THE IMPRINT OF A CITY: MASSA MARITTIMA

M. Micoli[a], T. Nomikou [b]

[a, b] University of Florence, Department of Architectural Composition, Survey Laboratory,
Viale Gramsci 42, 50100 Florence, Italy - [a] yanmic@inwind.it , [b] zhnobia@gmail.com

KEY WORDS: Digital, Databases, Surveying, 3D Models

ABSTRACT:

In July of 2005 a study project began, the protection of which and the evaluation was promoted by the Region of Tuscany (Italy), regarding the medieval walls in the city of Massa Marittima in order to propose a pilot project with the objective of the conservation and of the re-qualification of this important architectural complex.
This project has been entrusted to the Department of Architecture Projects and Design at the University of Studies of Florence and coordinated by Professor Emma Mandelli. The allocation has regarded the work carried out on the meridian area of the wall, utilizing a group of twenty people dedicated to the various functions of the survey and of the historical, icon, and photographic documentation. A topographical survey has been made for the geo-referencing of the three-dimensional scans obtained with laser scanner technology and it was necessary, for the inaccessible areas of the wall, to integrate a direct survey. Beginning with the acquired data in the first phase of the operation, we proposed the development of a critical analysis integrating the documented information with morphological information of the given state. Attempting to retrace the transformations that the wall has endured over the course of the centuries, we concentrated mostly on the period of construction of the wall, more precisely, the medieval wall. The final result was to represent an analysis of our research with a digital 3D model and to hypothesize regarding the organization of the defence system of the walls of Massa Marittima. In this project, the three-dimensional digital survey with laser scanner technology, the survey was fundamental given the impressive scale of the object.

1.THE WALLS DI MASSA MARITTIMA

Set upon a panoramic hill, the historical center of Massa Marittima was enclosed within city walls that are rather well preserved. They are divided into two great monumental zones: Città Vecchia (Old City) that spreads around the Duomo and has an intense medieval character; and Città Nuova (New City) that has developed on the north-east side of the historical center. Dividing these two zones is the bridge-house that creates a junction between the two zones. The walls of Massa Marittima, for the most part, are dated around 1228. During the 15th century the walls were reduced to the present layout seen today allowing for the clear division between the two zones.

2.RESEARCH OBJECTIVES

The evolution of the technology of the automatic survey of the geometry of the surveyed article has allowed for the creation of three-dimensional data banks that constitute a fundamental archive of geometric memory from the necessary goods to the outcome of the protection and conservation and to the eventual process of restoration or reproduction.
The three-dimensional model that can be obtained by the elaboration of the laser scanner data is measurable and it constitutes a realistic representation element. Such digital models are capable of supporting the possibility of the reproduction, the measurement, and the analysis of the state of decay and all other information that can be inferred from the geometric model, as well as the possibility to create simulations of further recuperative interventions in addition to the mass culmination in a museum environment.
We compared the historical analysis to this morphological data of the studied object. In order to create a three-dimensional model of the studied object, and in-depth historical and socio-economical examination was necessary as was to be able to restore the environment in which the object was constructed. At the same time we turned our attention to the accurate analysis regarding the defensive organize and how effective they would have been in the face of assault weapons of the medieval period.

3. ACQUISITION OF THE DATA

In the first phase of the operations, a number of reflective targets were positioned along the entire parameter of the wall, both the external and internal areas, after which the targets were registered by the total station and by the laser scanner (Fig.1). The coordinates of the centers of the corresponding targets were then utilized in the alignment and in the geo-referencing of the point clouds of the laser scanner.

Figure 1. Registration of the targets by the total station and by the laser scanner.

The distribution of the targets was projected in such a way as to include at least three or four of these in every scan. Based on the topographical survey, a direct survey was set-up for every building along the walls for the areas that are not visible or accessible by the instruments. The topographical measurements were taken by the utilization of a Leica 706 no-prism total station, whereas for the three-dimensional survey a Leica HDS 3000 laser scanner was used, with an shooting angle of 360°O and 270°V, capable of a quick measurement of approximately 1600 points per second. Supporting this was also a Leica HDS 2500 laser scanner, with a technology identical to the superior model, but with a shooting angle of only 40°O and 40°V.

4. IL DATABASE DELLE SCANSIONI

In order to render completed surveys more efficient and communicable to others, a praxis was adopted that is relative to the documentation by means of a ready-made database together with relative information to the completed single scans. Such a database, independent from the digital three-dimensional model, was developed in *Filemaker*. The card type of every position shows an explanatory image of the complex of completed scans according to their position, a series of information connected to the shooting conditions and to the structure of the acquired data and a reference plan mapping the placement of the positions in respect to the architectural complex (Fig. 2, 3).

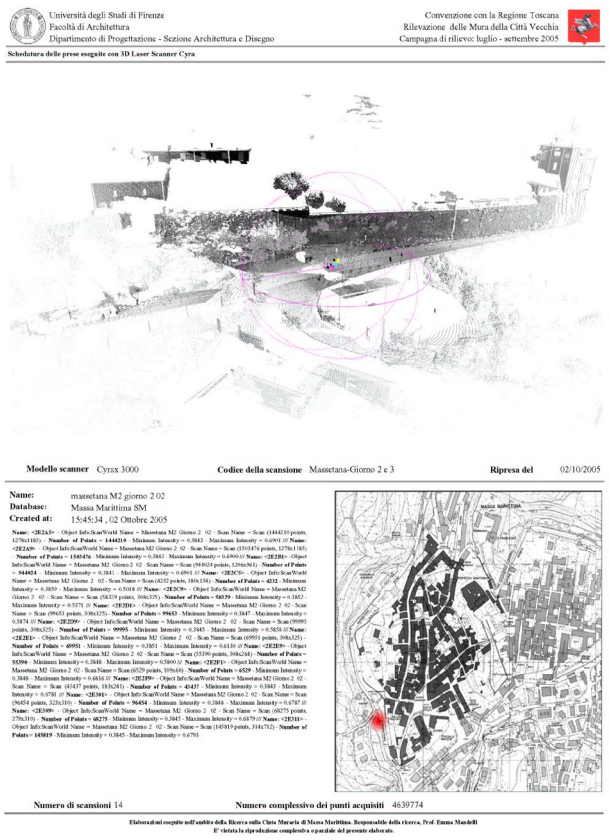

Figure 2. Sheet of the HDS 3000 database.

This way, the documentation cards of the operations, joined to the complex of the measurements, pinpoint quickly the parts of the model which are derived from the digital survey and render the orientation more simple to which then the elaboration of the more ample complex is added to the information and, especially in the case in which specific surveys are to be completed, and are more adequate for the given research.

It must be considered that despite however difficult it can sometimes be to utilize the information, the three-dimensional model of the point clouds directly obtained by the scans result as the greatest possibly achievable, for precision and correspondence to reality, for this type of instrument.

All of successive operations of elaboration gradually bring the model closer to the "perceived" model of the walls, however at the same time they introduce variations that are more or less conspicuous which simplify and modify the original data. In this way, the documentation and the archival of the data collected become important insofar as to create a basis for a new starting point and a new elaboration, according to a course that, dedicating the greatest attention to a diverse aspect of the examined architecture, leads to the most appropriate and optimal result oriented in respect to a new detected character.

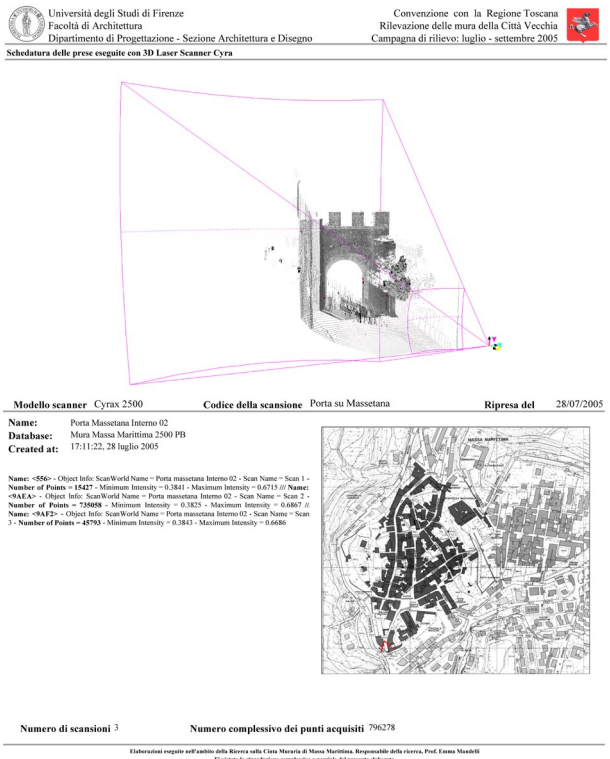

Figure 3. Sheet of the HDS 2500 database.

The point cloud registration is not carried out in an indistinct or simply sequential way. In fact such a choice could result in a complex model that is less versatile and more difficult to manage.

5. ELABORATION OF THE SURVEY DATA

The overall synthesis of the operations resulted in the execution of approximately 500 scans from nearly 50 different positions, with the acquisition of more than 400 million points all which create a total three-dimensional digital model. The elaboration phase of the data collected in the various survey sessions completed on the walls of Massa Marittima was developed based on a previous programmed organization and conducted by means of the utilization of the specific software *Leica Cyclone* version 5.1 (Fig. 4). In order to guarantee an easy conclusion of the unified data, the definition of diverse point cloud models was

rendered necessary, all in reference to the same coordinate system and perfectly measurable in every area, that constitute the

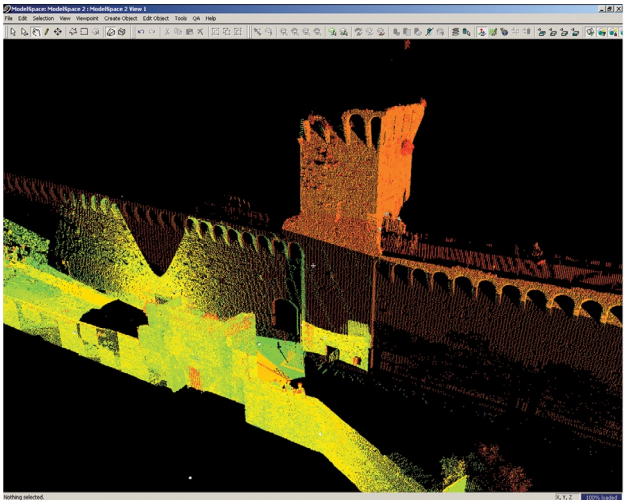

Figure 4. View of the model with *Leica Cyclone* version 5.1.

basis for successive elaborations. All of the models created are configured according to the organization of relative thematic layers in portions of the point clouds. This first elaboration allows for the easy management of the same models and also allows for the creation, within the examined model, of the views from which it is possible to create images at a high resolution. In fact, the software allows the visualization of the model both in central and in perpendicular projection and to block the rotation of the model as well as the zoom level relative to the placement of the represented scene (Fig. 5).

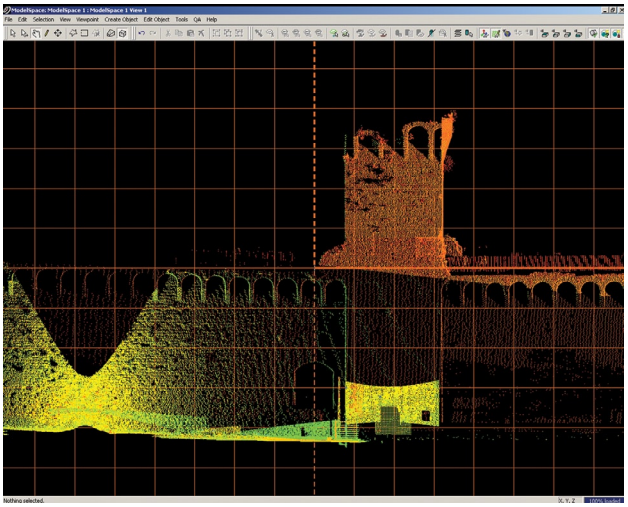

Figure 5. Perpendicular projection of the model with *Leica Cyclone* version 5.1.

These visualization properties allow for, making use of the software that is predisposed to the creation of the capture video (snapshot), the obtainment of a series of partial and super imposable images that can be unified through the utilization of photographic retouch software in order to obtain complex detailed images from every possible view of the model. The images obtained in this way are a detailed representation of the wall, not without there own specific graphic values, that are susceptible to ulterior treatments as for example in their vectorization, in a C.A.D. environment thus become bi-dimensional basis upon which graphic synthesis of thematic analysis are carried out directly upon the represented object. This type of bi-dimensional elaborations have constructed the foundation upon which we have developed our hypothesis of reconstruction, creating a three-dimension model of various scales (Fig. 6, 7), integrated with retouched photographic images that can enrich the information provided by the geometric data (Fig. 8, 9).

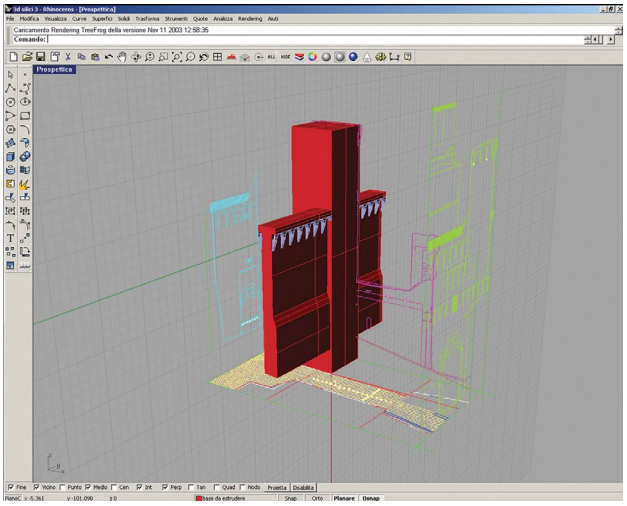

Figure 6. The creation of the three-dimension model based on the bi-dimensional elaboration.

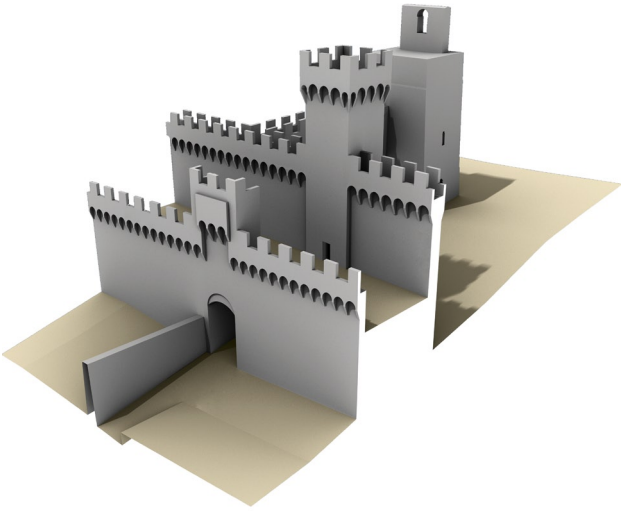

Figure 7. The creation of the three-dimension model.

The final graphic elaborations value as an efficient support in the editing of two-dimensional designs aimed at the restoration of the object, but the same time, can be utilized as a publishing objective or in a museum environment.

6. CONCLUSIONS

Overall these operations bring into production the bi-dimensional and three-dimensional elaborations having a diverse nature and completed with different objectives. In the process of the digital survey, the phase dedicated to the collection of the data consists predominantly in the operations of the quantitative type, intending with this that, not with standing the programming and

the survey project in which the preparation and the experience of the operators intervene in an important way, one proceeds to the acquisition of an enormous quantity of data that is not simplified and one depends notably on the quality of the instrument the completion of the single operations. Contrarily the phase of post-production, here referring to the joining of the operations from the registration of the scans to the end the production of the solid models, is characterized by a strong subjective component strictly connected to the competence and the personal sensibility deriving from the capability and from the experience of the operators: the survey does not lose it's interpretative value, rather it can be developed and implemented on the basis of the data that in their quantity are not comparable to those collected by means of traditional procedures.

Figure 8. Integration of the point cloud with retouched photographic images.

Figure 9. Final graphic elaboration.

The digital survey of an architectural complex from the notable dimensional and morphological characteristics such as the walls of Massa Marittima is established as a considerable part of the unification of the operations completed during the study conducted to this point and it is still considered important in the general framework of the research that requires a high level of integration of all the survey methodologies and of the studies carried out on the object. The entire survey project was completed in fact utilizing the instruments and the methodologies that support the operations of the digital survey.

REFERENCES

ANDREOZZI L., 2003, *Il laser scanner nel rilievo di architettura: la nostra esperienza*, Il Lunario, Enna.

BIANCHINI C., 2001, *Modelli discreti e modelli continui nel rilievo e rappresentazione informatizzata dell'architettura*, sta in Disegnare n.22, Gangemi, Roma.

DOCCI M., GAIANI M., MIGLIARI R., 2001, *Una nuova cultura per il rilevamento*, sta in Disegnare, Idee, Immagini n. 23,Gangemi,Roma.

MIGLIARI R. (a cura di), 2001, *Frontiere del rilievo: dalla matita alle scansioni 3D*, Strumenti del dottorato di ricerca, Gangemi,Roma.

MIGLIARI R., 2003, *Geometria dei modelli*, Edizioni K, Roma.

MIGLIARI R. (a cura di), 2004, *Disegno come modello*, nuovi quaderni di applicazioni della geometria descrittiva, Ed. Kappa,Roma.

SALVADORI F., 2003, *Three-dimensional scanning techniques applied to 3D modelling of pottery finds*, in Workshop 7 Archäologie und Computer 2002, Wien, CD-ROM.

TIOLI F., 2005, *Relazione del rilievo topografico delle mura di Città Vecchia*, Massa Marittima.

VERDIANI G., 2005, *Relazione delle operazioni svolte per il rilievo delle mura di Città Vecchia con tecnologia Laser Scan*, Massa Marittima.

VERDIANI G., 2005, *Il rilievo strumentale del Castello di Gisors: la campagna di rilievo digitale e le linee guida per la sua elaborazione e la restituzione*, in BINI M. (a cura di), *Il castello di Gisors. Resoconto della campagna di rilievo per una ricerca tipologica e funzionale*, Firenze.