A time section review of development of the City of Karlovac

Luka BABIĆ, Boško PRIBIČEVIĆ, Almin ĐAPO, Croatia

Key words: Karlovac, historical maps, city modeling, restoration

SUMMARY

The City of Karlovac was built in 1579 with the purpose of strengthening Austria's southern defences against Ottoman encroaches. On 1781 the Emperor Joseph II decreed it a free royal city. The City itself was designed as a six-pointed star fortress and built on the Zrinski estate near the old town of Dubovac at the confluence of the Kupa and Korana rivers. As the City later expanded, the urban area reached as far as the Mrežnica and Dobra rivers.
Karlovac is a city-based example of the leading architectural ideas of that time. It is to this day preserved as an ideal Renaissance city with its hexagonal fortress and a rectangular grid of streets. The unique star shape of the original city design is still visible, which makes Karlovac a rarity in Europe.
Unfortunately, Karlovac suffered extensive damage during the Croatian War for Independence (1991–1995). The southern sections of the city as well as the city centre, city hall and numerous other buildings were severely damaged by shelling. Although some buildings were restored, most of the "Karlovac Star" area still awaits complete reconstruction and rehabilitation. Thus, a detailed analysis has to be made to ensure reconstruction in line with the historic concept of the city. Restoration of "Karlovac Star", neighbouring historical parts of town and the distinctive common landscape areas surrounding it, is a task the Republic of Croatia, Karlovac County and the City of Karlovac have taken upon themselves.
The first step in its restoration entails digitalization of historical city maps dating from 1579 and 1818. Since the first known map providing a graphical representation of town inception dates from 1579, digitalization and creation of a digital 3D town model followed by a spatial relation with “Napoleons” map from 1818 is a logical progression for reconstruction and establishing a time-space development of the City and the "Karlovac Star".
The final step is a connection with the current reference coordinate frame, thus providing an analytical basis for all subsequent comparisons of the current City state with its historical origins. This will allow archaeologists, anthropologists and landscape artists to conduct detailed analysis of all case-specific segments necessary for restoration.

A time section review of development of the City of Karlovac

Luka BABIĆ, Boško PRIBIČEVIĆ, Almin ĐAPO, Croatia

1. INTRODUCTION

Unlike many others, Karlovac is a city whose inception can be determined with great accuracy. As written on a first known plan of the fortress by the construction foreman Zuan Baptista Bianchini: "Carlstadt, angefangen zu bauen 13.Jully 1579", construction began on Jully 13th 1579 (Nadilo 2003).
Karlovac was originally built as a renaissance fortress with earth walls and bastions at the confluence of Kupa and Korana and was named after its founder the Austrian archduke Karl II Franz Habsbsurg - Karlstadt. The fortress was built for protection against Turks, i.e. to stop further incursion towards Austrian countries, when old medieval and improvised fortresses proved to be ill suited to stop the invasion of the powerful Turkish army.

Image 1. The City of Karlovac "Zvijezda"

After cessation of Turkish threats, a prosperous city developed from the fortress, making good use of its excellent potential with respect to river and road traffic. Its significance somewhat diminished after the sea bound railway line was constructed, but the city developed into a successful industrial centre during the successive period of time (Nadilo 2003).
The idea on which construction plans were based is that of an ideal Renaissance town shaped as a hexagonal star with a central square and a rectangular street grid enclosed by strong earth ramparts and bastions (Kruhek 1995). Since beside Karlovac, there are only two other towns

of similar design in Europe (Palmanova in Italy and Novi Zamky in Slovak Republic, Image 2), therefore, the importance of its preservation is immeasurable (URL1).

Image 2. Palmanova (up) and Novi Zamky (down) (u.a. 1979)

Karlovac suffered extensive damage during the Patriotic War, as it was at the front lines of military confrontations. Much of the city centre and the surrounding area was damaged by shelling. But this was not the only cause of devastation. As the City expanded, vacant lots were built upon without regard for their historical value (URL2). Thus, much of original town areas, mainly the surrounding earth ramparts and bastions, are now irreversibly missing.

To stop further devastation, as well as preserve and possibly restore the remaining historic sites a study has been ordered which includes creation of a time section review of the City' development. The first part of the study entails digitalization of early city maps, georeferencing and creation of a 3D model and cross sections. As the project itself is still ongoing this first part of the study is what has been done so far and will be presented in this paper.

Although the first known map of Karlovac dates from 1579 (Lopašić 1993), that map was not suitable for 3D model creation because there were no elevations on the map. And why was that so important? The reason the 3D model had to be crated is to allow reconstruction of the earth ramparts. The idea behind this project is the restoration to the original fortification and defense design which ensured an unobstructed line of site across the moat from the walls outward, i.e. the earth ramparts were sloped to provide a perfect line of site for the artillery (Image 3). Thus, the restoration plan requires a precise 3D model comparable to the present conditions, which is why a map made by the Napoleons soldiers in 1818 was used for model creation.

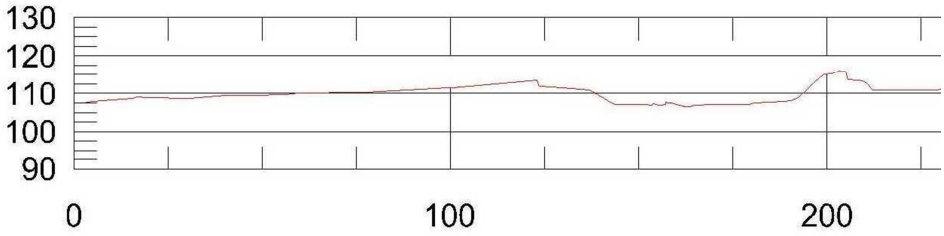

Image 3. A cross section segment depicting the slope of the earth rampart, moat and the wall of the fortress

As parts of Croatia, including the City of Karlovac, were under Napoleons rule at the beginning of 19th century, thus, the 1818 map was made by Napoleons soldiers (engineers). Still the inscriptions on the map were in German, and, as those inscriptions suggest, the map was made for the purpose of designing a new drainage system that would presumably prevent retention of water in the moat that was causing deterioration of earth ramparts. So, unlike the former "thematic" maps, this was the first "engineering" map of Karlovac making it suitable for the purposes of this project.

2. DIGITALIZATION AND GEOREFERENCING

As the above mentioned map is very old and rather delicate, it was important to find an appropriate method of digitalization which wouldn't cause further damage to the map. Thus, a special wide format flatbed scanner was used for digitization. It was the same scanner used for digitizing Croatian cadastral plans which themselves are also old and fragile. Unfortunately even that scanner proved to be too small, and, thus, the map had to be scanned in two segments.

The two segments were subsequently overlapped and merged using GlobalMapper software. GlobalMapper allows overlapping by selection of identical points and selection of method of transformation that is to be used for overlapping. As nine identical points were selected for overlap calculation the triangulation transformation method was used for conversion, thus minimizing incoherencies along the overlap area and the overall overlap error.

Once the two sections of the map were successfully overlapped and merged (Image 4), placing the map into a common coordinate system had to be attended. The fact that there was no common coordinate system at the time the map was made meant that the process of georeferencing had to rely on finding distinct common features on the map and the current cadastral plans.

This was done using GlobalMapper as the software allows import of vector data, as well as raster data, and export of georeferenced raster data for subsequent import into AutoCAD. Fortunately, the strict center of Karlovac, i.e. the "Star", hasn't been drastically altered over time providing a sufficient number of identical points for overlap. The center was, thus, primarily used for identification, but some additional common points were identified in the outer areas also.

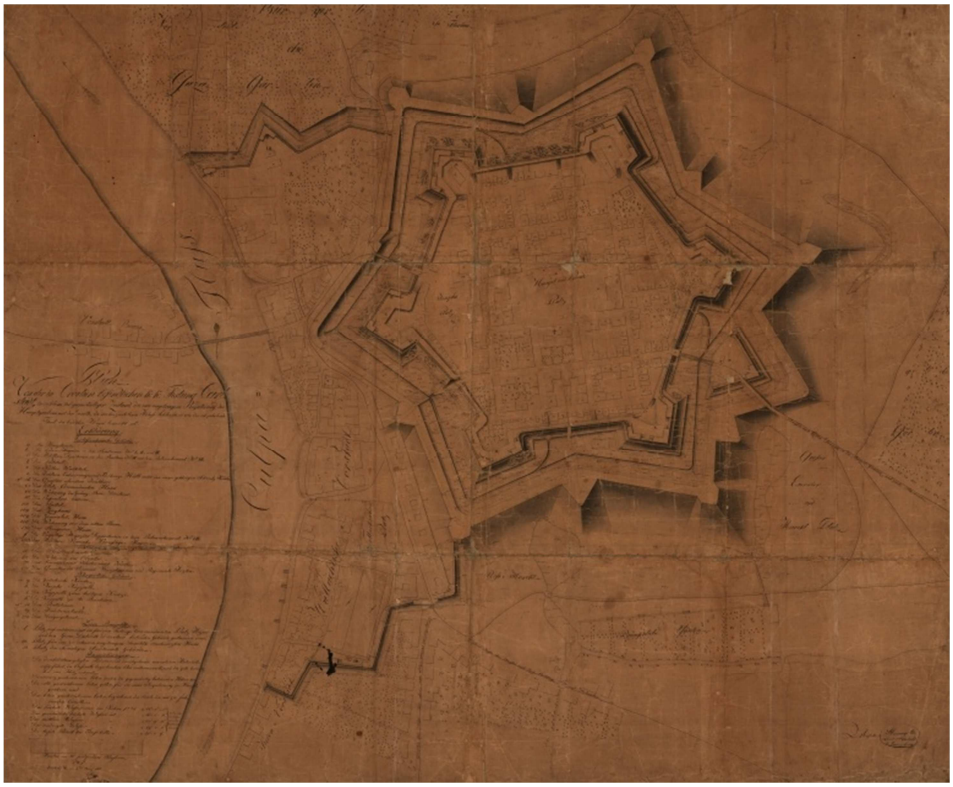

Image 4. A map of the Karlovac "Star" made by the Napoleons soldiers in 1818.

Considering the age of the map, the obvious deformations and tearing it has suffered and, presumably, the surveying accuracy achievable at the beginning of the 19th century compared to contemporaneous surveys, a compromise had to be made with regard to the overall adjustment accuracy. Thus, the town center was overlapped with an accuracy of roughly one meter while the outer reaches displayed discrepancies going even over eight meters. On a related note, as stated earlier, it is those outer reaches that changed the most over time through human intervention making the accuracy assessment in those areas rather bias.

3. VECTORIZATION AND 3D MODEL CREATION

Vectorization of the map was performed using AutoCAD Civil 3D. The task was far from trivial. As mentioned earlier there were no common coordinate systems in place at the time of map creation. Thus, the horizontal as well as vertical coordinate system origins were determined locally.

Since the map was georeferenced using current cadastral plans the problem of the horizontal coordinate system was resolved during that process (Image 6). But the vertical system was still an issue. Examination of inscribed elevations showed that an arbitrary high point was chosen as origin with the Z-axis pointing downwards meaning that elevated features were described with lower elevations and vice versa.

Additional problem presented itself in a form of "Klafter" units that were used during survey and consequently for map creation (Image 5). One Klafter is an equivalent of roughly 1.896 meters. The Klafter is then divided into 6 feet ('), 12 inches (") and 12 lines ("') which are,

then, respectively equivalent to 0.316, 0.026 and 0.002 meters. Since elevations were represented even in line units we can safely infer that elevation measurements were conducted in a highly precise manner.

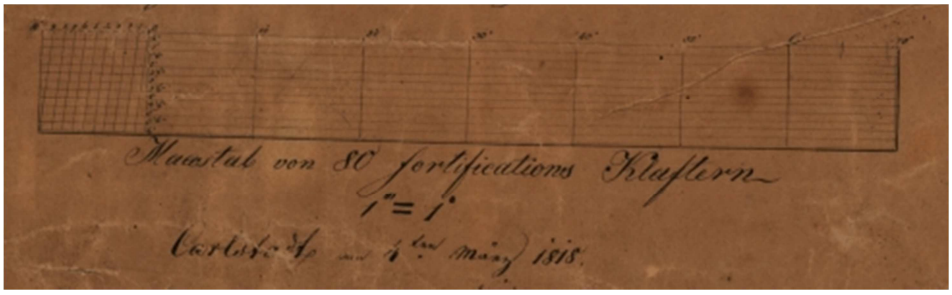

Image 5. Map scale in "Klafter" units

As the project required translation of Klafter unit into metric system, this was done by imputing values into Microsoft Excel table designed to automatically recalculate those units and then inserting the values as point elevations into AutoCAD.
After elevation points, feature lines were drawn. This was very important for surface creation because existing map elevation points are too scarce to produce a good surface model. Thus the surface needed to be supplemented with breaklines. Unfortunately, not all feature lines had endpoint elevations described, so guesswork and approximation had to be done to a certain extent for their creation.
Once the raster graphic elements were translated into vector graphics vertical adjustment had to be made. First order of business was to invert all elements vertically, i.e. to mirror them along the Z-axis. Mirroring provided a customary contemporaneous vertical representation with higher objects having higher elevations.

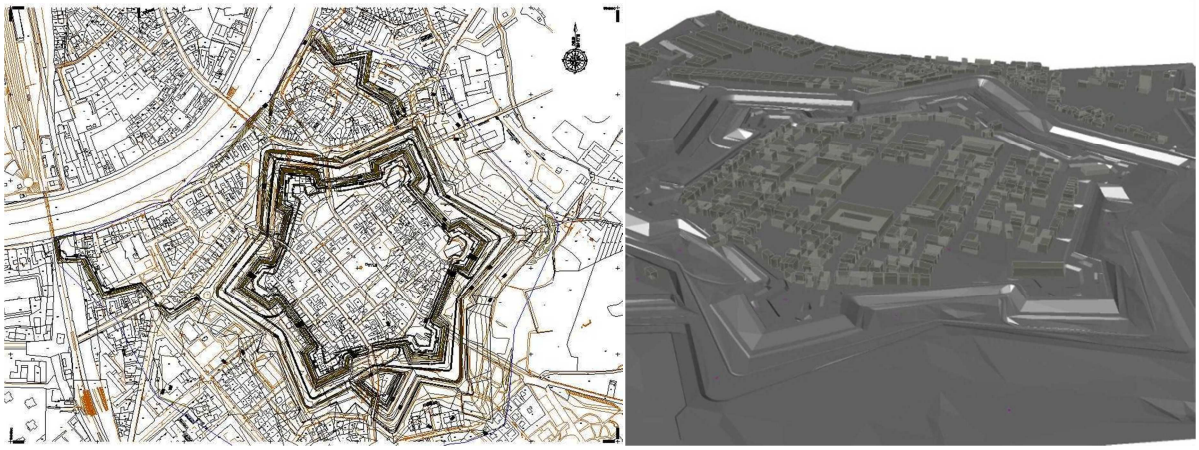
Image 6. Vector model overlapped over a cadastral plan (left) and a 3D model of the "Star" (right)

Second order of business came after surface creation. This also included some guesswork. Basically, a presumption was made that the elevation of the strict center hasn't changed (at least not dramatically). Thus, a comparison was made between the current level on six

discrete points located within the central area and the elevations of the designed surface on those locations. The mean difference in altitude was used for raising the surface to the desired level. Most of the elevation differences on those locations after translation were within ±5 cm, which was deemed satisfactory.
Buildings represented on the map were translated into a vector form, extruded and fitted to the model for, more or less, representation purposes (Image 6). The first phase of the study concentrates on walls and earth rampars of the "Star" meaning they were not important for this phase. Greater attention to buildings will, thus, be given in the second phase.

4. CONCLUSION

This paper presented the initial stage of the project conceived with the importance of cultural heritage in all its forms in mind, and, as with any spatially related project, the role of geodesist was found indispensable for creation of a competent, knowledgeable and above all relevant study. The task demanded the skills, experience and specific background knowledge on the history of survey and the coordinate systems that were in use.
The resulting model of the "Star" and its positioning in a referent coordinate system represent the first reliable and, thus, notable undertaking of its kind. So far, all preservation and archeological projects undertaken on the "Star" were based on pure speculative guesswork. Now, for the first time, any future findings can easily be identified as either relevant or dissociated to the "Star".
In the following phases of the project this model will be relied on, and enable informed decision making on the actions that need to be taken for the preservation and restoration of the "Star". Thus, does, once again, the often disregarded effort of geodesists, make preservation of cultural heritage possible on a higher level than before.

REFERENCES

Kruhek, M. (1995): Karlovac- utvrde, granice i ljudi, Matica Hrvatska- Karlovac, Karlovac
Lopašić R. (1993): Karlovac – povijest i mjestopis grada i okolice, Karlovac pretisak,
Nadilo B. (2003): Izgradnja renesansne tvrđave iz koje je nastao grad Karlovac, Gađevinar, no. 55, pp. 113-120, Zagreb
u.a. (1979): KARLOVAC 1579-1979, Historijski arhiv u Karlovcu, Karlovac
URL 1: http://katravel.hr/
URL 2: http://www.karlovac.hr

BIOGRAPHICAL NOTES

Luka Babić, born in 1982, graduated from high school in 2000 and enrolled into Faculty of Geodesy the same year. During his studies he already participated in various projects for the economy. After graduation in 2008 he found his first official employment on the Faculty of Geodesy were he started as a professional associate but was, in 2010, employed as a research assistant and started his postgraduate studies. During his employment he authored and coauthored four scientific and expert papers and presented them on international conferences.
He is currently actively involved in professional, research and European funding projects as

well as production and publication of papers.

CONTACTS

Mr. Luka Babić
University of Zagreb, Faculty of Geodesy
Kaciceva 26
Zagreb
CROATIA
Tel. +38514639524
Fax +
Email: lbabic@geof.hr
Web site: http://www.geof.unizg.hr/osobna.php?id=155