) were probably used as graphical base. One map section, measuring 62×41cm, covers approximately 209km² (see Figure 1).

More Military Mapping

Due to the inadequate quality of the initial military mapping, new surveys were carried out in the nineteenth century under the reign of Emperor Franz II; in the Czech lands this work was done between 1819 and 1858. The mapping was now based on a trigonometric network used also for cadastral survey. The datum for Bohemia was in Graz (Austria) and for Moravia and Silesia it was the tower of the St. Stephen church in Vienna. The scale of the maps in transverse cylindrical projection equidistant in cartographic meridians (Cassini-Soldner) was 1:28,800. Mapping was conducted using a measuring table, distances being derived from spacing or estimated. In those localities where cadastral surveys had already been carried out the planimetry of topographic maps could be based on a simplified planimetry of cadastral maps ('stable cadastre') decreased to the scale 1:28,800. This mapping was thus relatively precise. The quality of the first and second military mapping can be visually compared in Figure 1.

Positional Accuracy

The study being carried out by teams from the Czech Technical University (CTU) in Prague, J.E. Purkyně University in Ústí nad Labem and University of West Bohemia in Plzeň between 2004 and 2006 focuses mainly on positional accuracy and involves:
- methodology of interpretation of old map content
- linking maps to current coordinate systems
- determination of relationship between cadastral mapping and the second military mapping
- development of a web interface to make raster files of map sheets available on the internet.

The coloured originals are stored in the Military Archive in Vienna, Austria. A previous project by

Figure 1. (Left) part of map section 253 in Jindřichohradecko created during the first military mapping; (right) the same area on a map created during second military mapping.
the Czech Ministry for Environment converted the maps to raster files; they can be seen on the website www.geolab.cz. We made use of these raster files for our own research.

**Test Areas**

Map sections of two test areas were chosen: Susicko and Jindrichohradecko. Both are located in South Bohemia and each covers around 100 km² (Table 1). The specific scenic nature of Susicko has been conserved; most of the changes that have affected landscape over time are evident within built-up areas. Jindrichohradecko is characterised by gorgeous natural beauty, with extensive coniferous woods, granite boulders and many pools. This region is partly located along the border with Austria, where a number of villages were evacuated and destroyed after 1945. Selected map elements were identified on old and current maps, and preferably also in the field. Suitable points for comparison were found mainly on churches, village chapels, wayside crosses, at the corners of important historical buildings, and on pond dams and bridges (Table 2).

**Map Objects**

After transformation into the current Czech national coordinate system S-JTSK using four to six points for each map section, coordinates of selected points in the raster files were compared with their counterparts in three present datasets. These were, firstly, the digital terrain model DMU25 scale 1:25,000, secondly, coloured orthophotos of resolution 1m, and thirdly GPS points measured with Garmin, accuracy 10m (Figures 2 and 3). The differences are presented as shifts and standard deviations (SD) for every set of shifts of points (Tables 3, 4 and 5). The results are reliable since the shifts and standard deviations between the old maps and the three present datasets are fairly constant.

**Results**

The positional accuracy of the first MM is much worse than that of the second MM. Even transformation of raster files of the first MM into the present coordinate system does not result in precise results.
and sometimes imperfections in location of some map elements can be recognised. The accuracy for Jindrichohradecko is better than that for Susicko, perhaps due to the selection of points used in the transformation. Nevertheless, the SD of the first MM for Susicko is, at 336m, almost twice that for Jindrichohradecko, which has 176m, indicating possible differences in quality of field mapping or additional rectification work. The second MM is relatively accurate. The accuracy of maps may differ depending on landscape, quality of mapping work and period at which mapping took place.

Concluding Remarks
This project may contribute to further exploitation of these unique maps using GIS technology in fields including the geographical sciences, environmental ecology, flood control, land management, cartography, history and archaeology.

Table 4, Results of accuracy analysis for Test Area 2 (Jindrichohradecko).

<table>
<thead>
<tr>
<th>Present datasets</th>
<th>1st MM</th>
<th>2nd MM</th>
<th>1st MM</th>
<th>2nd MM</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD</td>
<td>Ground [m]</td>
<td>map [mm]</td>
<td>ground [m]</td>
<td>map [mm]</td>
</tr>
<tr>
<td>GPS</td>
<td>173</td>
<td>6,0</td>
<td>40</td>
<td>1,4</td>
</tr>
<tr>
<td>DMU 25</td>
<td>176</td>
<td>6,1</td>
<td>38</td>
<td>1,3</td>
</tr>
<tr>
<td>Ortho photo</td>
<td>178</td>
<td>6,2</td>
<td>38</td>
<td>1,3</td>
</tr>
<tr>
<td>Mean</td>
<td>176</td>
<td>6,1</td>
<td>39</td>
<td>1,3</td>
</tr>
</tbody>
</table>

Table 5, Comparison of results for Test Areas.

<table>
<thead>
<tr>
<th>SD</th>
<th>1st MM</th>
<th>2nd MM</th>
<th>1st MM</th>
<th>2nd MM</th>
</tr>
</thead>
<tbody>
<tr>
<td>T 1</td>
<td>Ground [m]</td>
<td>map [mm]</td>
<td>ground [m]</td>
<td>map [mm]</td>
</tr>
<tr>
<td>TA 1</td>
<td>336</td>
<td>11,7</td>
<td>49</td>
<td>1,7</td>
</tr>
<tr>
<td>TA 2</td>
<td>176</td>
<td>6,1</td>
<td>39</td>
<td>1,4</td>
</tr>
<tr>
<td>Mean</td>
<td>256</td>
<td>8,9</td>
<td>44</td>
<td>1,5</td>
</tr>
</tbody>
</table>

Further Reading

Accuracy may differ depending on landscape, quality of work and period.

Coruna, Spain, July 9-16, 2005, ICA - Comité organizador ICC 2005, p33 abstract, full text on CD.

Biographies of the Authors
All authors are with the Department of Mapping and Cartography, CTU Prague, Faculty of Civil Engineering, Czech Republic.

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