



A time section review of development of the City of Karlovac



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Rome, Italy 6–10 May

Knowing to: Manage the territory
Protect the environment
Evaluate the cultural heritage



History - Inception of Karlovac

- ❖ Construction began on July 13th 1579
- ❖ Originally built as a renaissance fortress with earth walls and bastions at the confluence of Kupa and Korana
- ❖ Named after its founder the Austrian archduke Karl II Franz Habsburg – Karlstadt
- ❖ The fortress was built for protection against Turks
- ❖ After it became prosperous due to traffic and river potentials and later due to industry





Ideal Renaissance town

- ❖ 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
- ❖ Since beside Karlovac, there are only two other towns of similar design in Europe (Palmanova in Italy and Novi Zamky in Slovak Republic, therefore, the importance of its preservation is immeasurable



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Historic preservation

- ❖ 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. 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.

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Historic map for 3D modeling



- ❖ Although the first known map of Karlovac dates from 1579, 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 created 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.
- ❖ 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.

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Historic map for 3D modeling



- ❖ 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.
- ❖ Unlike the former "thematic" maps, this was the first "engineering" map of Karlovac making it suitable for the purposes of this project.

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The map of the Karlovac "Star" made by the Napoleons soldiers in 1818.



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Digitalization and Georeferencing

- ❖ Very old and rather delicate map –appropriate method of digitalization - no further damage to the map - special wide format flatbed scanner was used for digitization.
- ❖ No common coordinate system - process of georeferencing - finding distinct common features on the map and the current cadastral plans.
- ❖ 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.
- ❖ 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.

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Vectorization and 3D model creation

- ❖ Vectorization was performed using AutoCAD Civil 3D
- ❖ no common coordinate systems in place at the time of map creation - 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.
- ❖ 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.

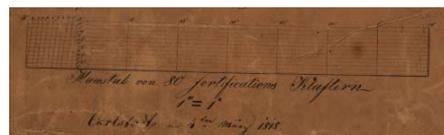
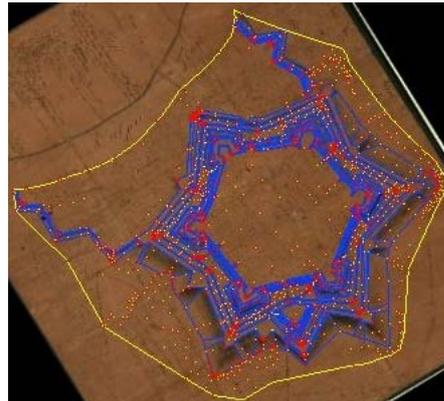
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Vectorization and 3D model creation

- ❖ Additional problem - "Klafter" units were used during survey and consequently for map creation.
- ❖ 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.



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Vectorization and 3D model creation

- ❖ Translation of Klafter unit into metric system and then inserting the values as point elevations into AutoCAD.
- ❖ After elevation points, feature lines were drawn. 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.



Vectorization and 3D model 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.
 - Second order of business came after surface creation. Basically, a presumption was made that the elevation of the strict center hasn't changed (at least not dramatically), 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.

Digital model – overlay with cadastre

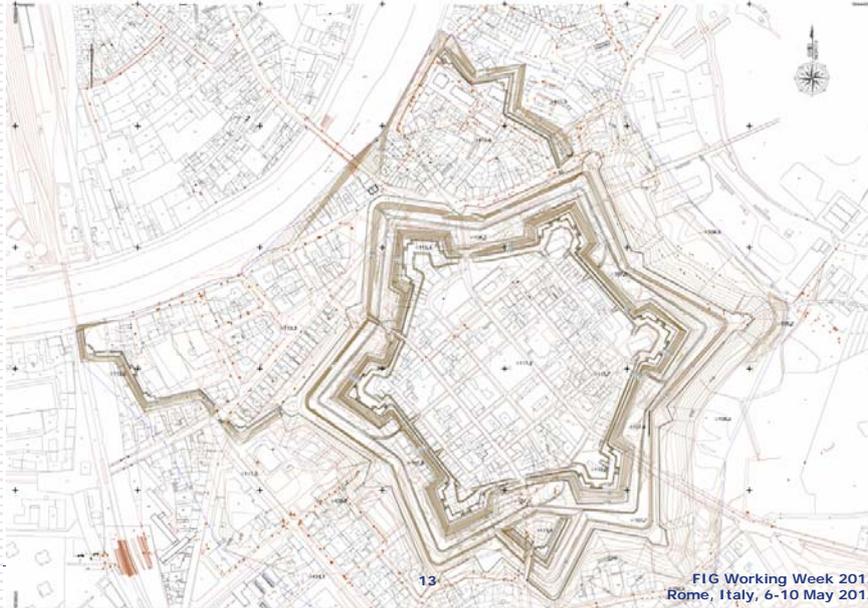
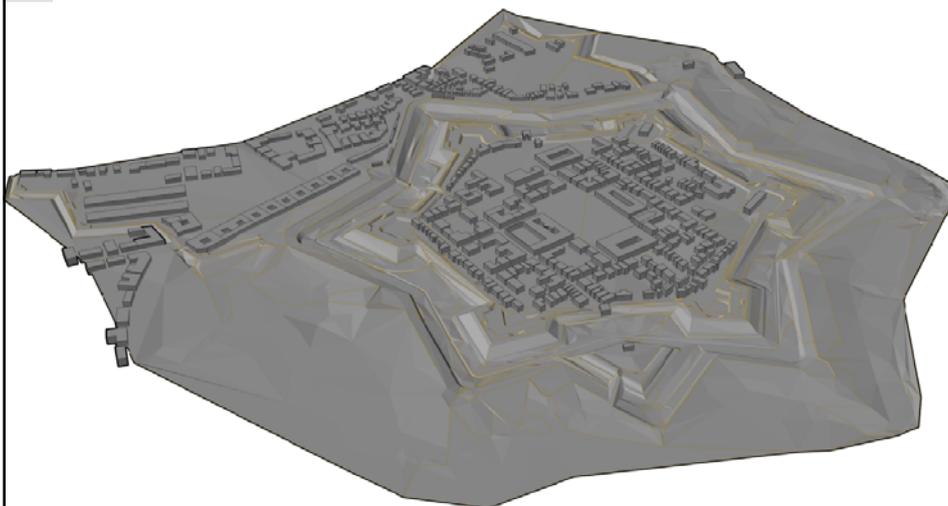


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Shaded 3D model



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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.

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Zaključak



- ❖ Kvalitetno izvedeno skeniranje i vektoriziranje – skenirana karta je predana Gradskom muzeju i tako trajno zaštićena
- ❖ Niska točnost mjerenja 1818 god.
- ❖ Preklop sa HDKS na osnovi katastra trebalo bi poboljšati sa stvarnim geodetskim snimcima identičnih dijelova – slijedeće faze
- ❖ Izrađeni 3D model predstavlja modernu reprezentaciju stanja sa karte iz 1818. god
- ❖ U specijaliziranim softverima bilo bi moguće napraviti realističnu vizualizaciju Karlovca iz 1818.
- ❖ Daljnje analize i kvalitetnija usporedba 1818. – 2012. moguća tek po izradi novih snimaka

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