

## RELIEF AND DIGITAL METRIC RESTITUTION OF MOSAIC FLOORS OF MEDIANA

Mediana is concentration of various constructions from III<sup>o</sup> - IV<sup>o</sup> century a.C on a territory of forty hectares, near the river of Nišava and thermal waters. It is supposed that Mediana had two construction stages – the first one in 319 a. C. and the second one around a year 330, after a previous destruction. Infact, it is supposed that a triclinium and rustic villas, which today are on a territory of Electric Industry, belong to the first construction stage and at the same time there are materials from this stage used as a construction material in the next one. The villa with peristyle, *horreum*, the building with an octagonal tower and military sheds were build during the second construction stage. (fig.1)

Even though Mediana is located near the road the leads to Sofia and Costantinopoli (the road that today connects Niš to Niška Banja), there are no news of this archeological site until the beggining of XVI century.

Felix Kanic, a german scientist, was the first one to start archeological inquiries on Mediana in 1864. After these first researches, the site of Mediana was exposed to a continuous destruction while material of its buildings was used for a construction of a nearby village, Brzi Brod. Various collectors got in a possession of sculptures and metallic objects which were later sold or dispersed in private collections.

Adam Oršić Slavetić supervised the enquiries that started in 1933. A Museum and its administration were formed after discoveries that were found until the '30 and this institution overtook the research which continued in the period 1934 – 36. During this time thermal baths, *ninfeum* and *horreum* with *pitos* are found. In 1936 ninfeum was protected by a cement construction, which later became a building of Mediana Museum. In august of 1961 the archeological research is done on a vast territory, in an area of nearly 100 hectares while some detail inquiries are done on a section that contains antient imperial residence. Using 246 layer samples something like 80 buildings were found, from luxurious villas to administration and commercial constructions, even though they were rather destroyed.

All private constructions indicate that Mediana was a luxurious suburb of Naissus, an imperial residence and an economic centre of this area. According to the last inquiries, this site has around eighty buildings, although only few of



Fig. 1 Archeological site of Mediana. Aerial view.

Сл. 1. Археолошко налазиште Медијана.  
Поглед из ваздуха.

them have been explored and exposed to public.

According to an agreement, a collaboration has been established between a Politecnico of Milan and Niš University, and as a first study case it had an archeological site of Mediana and its mosaics.

Rilief operations took place with sophisticated topografic and photogrammetric apparatus, and later integrated with consistent direct relief operations to obtain Ground Control Points necessary to prosecute photogrammetric images.

Metric and analogic images, in this case, are afterwards transformed to digital format by scanning operation at a very high resolution in

order to proceed with a restitution with the Analytical Rectification Method. This operation was followed by a necessary radiometric equalisation and an analytic fotomosaic operation. (fig.2)

In order to project a fotogrammetric coverage of Mediana mosaic floors, it was necessary to consider various facts. On this site, there are beautiful Ninfeum mosaics covered by a Museum building so some sophisticated illumination devices would have been needed. They were not possible to obtain for the already fixed period of operations so outside mosaics were chosen to be relieved.

The rectangular peristyle of the main villa has mosaic floors that have been covered with a layer of earth, in order to be protected, for the last thirty years. An agreement with a Serbia and Montenegro superintendence office provided for an elimination of a protective layer only for one wing of the peristyle. The east wing was chosen as a section to be relieved, since it is the most distant one from the present site entrance and thus less exposed. (fig.3)

On the site the possibility to relief another two already uncovered figurative mosaics, Medusa and Fluvius, was verified. (fig.4;fig.5)

The camera that had been used for the relief is a semimetric analogic Rolleiflex 6008. The film used was a roller 120, of dimensions 6 x 6 cm, with 12 exposures. The objective Distagon 4/40 has a focal length of  $f = 40,42$  mm



Fig. 2 East wing mosaics

Сл. 2. Мозаици у источном крилу



Fig. 3 Mosaics of the west wing of peristyle

Сл. 3. Мозаици у западном крилу перистила

and a shutter electronically controlled with time that varies from 1/500 to 30 sec while the depth of the field is easily controlled by button for diaphragm closure. (fig.6)

Some “tryouts” were done with films in positive and negative in order to have greater quantity of material to chose from for the operations in laboratory and possibly indentify the best one to use for the next reliefs on this site.

For Mediana mosaics the method of terrestrial photogrammetry was used

In general, in terrestrial photogrammetry the object to relief is vertical (facade, walls etc.) while optic axes is horizontal. Here, on the contrary, the optical axes is rotated for an angle of 90° in order to be verical with a direction towards the mosaic floors.

Considering the fact that the floors of east wing is around 3m wide and that the scale of the final product was supposed to be 1:10, some calculus were done in order to obtain oportune height for the cameras objective.

Using the equation:

$$1/L = f/h = 1/n$$

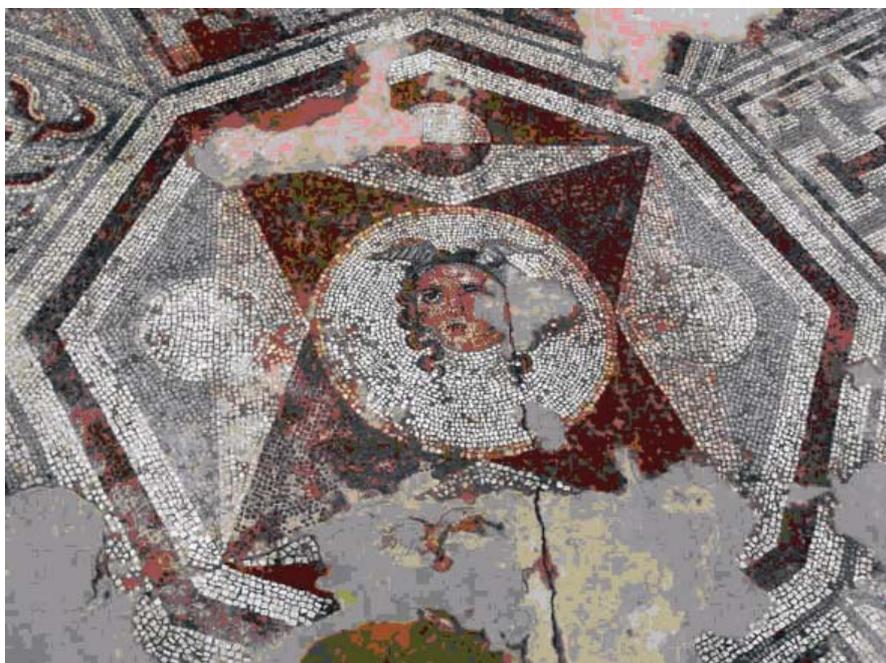


Fig. 4 Medusa

Сл. 4. Медуза



Fig. 5 Fluvius

Сл. 5. Флувијус



Fig. 6 Some semi metric cameras  
Сл. 6. Неки семиметријски фотоапарати



Fig. 7 Operation on the site: the camera fixed on an iron frame

Сл. 7. Рад на терену: фотоапарат причвршћен на челични оквир

where:

$l$  – photogram dimension;

$L$  – dimension of the ground covered by one photogram;

$f$  – objective focal length;

$h$  – height of the objective.

$$h = (L \times f) / l = (300 \times 4,042) / 6 = 202,1 \text{ cm}$$

In this way, the determined distance between the camera and the mosaiced floor was calculated to be around 2 m. This value nonetheless varied during the numerous exposures but it was always written down in the work diary. (fig.7)

During the first working day on the site, the sun movement was observed in order to find the best light for homogeneous exposures and the period in which the shadows are as minimal as possible. Since there were various shadows in different places of mosaics, the final decision was to carry out the exposures with the negative films during sunset (around 5 – 6 p.m.), while the positive films were used with the sunrise light (around 5 – 6 a.m.).

The first operation in the site was to put down the targets to be framed by the camera. Targets have dimensions of 2 x 2 cm.

All targets were numbered in order to be recognisable in the next operation phases. (fig.8)

The positioning of the total of 51 targets on the whole portion of east wing was done so as every exposure contains five of them, located in three different rows (figure above).

The targets were positioned 25 cm from the left border and with a distance of 250 cm between each other so as to form an hypothetical square. All the central targets, positioned on the intersection of diagonals of the imaginary square, are at a distance of 250 cm one from another.

Unfortunately, the north portion of the east wing floor is covered by an only 2 m high shed that obstructed the access to covered mosaics with the iron frame.

The relief was done to the point where the shed begins for a total of about 45 m of mosaic floor in 16 exposures.

During the exposure, the target aimed was always the central one while it was checked that other four entered the frame as well. As mentioned before,

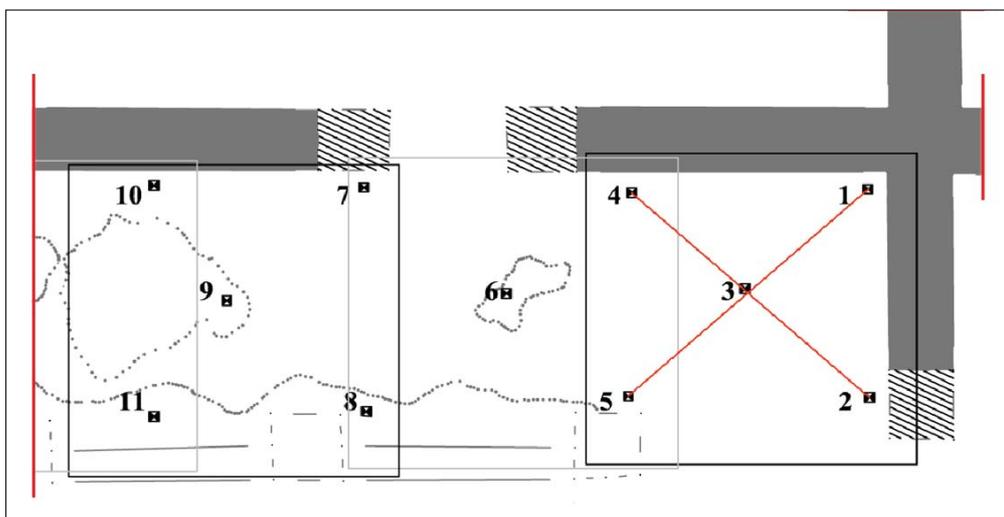


Fig. 8 Target positioning: east wing of villa's peristyle

Сл. 8. Фиксирање циља: источно крило перистила виле

both negative and positive films were used so as to have greater range of photos to choose from in order to obtain the final product – orthophoto.

Since the mosaics of the east wing are delimited on the east side by a remaining wall of villa (around 60 cm high) and on the west side by an arcade base (30 cm high), it was necessary to observe with attention the sun movements in order to avoid any possible shadows.

As long as figurative mosaics, Medusa and Fluvius, are considered there were no obstacles that created shadows so it was possible to proceed with a photogrammetric relief in the direction east – west and avoid the shadows given by the iron frame.

The exposures were taken in the same way as the ones for the east wing mosaics. The only difference was a target number because both of the figurative mosaics are of smaller dimensions. Targets used for Fluvius were only eight, while for Medusa only nine were needed.

In the first case, the aims used during the exposures were targets T92 e T95 while in the second one all central targets were aimed (T2, T5 e T8).

The graphic scheme of target positioning can be observed in two figures below. (fig.9; fog.10)

After the exposures were made with a semi metric camera, trigonometric measures were taken for all targets of the three mosaics.

In addition, some monograph drawings were done for all three mosaics, containing the most important informations about their general condition and degradation.

Geometricians of the firm GEOSISTEM have done a topographic relief and the main data in dwg format were given to Politecnico team.

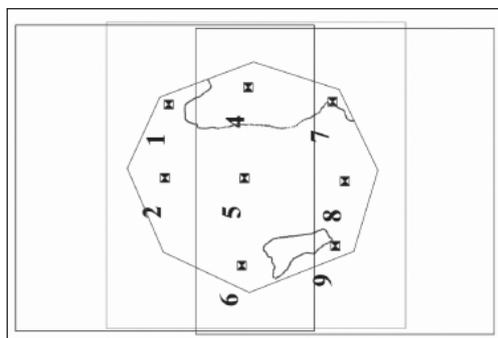


Fig. 9 Target positioning: Medusa  
Сл. 9. Фиксирање циља: Медуза

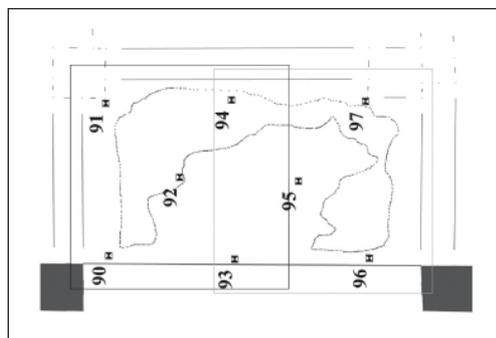


Fig. 10 Target positioning: Fluvius  
Сл. 10. Фиксирање циља: Флувијус

This kind of relief is done by a *total station* with a electromagnetic distancemeter. The instrument is positioned in point chosen as a “coordinate origin” while the reflecting prisma is positioned on the points to be relieved. (fig.11)

The physical phenomenon used to determine the distances is a propagation of electromagnetic waves divided in two different operations: one is a modulation of the outgoing wave with the out of phase measurements after its return to the emitting source, obtained by a reflection of the prism; the second emission is an impulse with the value of time that passes between the emission and the reception. In this way it is possible to measure distances between the coordinate origin and the points to relief. With an analogous method it is possible to measure level difference as well, in order to obtain the elevation of different points. With the topographic relief all the necessary information for the orientation of fotograms, both internal and external, were obtained.

Furthermore, since these informations were transfered to an AutoCad file it was possible to insert the final product in a general site plan with appropriate scale.

Once in Milan, all 14 films were developed and all photograms were scanned using high resolution (1600dpi). Every single fotogram was named using a nomenclature **filmn° of exposure\_T target n°** where the number of film, the number of exposure and the number of the target aimed during the exposure are found.



Fig. 11 Total station  
Сл. 11. Цела станица



Fig.12 An example of a photogram of third film (target n° 6)

Сл. 12. Пример фотограма од трећег филма (циљ бр. 6)



Fig. 13 Rectified photogram (target n°6)

Сл. 13. Ректификовани фотограм (циљ бр. 6)

Using an example of the next figure, it is possible to find out the position or any photogram in the digital archive. It is an exposure n°4 of the third film with the central target T6. Its name will thus be **ruzzo3\_04\_T6**.

In this way an easy to consult digital archive that contains all photograms of Mediana mosaics was made.

Thereafter, the choice of photograms that could make an ipotetic strip was made. Only the ones of negative films were used since the ones made with positive films had colours unacceptable for the final product. A 16-photo sequence was made and its radiometrical modification was done with PhotoShop program in order to obtain images of homogeneous colour and illumination. An analogous method was used for mosaics of Medusa and Fluvius. (fig.12;fig.13)

In the next work phase **OrthoEngine** program was used to rectify all digital images and proceed with a fotomosaic operation in order to obtain the final product – orthophoto. For this purpose, it was needed to prepare the files necessary for the program mentioned: file *txt* and a file in *dxf* of the Ground Control Points (this kind of conversion is done by using software of AutoCad and *tcmr\_2\_dxf*). In cases of significant elevation change it is necessary to have separate files, deviding the area in portions with a similar

medium elevation in order to have a medium plane of rectification of a single photogram. Infact, as far as Mediana is considered three different documents-

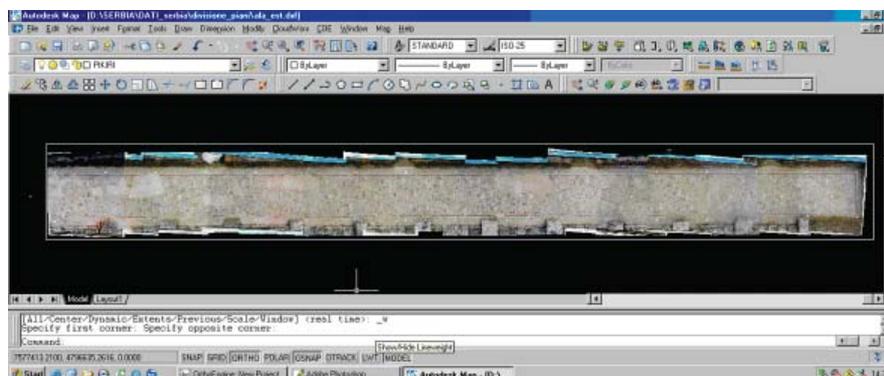


Fig. 14 The view in AutoCad of the mosaic's orthophoto and the Ground Control Points

Сл. 14. Изглед ортофотографије мозаика и контролних тачака на земљи дат у "AutoCad" програму

were made because there was a change of the medium elevation of 19 cm between the first and the last photogram.

Thereafter a *fotomosaic* operation image was made with 16 fotograms in order to obtain an orthophoto of mosaic of Villa's east wing in 1:50 scale. This document offers two different types of informations, the qualitative and the quantitative ones. In this way it is possible to observe the photografic image of the mosaic and have a precise measures of its every part. It is furthermore possible to read elevation values of different points and obtain, if necessary, information that considers the variation of their third dimension.

The figure below represents the final product viwed with AutoCad. The white crosses are the Ground Control Points and they correspond exactly to the targets fixed on the mosaic floor. Those are the ones to determinate the final product precision and thus the scale in which it is to be done, 1:50. (fig.14)

Analogous operations were done for other two mosaics, Fluvius and Medusa. Since of smaller dimensions, they were framed by only two photograms. Their *photomosaic* thus was much more simple to execute.



Fig. 15 Medusa: orthophoto and its details

Сл. 15. Медуза: ортофотографија и детаљи

Once again the product is an orthophoto with analogous information as the ones of east wing mosaics but in a larger scale, 1:20. (fig.15; fig.16)



Fig. 16 Fluvius: orthophoto and its details

Сл. 16. Флувијус: ортофотографија и детаљи

#### BIBLIOGRAPHY

- Achille, C., Brumana, R., Fregonese, L., Savi, C., Monti, C. *3D models generation from laser scanner data to support digital orthophoto 3D: the mosaic surface of the floor of S. Marcus Basilica in Venice*, Commission V Symposium, Atti ISPRS WG V\4 - Close-range vision, Corfù, Greece 2002.
- Achille, C., Fregonese, L., Savi, C., Monti, C. *Advanced methodologies for surface analysis: methods, comparison and monitoring of the mosaic surface floors of the St. Mark's Basilica in Venice*, CIPA 2005, XX International Symposium, Torino 2005.
- Bezoari G., Monti C., Selvini A. *Misura e rappresentazione*, Casa Editrice Ambrosiana, Milano 2001.
- Brumana, R., Monti, G., Vio, E. *Laser scanner integrated by photogrammetry for reserve engineering to support architectural site and restoration of the mosaic floor inside St. Mark's Basilica in Venice*, CIPA 2005, XX International Symposium, Torino 2005.
- Petar Petrović *Mediana: residencija rimskih careva*, Srpska akademija nauka i umetnosti, Beograd 1994.
- Vio, E., Lepschy A. *Scienza e tecnica del restauro della Basilica di San Marco: atti del Convegno internazionale di studi*, Istituto veneto di scienze, lettere ed arti, Venezia 1999.

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РЕЉЕФНА И ДИГИТАЛНО-МЕТРИЧКА РЕСТИТУЦИЈА  
ПОДНИХ МОЗАИКА МЕДИЈАНЕ

Описани су радови обављени на рељефу мозаика из IV века у вили лоцираној на археолошком налазишту Медијана у Нишу.

Рељефне операције на налазишту изведене су помоћу модерних топографских и фотограмских мерних инструмената, заједно са мануелним рељефним операцијама, како би се обезбедиле контролне тачке на тлу потребне за обраду слика.

Слике, у овом случају аналогно-метричке, које су дигитално обрађене, скениране су у високој резолуцији ради процеса реституције методом аналитичке ректификације, и подвргнуте неопходном радиометријском уједначавању и процесу аналитичког прецизног фото-мозаика.

