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THE URBAN PLANNING OF DOCLEA: REMOTE SENSING AND TOPOGRAPHICAL SURVEY

1. Introduction

One of the most innovative aspects of the Doclea project is the interdisciplinary approach that enables surveying at different levels of scale: from the diachronic analysis of the landscape use, we can pull back the focus to the reconstruction of the urban organization, or go down to a detailed analysis of the individual monuments.

In this paper we present some preliminary observations concerning the urban planning of Doclea, with particular attention to the shape and extent of the urban layout. The hypotheses are based on the results drawn from study of the published data, analysis of ancient and modern cartography and systematic aerial (drones and satellites) and topographical surveys. It is important to appreciate that a methodological approach based on remote sensing data and their photo-interpretation was never to now adopted in the study of Doclea.

F.C., P.Me., P.Mo.

2. Doclea and the Roman province of Dalmatia

Doclea is one the most thoroughly explored cities in the SE part of the Roman province of Dalmatia. Lying at the confluence of the rivers Zeta and Morača, near the Skadar Lake, the Flavian *municipium* of Doclea is located in the interior of the Roman province, between the Adriatic Sea, which was characterised by an early process of Romanization and urbanization, and the inner mountain area, which was abundant in raw material deposits but difficult of access and inhospitable and therefore less permeable to Roman cultural influences.

Apart from the railway constructed between 1947-1948, which divided the city into two parts and permanently destroyed many archaeological structures, the absence of modern buildings and the lack of intensive agricultural activities means that Doclea today preserves to an extraordinary degree both its urban and architectural combination, whose layout is still intelligible in its basic components. The Roman city has been the focus of systematic archaeological investigations since the end of the 1800s (see Burzanović, Koprivica this volume). At the beginning of the 1900s, the first plans of the inhabited area were drawn up and the main public building structures were

investigated. Piero Sticotti's plan (1913) is certainly the most complete and reliable one (Plate 1).

No significant and systematic urban-planning studies were conducted in Doclea until the new millennium. As a consequence, scholarly attention was mainly devoted to making an architectural comparative evaluation between the main Roman buildings of Doclea (*forum*, *Capitolium*, *basilica*, temples, *thermae*, etc.) and those of other well- or less-known Roman cities (see Sfameni, D'Eredità, Koprivica this volume). As for the urban-planning layout, Doclea has generally been defined as a city built to conform to the terrain, probably without a regular plan, but with its main road axes well-identifiable (Rinaldi Tufi 2004).

From 2000 onwards, new strategies of data acquisition techniques and the development of geo-referencing methods in a GIS environment aroused the interest of a number of archaeological research teams. At the same time, renewed attention was paid to the urban planning and monumental architecture of the Roman cities in Illyria, in Dalmatia and along the coasts of the Adriatic Sea[1]. Doclea and its territory became a magnet for experts attracted both by the favourable ground conditions for the undertaking of geophysical and remote sensing survey activities and for experimenting with drone-mapping technologies[2]. All the efforts were concentrated on re-interpreting archaeological remains, integrating past documentation to achieve new technological outcomes, and producing 3D virtual reconstructions of its architectural and urban heritage.

In particular, during the first decade of the 21st century two important interdisciplinary initiatives were promoted. As part of the 'New Ancient Doclea Project', jointly sponsored by the Municipality and the Museum of Podgorica, the British School at Rome along with the Archaeological Prospection Services of Southampton University, a geophysical survey was conducted (Pett 2010), while the Urbino University 'Carlo Bo' undertook a topographic and building survey (Rinaldi Tufi, Baratin, Peloso 2010; Baratin, Checcucci, Peloso 2010). A GIS platform was implemented, a new digital map and a DEM of the Roman city were produced, and parts of the ancient *forum* were reconstructed by laser scanner surveying techniques. As part of the second project, also sponsored by the Podgorica Municipality and focused on Doclea in the late antiquity and early medieval periods, the Venice University Ca' Foscari

[1] De Marinis *et al*. 2012, and in particular Rinaldi Tufi 2012; for an update see the journal «New Antique Doclea» and for ICT projects and virtual reality applications, see also Moscati in press. As an example of an innovative research project on the Roman *castrum* of Burnum, jointly promoted by Italian and Croatian scientific institutions and aimed at integrating new technological solutions, see lastly Campedelli, Dubbini, Monica 2017.

[2] See in particular the docu-film 'Italia e Montenegro, solo un piccolo mare', produced in 2016 by the CNR-ITABC (http://www.itabc.cnr.it/progetti/italia-montenegro-solo-un-piccolo-mare).

(Gelichi *et al*. 2012) carried out a new digital survey of the main ecclesiastical buildings, superimposed their plans on the numerical map of the city, and made a census and comparison of the wall techniques.

In 2017, as part of the CNR 'Joint Archaeological Laboratories', the Italian and Montenegrin team jointly promoted a new research project, which is now in progress. One of its first actions was to gather past and new archaeological documentation of the ancient city of Doclea onto a single digital platform. Two new digital base maps were created to support the research activity. The first one (Plate 2) shows the central part of the city, with Roman remains and the railroad layout verified on site thanks to the integration of several multi-sources data (archival and cadastre maps, satellite and drone orthophotos) and surveying methods (onsite GPS survey and total station measurements).

In the second one (Plate 3), using the satellite image of the urban area as a basis, the results of both geophysical prospections (red) and archaeological survey (green), as well as GPS data concerning architectonical elements and the cross of roads (cyan), are geo-referenced and shown in multiple colors. Lastly, the blue lines show the hypothetical reconstruction of the urban layout, based on terrain data and some urban comparisons in Italy and in the Roman Provinces, as well as on latest trends in the topographical studies of the 'geometric' urban grids of Roman cities (see lastly Sommella 2018).

P.Mo.

3. Methodological aspects

3.1 *Investigation by remote sensing*

The term 'remote sensing' refers to all the remote photo-shooting systems; in this project all the passive detection systems (Gomarasca 2009), installed on satellite, aerial and unmanned aerial vehicles (UAV), have been included in order to support traditional surveys and operate at various levels of scale and time. We have therefore selected a dataset compiled from sources of several periods, consisting of historical and recent cartography, aerial photos (in particular, a very clear historical photo taken during the World War II[3]), and finally recent drone and satellite images in raster format (Tab. 1).

The quality and quantity of information that can be deduced from the remotely sensed images depend on the technical specifications of the sensors used during the shooting phases. The spatial resolution is among the most important features of the observation systems, as it is related to the ability to

[3] Istituto Geografico Militare, Firenze, 1942, Flight 26.09.1942, series 52, frame 42.

DATASET	RESOLUTION	FORMAT
GeoEye-1 Satellite images belonging to Google Earth™ 2017 Google Inc., acquired on 17th October 2016	2 m/px, 0,25 m/px, 0,125 m/px	raster
Satellite images (World View-2, World View-3 and GeoEye-1) belonging to Google Earth™ 2017 Google Inc. acquired from 29th August 2014 to 14th August 2016	0,25 m/px	raster
Detail of World View-3 satellite image belonging to Google Earth™ 2017 Google Inc. acquired on 15th June 2015	0,25 m/px	raster
World View-3 satellite images belonging to ©Esri ArcGis of Digital Globe and Compagnia Generale Riprese Aeree (CGR Spa) acquired on 29th August 2014	0,84 m/px	raster
Images from UAV, model Phantom 4 Pro, acquired on October 2017 and April 2018	0,02 m/px	raster
Cartography of the site with emerging structures		raster
Plan of Doclea designed by P. Sticotti (1913)		raster
Re-elaboration of the site cartography (from General Plan 2008. Archaeological Remains and Anthropical Elements, TAV 06), with plans of the monuments (Gelichi *et al.* 2012)		raster
Digital Terrain Model (DTM)	20 m	raster
Map of the archaeological survey	1:25.000	raster
GPS points		vector
Extraction of contour lines		vector

Tab. 1

interpret the detected scene. For this work, we used images with a very high spatial resolution (2 cm/px).

The aerial photos acquired by means of a drone (Phantom 4 Pro model) have been subjected first to a pre-processing phase, before being used for the interpretation. In this way it was possible to obtain the geo-referencing of the raw images and to make them geometrically appropriate to the chosen reference system (UTM, WGS84).

During the archaeological photo-interpretation phase, different processing techniques have been applied, to better emphasize the minimal differences among the pixel values in terms of colour, hue and saturation (Liu, Mason 2016). Finally, the images have been interpreted from an archaeological and topographic point of view, trying to attribute a precise meaning to each single trace, and then comparing it with our hypotheses and with the results obtained through the archaeological survey.

P.Me.

3.2 *The archaeological survey*

The survey has concerned the territory within the city walls, with the following two objectives in mind: first, the control and geo-referencing of the monuments still visible above ground that were studied and surveyed by the British team at the end of the 19th century (Munro *et al.* 1896) and by Sticotti in 1913 (Sticotti 1913); and then the identification and positioning

of the emerging structures probably related to the residential quarters of the city (Fig. 1).

For reasons of clarity in terms of visibility, the research has mainly focused on the land between Zeta and Morača, southward of the *forum*, while the area to the E of the paved road (*cardo maximus*), from the *forum* to the churches area, will be explored in future field campaigns, as it is now covered by dense vegetation. The territory chosen has been surveyed completely, resulting in an almost total coverage of the area under investigation (Fig. 2). In some places the growth of short-lived vegetation and the accumulation of stones prevented investigation, as in the case of an area S of the temple of Diana. Particular attention was paid to the analysis of dry stone walls, which today have the function of dividing up the landscape, but which in many cases follow the orientation of the Roman city. Below them, in fact, it is possible to identify the alignments of the Roman structures, recognizable by the presence of more regular limestone blocks and by the use of mortar.

The emerging walls were positioned by means of a differential GPS Topcon GR5 that offers an accuracy of about 1 cm. The antenna reference has always been placed at a fixed point inside the *basilica*, while the rover, mounted on the pole, has been used in the stop-and-go mode (Gabrielli 2001; Colosi, Gabrielli, Lazzari 2006). By using the rover, the coordinates of the corners of the structures and the alignments of the walls have been acquired (Fig. 3A), so that they could be inserted and studied within a Geographical Information System (GIS) (Fig. 4).

F.C.

3.3 *The GIS construction*

The historical-topographical study of this area was greatly facilitated by the use of a GIS, through which a large volume of data, also heterogeneous, related to the Roman city in all its natural and anthropogenic components, were managed, analysed and processed (Biallo 2006). The combination of remote sensing techniques with a GIS allows one to elaborate and manage large quantities of spatially distributed data. These techniques are ideal for advanced site-selection studies and their application for archaeological sites. The GIS collects, on different layers, the cartographic data, the 3D modelling of the terrain and historical buildings, the georeferenced database with some fundamental contents (such as the archaeological map built on the basis of the literature), the map of the archaeological investigations, and the photo-interpretation of the remotely sensed images (Cirelli 2016, 210).

In order to represent the natural elements of the landscape, a land-use map, a gradient map and an altimetric map have all been constructed. The 3D gradient map is important in order to understand the altimetric characteristics

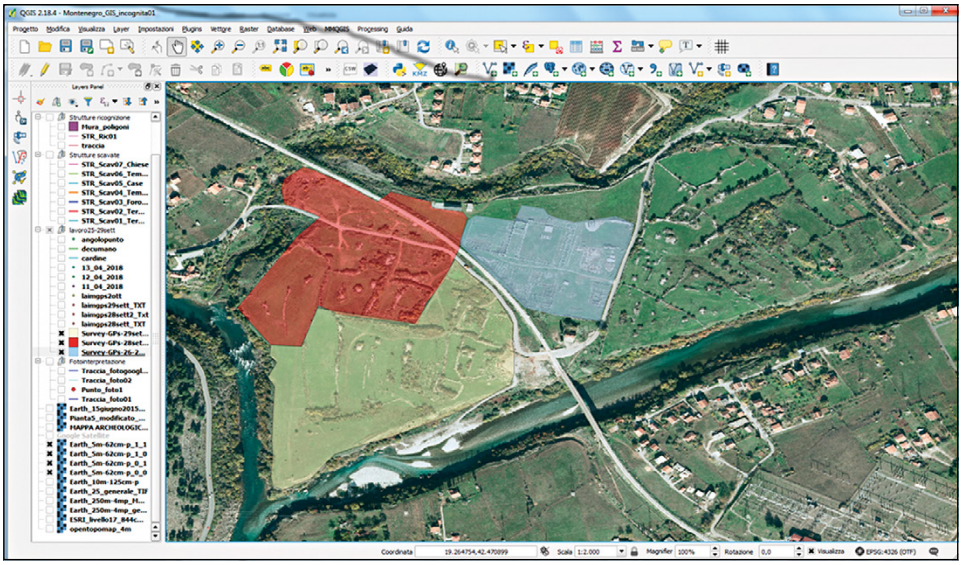

Fig. 1 – GIS elaboration, with the extension of the surveyed area.

Fig. 2 – The territorial survey. The image displays the survey routes followed on three different days, as registered by tablet.

Fig. 3 – A: acquisition of coordinates by means of differential GPS; B: corner of a masonry structure standing in the SE part of the Doclea plateau; C: paving in limestone slabs covering a channel in the SW part of the plateau; D: stone paved road identified during the survey.

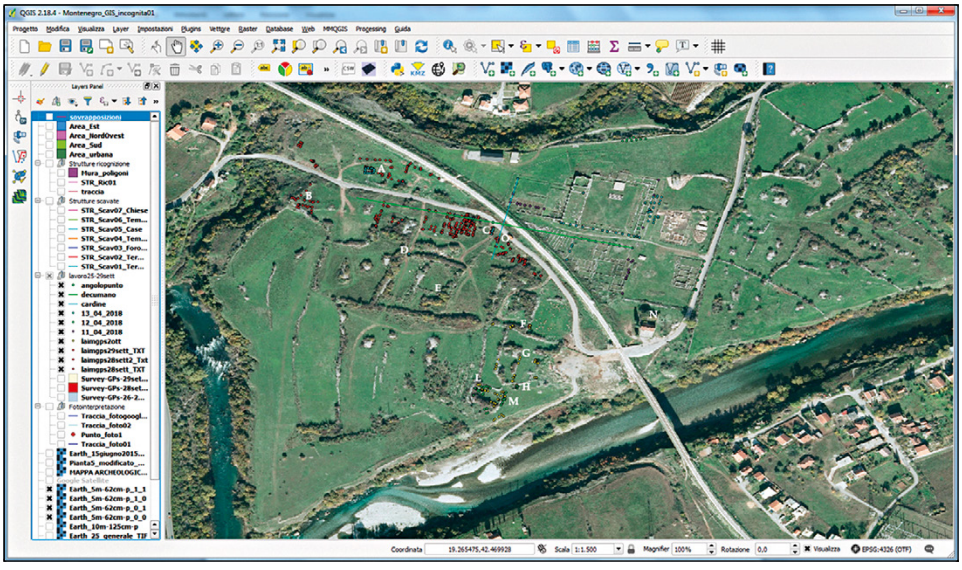

Fig. 4 – Satellite image with the GPS points superimposed. The different colours correspond to the different days of acquisition.

of the territory. To produce this map, the Spatial Analyst extension of the QGIS software was used: in this way we obtained a series of classes in which the highest value represents the maximum slope on the territory.

The possibility of separating or overlapping the different layers, each representing a specific theme or set of information, and the opportunity of questioning them and relating them to each other in variable combinations, produced objective information and a synoptic view of the archaeological site, useful for a better reading and interpretation of the settlement model.

Moreover, the GIS provided useful elements for the future processing of models aimed at protecting the site and its environs. The GIS is an 'open' tool: it is possible to update or enrich the data with greater detail or add new information acquired during future archaeological and aero-topographic researches. In fact, the updating of information should be continuously reviewed and improved, given the speed of changes and alterations that occur in a landscape subjected to anthropic activities and, at the same time, to environmental phenomena.

P.Me.

4. The results of the topographical investigation

4.1 *Interpretation of the remote sensing data*

The city of Doclea, located within a large trapezoidal plateau, stands at the confluence of two important waterways, which run along the southern side (Zeta) and along the western side (Morača), while the northern side is bordered by a small stream (Širalija). Within the archaeological area of Doclea, there are no modern buildings. Though there are agricultural activities, part of the terrain is left uncultivated. The actual landscape conserves yet today some elements of the Roman city: the walls and several other structures are present on the surface. The *forum* is located in the centre of the city; the remains of the *basilica*, of the *Capitolium* and of two bathing buildings, the so called small and large *thermae*, cluster round it.

On the remotely sensed images, the perimeter of the city is visible as a clear line. On the eastern side, the walls are placed next to a darker trace, attributed to a ditch or moat. Further, the northern side of the settlement is protected by walls which follow a non-linear course while, along the southern side, the walls extend along a line that follows the river.

The continuity of the walls is interrupted by two urban gates, still today identifiable by the presence of the roads which pass through them (Živanović, Stamenković 2012). A gate represents a potential vulnerable point within a defensive structure: it requires garrisoning, bastions or defence towers. One structure identified on the N walls has been investigated by a recent

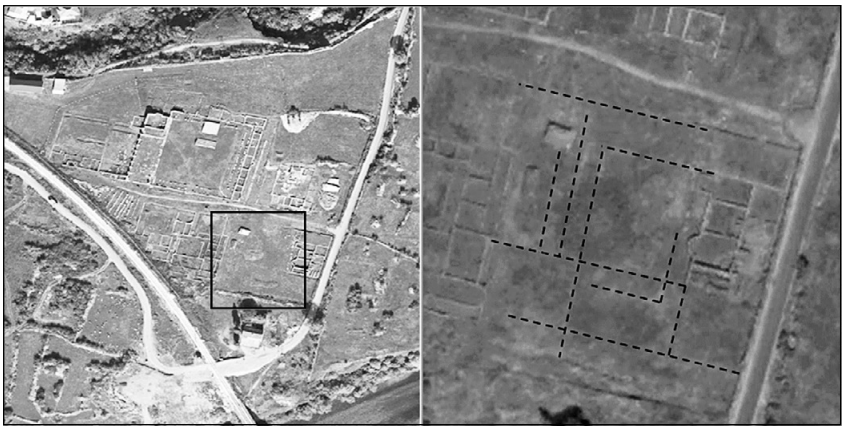

Fig. 5 – Satellite image of the *forum* area. On the right, the archaeological photo-interpretation of the *thermae* zone (World View-3 satellite image belonging Google Earth™ 2017, Google Inc. acquired on 15th June 2015).

archaeological excavation conducted by the Centre for Conservation and Archaeology of Montenegro. This structure could be a tower or bastion with the defensive purpose of controlling men and animals entering the Roman city.

The photo-interpretation was supported by geophysical research and by archaeological surveys carried out at different times. By using the remote sensing data, numerous archaeological features have been characterized by analysing the vegetation status. In particular, the identification of archaeological traces in the *forum* area is the result of the spectral difference between the surfaces above the ancient structures and those in the surrounding area. This result is achieved because of the different value of absorption and reflection of the vegetation in the Visible and Near Infrared wavelengths. The anomalies, interpreted as Roman structures, suggest that the two *thermae* were part of the selfsame complex, since their traces follow the same alignment as the walls visible above ground (Fig. 5). This hypothesis was confirmed by the recent geophysical tests carried out in the area that have highlighted the traces of masonry structures (see Cozzolino, Gentile this volume).

Employing the same dataset, we found also signs related to buildings and anomalies connectable to the internal road network, which is particularly regular in its lay-out. Several traces exist that are appropriate for dwellings, ancient roads or other structures of anthropic origin. Archaeological alignments identified in the northern area of the *forum* have allowed the reconstruction of a part of the city planning. Among them, is an anomaly evident to NW of the *basilica*: it is a clear round signal, characterized inside by a series of bright features, which represents a disturbance in the area studied.

Thus, several structures identified in the area of Doclea greatly assist the study of the inner organization of the urban area. An accurate analysis of the buried structures and the visible monuments has offered sufficient topographical references to define the urban road network, even before any systematic excavation activities are carried out. All the archaeological information (roads, urban walls, parts of buildings) garnered was beneficial in estimating the form and extension of the Doclea *insulae*. Now, only a prompt and direct intervention on the ground can confirm the hypothesis so formulated.

P.Me.

4.2 *The results of the archaeological survey*

The first part of the survey has investigated the monuments to the S of the *decumanus maximus*, as exhaustively described by Sticotti: the temple of Dea Roma, the private house and the little private temple and the temple of Diana (Sticotti 1913) (Plate 1; Plate 3).

The structures visible on the ground are in part recognizable as those indicated on the map of the city dated to 2012 (Živanović, Stamenković 2012). It was possible to detect a portion of the *temenos* and the *podium* of the temple of the Dea Roma, as well as the enclosure of the private temple and the base of the monument inside. The structures of the *domus* are still quite well preserved: the rooms are arranged around a central courtyard and a cocciopesto-lined pool (Fig. 4, red points; Plate 3, private house). The temple of Diana, however, has now practically disappeared: it is possible to identify only part of the *podium* and a segment of the paving of square limestone blocks.

A series of structures with an orientation different to that of the Roman city is visible in the portion of land between the road and the railway, where in 2017 a bath-building was excavated, close to the walls near the tower h (Fig. 4, A and B; Plate 3, A and B).

Regarding the city layout, the most significant findings were made to the S and E of the *domus* and near to the SE section of the walls. To the E of the *domus*, an alignment of paving stones (*basoli*) appropriate to a *cardo* of the city was identified (Fig. 3D; Fig. 4, C; Plate 3, C). It is possible to distinguish the western side of the road, though the eastern one is hidden in the ground. The discovery of the *cardo* was fundamental, as we will see, for the hypothetical reconstruction of Doclea's *insulae*.

About 10 m E of the road, walls on the same line emerge, though a channel made of small blocks, of which both sides are visible, presents a totally divergent orientation (Fig. 4, O). Moreover, some structures along the dirt-road SW of the *domus* are very intriguing: a wall covered by vegetation could trace the line of an ancient *decumanus*, and another wall S of this has the same orientation (Fig. 4, D and E; Plate 3, D and E).

The structures that are perfectly visible and in some cases preserved to some height (Fig. 4, F; Plate 3, F) in the area SE of the plateau are also oriented according to the layout of the Roman city. The alignment of these structures, covered by the modern dry walls, can be followed for a long distance and, at least in one case, seems to coincide with the path of a *cardo* (Fig. 4, G; Plate 3, G).

Near the tower n (Plate 3), a probable paving of limestone slabs was found, covering a channel constructed from small irregular blocks assembled with mortar (Fig. 3C, Fig. 4, H; Plate 3, H). The discovery of this paved area could indicate a public building of a certain importance, as can be observed by similar cases in different areas of the *forum* and in the main temples. The hypothesis is further supported by the presence, a little further S of these remains, of a mighty structure, still standing to some height, that delimits the corner of a large quadrangular space (Fig. 3B; Fig. 4, L; Plate 3, L). Within this space, is the corner of a second structure and a series of parallel and perpendicular walls. It is interesting to note that the eastern wall of the probable building has a curvilinear pattern (Fig. 4, M; Plate 3, M). The construction technique, of small squared blocks assembled with mortar, is the same as in the buildings of the *forum*. On Sticotti's map, the presence of more structures a little further S of this area is designated (Plate 1).

Finally, walls, architectural fragments and columns emerge around the modern building, used as a school in the past, where both Munro and Sticotti indicated the presence of ancient constructions (Fig. 4, N; Plate 3, N).

F.C.

5. Some preliminary notes on the urban plan

As with the cities of the Italic peninsula, so also the other centres of the Empire were founded on the basis of a rationalization of urban spaces that corresponds to common needs and, above all, to the Roman pattern. The essence of a typical Roman city plan, after a period of functional and aesthetic experimentation, became a strong, exportable and instantly recognizable concept (Conventi 2004, 13-14).

Analysing the collected data, it is possible to propose a first reconstruction of the Doclea urban plan which, naturally, can only be verified with further research and with excavation on the spot. The hypotheses presented in this paper are entirely preliminary, based as they are on the interpretation of the images and the archaeological survey, on the geophysical data and on some GPS measurements of well recognizable architectural points.

In order to reconstruct the shape and width of the *insulae*, it was necessary first to determine the width of the roads, at least those of the main ones that crossed the monumental area of the city. Recent archaeological researches conducted by the Centre for Conservation and Archaeology of Montenegro have confirmed that the *decumanus maximus* had a width of 10 m and was

Fig. 6 – Satellite image of Doclea. In red, the ancient structures that overlap the Roman roads.

flanked along the southern side by a covered walkway. The geophysical anomalies identify the colonnade (see Cozzolino, Gentile this volume) and a base of a column came to light during the archaeological excavation. The considerable size of the *decumanus* of Doclea can be compared with those of some Augustan cities of northern Italy, characterized by a regular layout, but conditioned by an important pre-existent communications network, such as Libarna, Verona, Concordia and Tridentum (Libarna: Panero 2000, 115-131; Verona: Cavalieri Manasse, Bruno 2003; Concordia: Conventi 2004, 132-134; Tridentum: Conventi 2004, 141-143; Rossi *et al.* 2008). The main axes of the cities were frequently embellished over time as happened, for instance, at Aquileia where paved roads lined with porticoes are positioned close to the *forum* (Bertacchi 2003; Muzzioli 2004).

To calculate the width of the *cardo*, the alignment of the stone paved road between the *forum* and the *Capitolium* was considered: clearly visible on the ground even if not continuously, this runs along the walls on the western side of the *Capitolium* (Plate 3, S1). The distance from the eastern side of the road to the eastern limit of the *forum* is 8 m (Plate 3, S2); the 10 m measured from a threshold (Plate 3, S3) indicates the distance from an entrance to the *Capitolium* up to the same wall of the *forum*. This latter measurement should correspond to the width of the *cardo*, including a pedestrian footpath.

That this too was a porticoed way is testified to by the geo-radar investigations: they highlight a colonnade along the eastern side of the road. The *cardo* is clearly visible on the geophysical map, S of the *decumanus maximus* (see Cozzolino, Gentile this volume; Plate 3, G1): the western limit of the anomaly here coincides with the alignment of large quadrangular blocks, assembled without mortar, that emerge inside the large *thermae* – they could be related to a paved area (Fig. 6 A; Plate 3, S4).

The measurement of the distances between the corners of the public buildings that overlook the *decumanus* allowed us to formulate the first notions on the city planning. It has been verified that the southern facade of the *forum* runs for 59 m (Plate 3, from S2 to S5). The same measurement can be seen between the wall that runs E of the *Capitolium* and the eastern edge of the *cardo* that passes between the *Capitolium* and the *forum* (Plate 3, from S3 to S6).

From the NE corner of the small *thermae* to the NW one of the large *thermae*, 128 m are measured: this should correspond to two *insulae* (of 59 m apiece) separated by a *cardo*, as calculated with a width of 10 m (Plate 3, from S7 to S8).

A further verification of the distances was made by projecting southward the alignment of the wall which closes the block of rooms to the W of the *basilica* (which is a limit of an *insula*) up to the intersection with the alignment of the northern front of the large *thermae* (blue and green lines in Fig. 4; Plate 3, S9). In this way the NW corner of an *insula* is delineated: one that seems to be perfectly in line with a structure found in the western area of the Diana temple (Fig. 4, O; Plate 3, G2). Measuring 59 m from this point towards the large *thermae*, one may reconstruct the probable N front of the *insula* (Plate 3, from S9 to S10). The NE corner (Plate 3, S10) would then be aligned with the E wall of the *temenos* of the Diana temple, as reported on Sticotti's map, and with some segments of walls identified during the survey. The distance between the *temenos* wall and the western front of the large *thermae* is 10 m and confirms, once more, the passage of a *cardo* between the two *insulae* (Plate 3, from S10 to 58).

Finally, at 10 m westward from the eastern front of the *insula* thus graphically reconstructed, the road identified during the survey runs (Fig. 3D; Plate 3, C), while the NW corner of the enclosure of the little temple in the private house – which should correspond to the limit of the next *insula* – is located at a distance of 63 m from the road (Fig. 6, C; Plate 3, from C to S11). This last measurement does contrast with the 59 m verified for all the *insulae* along the *decumanus maximus*, but this apparent difference can perhaps be clarified by referring to the drawing of the building by Sticotti (1913, fig. 37; Plate 1). On that map, inside the enclosure two perpendicular walls of squared stone blocks are drawn: these, according to the author, coincide with the edges of a paved area. The last could be the limit of the sacred area in a phase preceding the one visible today. Significantly, the distance between the western wall of the *temenos* and the alignment of squared stone blocks

	URBAN SYSTEM	ROADS NETWORK	INSULAE	FORUM
Type		Orthogonal		Central
Shape	Trapezoidal		Square (?)	Rectangular
Modulus			59×59 m (?)	59 ×75 m
Geographical conditions	Hydrography: all sides are influenced by the presence of rivers			
Location	N of Podgorica			
Orientation	NE-SW	*Decumanus* NW-SE		
Road width		*Decumanus* 10 m (?) *Cardo* 10 m (?)		
Perimeter	About 2400 m			268 m
Surface	28 ha			4425 sqm

Tab. 2

corresponds on Sticotti's map to 4 m. The gap between the road and this paved area would therefore be exactly 59 m.

Thus, the constant measurement of 59 m seems to be present even in the NS delimitation of the *insulae*. The complex of the *thermae* is 59 m in length and, projecting and replicating this distance along the plateau southward of the *forum*, especially along the western sector, one constantly encounters dry stone walls built on ancient structures with a NE/SW orientation. The *forum*, however, alters the pattern, extending northward as it does for a total length of 75 m.

It is possible then to conclude that the probable width of a Doclea *insula* was 59 m and that this dimension was a constant also in its length, thereby determining a layout of square blocks or of rectangular ones, if the NW/SE sides are doubled up (Plate 3). The *insula* was therefore designed on a unit of measurement of exactly 200 feet, with a foot equating to 0.295 m (Tab. 2). In this case the 'foot' of Doclea could correspond with that probably used in the planning of Aquileia which, according to recent studies, was organized in *insulae* 240 feet wide (2 *actus*) and 480 long (Muzzioli 2004; Ghiotto 2013 with previous bibliography). Moreover, the probable quadrangular form of the *insulae* finds a correspondence in some Roman cities of the Italian peninsula. With the exception of few examples dated to the 3rd to 2nd centuries BC, such as Placentia[4] or Interamna Nahars (Placentia: Pagliani 1991, 42-43; Dall'Aglio *et al.* 2006; Interamnia Nahars: Manzoli 1997, 83-90), the square shape of the *insulae* seems to be spread abroad especially in the first Augustan age, with the introduction of a basic module more compatible with new standard models of private and public buildings (Conventi 2004; Sommella 2018, 50).

The square form of the urban layout is adopted in Florentia, with blocks of modular *domus*, in Venafrum, which used an almost square module of

[4] The regular layout of Placentia, however, appears to be dated after the Civil War (Sommella 2018, 53).

70x75 m and in Asculum (Florentia: Sommella 1988, 168; Mirandola 1999; Maffei 2000, 9-25; Venafrum: Sommella 1988, 172; Conventi 2004, 60-62; Asculum: Sommella 1988, 175; Conventi 2004, 135-137). This type of extremely rational plan, very often based on a module of 2 *actus*, is common especially in the cities of northern Italy such as Verona, Parma[5] and Alba Pompeia and in new cities deriving from military camps (*castra*) such as Aosta (with its large roads and rectangular *insulae*) and Turin (Verona: Cavalieri Manasse, Bruno 2003; Parma: Sommella 1988, 79, and 2018; Alba Pompeia: Filippi 1997, 57-60; Marini Calvani 2000; Aosta and Turin: Sommella 1988, 171, and 2018; Panero 2000, 153-170).

A module of 2 *actus* could have been used also in Doclea, as the *forum* length (75 m) and the width of an *insula* in the eastern sector suggest (Plate 3). A further comparison is the *municipium* of Libarna, near Serravalle Scrivia, which has a regular layout set parallel to the river and is organized in regular blocks of almost square shape, but of different sizes (58.50×60 m; 50×60 m) with a square *forum* in a central position. The main axes of Libarna measure from 9 m (*decumanus maximum*) to 12 m in width (*cardo maximus*), while the secondary roads are about 8 m wide (Panero 2000, 115-131; Rossi *et al.* 2008).

A final observation regards the chronological phasing of the city in relation to the urban planning. Some buildings, while maintaining the same orientation, underwent extensions and changes that did not respect the limits of the *insulae*, with the consequent invasion of the space intended for the roads (Fig. 6, red lines). This situation can be observed along the eastern side of the large *thermae*, where some rooms were added to the original building (Fig. 6, A). Furthermore, according to Sticotti's map (1913, fig. 52, Plate 1), a group of service rooms, latrines and tanks, no longer visible, extended from the SW corner, beyond the presumed limit of the *cardo*. Other examples of occupation of the road-space could first be the one, already described, of the enclosure of the private temple (Fig. 6, C) and the one, very evident, of some rooms of the private house (T room on Sticotti 1913, fig. 37) that invaded the *decumanus maximus* (Fig. 6, B).

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[5] In Parma the square *insulae* of Augustan age probably derive from a subdivision of original rectangular blocks (Sommella 2018, 57).

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ABSTRACT

The paper presents the study of Doclea by remote sensing (satellite, aerial photos, drone) and the first results of the topographic survey conducted within the urban walls. The analysis of the images has highlighted buried structures that follow the same alignment as the walls visible above ground. The same anomalies are detected on the geophysical maps. The territorial survey, conducted with the aid of a differential GPS to position the emerging structures, has allowed one to identify numerous ancient structures, sometimes preserved to some height, which have the same orientation of the buildings of the *forum* and a stone paved road corresponding to a *cardo* of the city. Analysing the archaeological findings, the geophysical results and the measurements of the principal monuments and the roads, a hypothetical reconstruction of the Doclea urban plan is presented, which, naturally, can only be verified with further research and with excavation on the spot.