Digital Documentation in Architecture.

Methods of analysis for the preservation and development of the Nordic Built Heritage.

Sara Porzilli
University of Oulu
sara.porzilli@oulu.fi

Abstract

This article presents the potentialities of digital methods and techniques for the documentation of the Nordic cultural heritage applied to two architectural examples, which then are monitored with the goals of the Madrid Document (2011). The verification of authenticity and the understanding of architectural values are beneficiaries from the current technological advancements.
The research question starts from the common consciousness that the processes of knowledge, both theoretical and practical, cannot ignore today the traces of the past, the presence of old buildings and traditional constructions. On the contrary, they serve as a testimony of the past and provide a solid starting point for new, more coherent, sustainable, harmonic and creative urban development. So, which are today the methodological and digital tools that can support a correct documentation? This article tries to answer to this question by presenting the research carried out as two case studies located in Oulu and then examined in the light of the Madrid document. The method and practical procedure used have produced specific outputs and results, which are commented and described also through pictures in order to share the great advantages but also some disadvantages and shortcomings of the latest digital survey technology.

Keywords: Digital Documentation, Cultural Heritage, Digital Survey, The Madrid Document, Value and Authenticity.

PEER-REVIEWED ARTICLE

Introduction

The work presented in this article is part of the European Research Project *Preserving Wooden Heritage. Methods for monitoring wooden structures: 3D laser scanner survey and application of BIM systems on point cloud model*. Wooden Heritage represents one of the oldest examples of architecture developed by different cultures all over the world, creating specific features with unique compositional solutions (K. Zwerger, 2012). In Northern Europe, wooden buildings existed already during the early 11th century. They were built in tight connection with the surrounding environment creating intimate relationship with the landscape. Materials belonged to the nearest forests, decorative details took inspirations from the Nature and its elements.

The question about how to link the contemporary architectural practice with the tangible and intangible elements of a site is still representing the focus of the debate in our design operations.

The study of the past, of the ancient and historical architecture has always represented both theoretical and practical knowledge for the understanding of architectural and environmental identity. The main reason has often been the need to get information about our ancestors, the specific background of a place, styles, construction solutions and traditions[1]. Today the question about how to link the contemporary architectural practice with the tangible and intangible elements[2] of a site is representing the focus of the debate in design operations.

From a theoretical point of view already at the end of the XIX Century experts in architecture and archaeology such as Giuseppe Fiorelli, Camillo Boito and Gustavo Giovannoni began the production of documents aimed at describing the principles necessary for the conservation and restoration of *monuments*, a term which then replaced with *cultural heritage* (1975 Declaration of Amsterdam). This term represented a more precise way for including also spiritual, cultural, economic and social values, closely related to the architectural object analyzed. (Niglio, 2005, 134). Today the most important guidelines concerning the preservation and protection of our heritage commonly use the term *cultural heritage*[3].

During the past centuries, wooden buildings and timber structures were often considered less important in many European countries, evidently due to the durability of the ancient stone and brick architecture. However, thanks to the specific technological solutions and constructive details, a substantial part of the historic wooden heritage survived until now and it is still present in many northern regions (Hansen, 1969). During the past decades, a reassessment of this material has increased, mainly due to its capacity of improving the quality of life of the inhabitants and because of faster construction time.

Figure 1. Survey activities on field. On the left side, laser scanning survey of Villa Lehmus, inner parts. On the right side, urban survey of Raksila neighbourhood.

[1] Norberg-Schulz C., *Genius loci : paesaggio, ambiente, architettura*, Milan: Mondadori Electa, 2016.

[2] How to define these two categories, recognise them and work in practice for discovering the constituent elements have been the main questions addressed during two important conferences:
1. International Conference at the University of East London entitled “Tangible – Intangible Heritage(s) – Design, Social and cultural critiques on the past, the present and the future”
2. XI International Conference of representation Disciplines Teachers entitled “Representation / Material / Immaterial. Drawings as (in)tangible representation”, held in Milan during 13-14-15 September 2018.

[3] In Finland, the Land Use and Building Act and the Land Use and Building Decree compose the legislation on building and landscape protection, which are aimed at the promotion of the cultural heritage.

Karelian architecture is now an entirely valid question, since its meaning is not confined only to values ethnographic or historical existence. There are values that have a direct connection, even the most useful for modern times.

(Aalto, A., 1941)

Even if the consciousness of the importance of wooden architecture has improved, still fires and abandoning for negligence are the main factors, which are compromising the preservation of wooden architecture. Even if the paper focuses on timber buildings, methods and procedures described can be extended to the general documentation of architecture through digital systems.

The two selected cases have represented the testing ground to examine the latest digital equipment; the outcome is then compared with the recommendations of the Madrid document. The investigation explores environmental, urban and building scales, deepening the applicability of certain procedures on both historic and modern Nordic Heritage. This research has been done respecting the principles described and promoted by the actual legislation on Heritage protection: from the treatment of a heritage, up to the part of dissemination for the activation of policymaking strategies.

Presentation of the case studies, method on different scales

The project has been developed through the selection and analysis of specific case studies. The selection of the cases followed specific criteria:

- Buildings from different historic periods;
- Isolated and grouped buildings;
- Buildings located in non-original environment or in non-authentic environment.

The choice and identification of these criteria has been necessary and very useful in order to obtain a wide range of architecture located in different contexts. The historical period, the framework in which they are located, and the presence or absence of active protection systems have been fixed and taken in consideration for the analysis and documentation of each case.

In order to illustrate the activities and the method used this paper focuses on two of the most significant case studies analysed. They are both situated in the municipality of Oulu. They origin from different historic periods and placed during different urban processes. Even if their characteristic features differ significantly, they are presented together here as a demonstration of the wider applicability of the research method used. The first case is the historic wooden neighbourhood of Raksila and the second one is the modern Villa Lehmus with the interesting riverside wooden sauna, both designed by Alvar Aalto and located in Laanila area (Figure 1).

The historic wooden neighbourhood of Raksila

The wooden railway station along with the new connection was opened in Oulu is dated on the 1888. On the other side of the new railway, a suitable housing area became Raksila district. The wooden neighbourhood of Raksila was planned during the early XX century as a regular district, characterized by wooden buildings aligned along the main streets. The image of this place did not change during the years and today it appears almost in its authentic configuration (Figure 2). Despite this, over decades new buildings and services for public uses (such as supermarkets and sports centres) segregated the area and today the entire neighbourhood does not interact with the rest of the city (Figure 3). Well-preserved wooden family houses characterize the area, surrounded by private gardens with the main accesses located along the main streets. At the time of the investigation, the area had not specific guidelines of interventions and technical recommendations for the preservation of its authenticity[4].

[4] Özlem Özer-Kemppainen (edited by)"Historiallisen Kaupunkimiljöön Suojeluatlas: Oulun Raksila" Oulun Yliopisto: Oulu. 2017. ISBN 978-952-62-1786-4. ISSN 2342-9062.

Figure 2. The map of Raksila updated on the base of the point cloud from the digital laser scanning survey. The map includes all different levels of information, from the measures to the characteristics of buildings, streets and vegetation.

Figure 3. Urban development of Raksila district. First nucleus is in yellow. Residential buildings from '50-'60 are marked in red. Services buildings from '60-'70 are in blue color.

In some parts of Raksila, it is possible to identify inaccurate interventions such as addition of volumes, use of non-original materials and an organization of the private yards not totally coherent with the original urban plan of the place. For all these reasons, the survey of Raksila has involved both the architecture and its environment as two essential parts of the same research topic. The analysis has the role to investigate and define the values and aspects, which need to be considered for the preservation of this heritage.

Alvar Aalto's work of Villa Lehmus and the wooden sauna in Laanila area

Villa Lehmus was designed by Alvar Aalto within the wider project concerning the Typpi Oy factory. In 1950, the Finnish State bought the area starting a new industrial production of formic acid and commissioned Aalto for the master plan of the area. The project had to be composed in two parts: the industrial area and the residences for the workers, located along the riverbank of the Oulu River. The original masterplan designed by Aalto included residences for workers, engineers and managers with additional services. Through the decades, several masterplans were produced after Aalto, the latest from 1999, when the urban plan was modified[5]. The industry was built with a horizontal rhythm referring to the natural image of the Nordic forest. The architect placed the buildings in a freeway effect, following the functions and needs of the work and workers (Figures 4 and 5).

[5] Jari Jetsonen and Sirkkaliisa Jetsonen, *Alvar Aalto Houses,* NY: Princeton Architectural Press, 2012. pp. 154-156. ISBN: 9781616890810

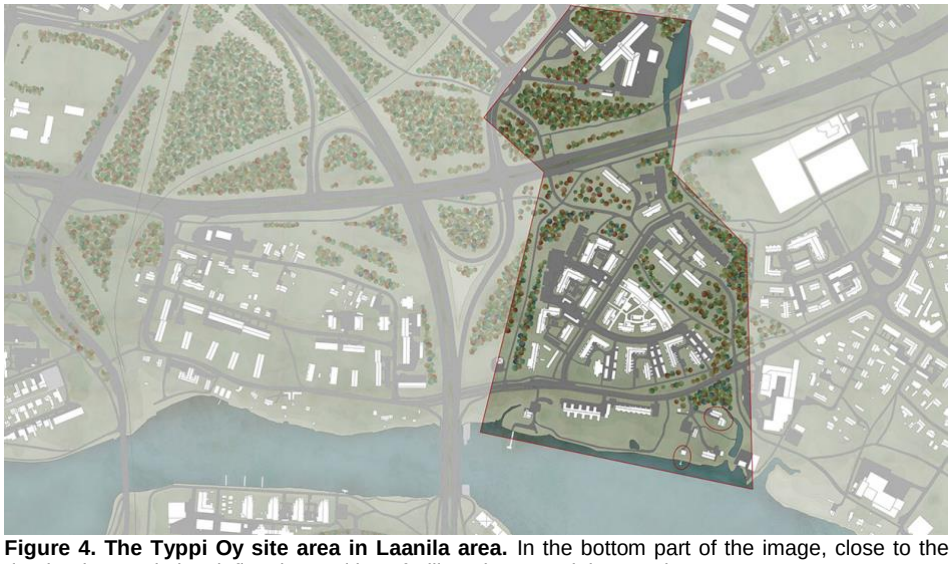

Figure 4. The Typpi Oy site area in Laanila area. In the bottom part of the image, close to the riverbank, two circles define the position of Villa Lehmus and the wooden sauna.

Figure 5. External and inner images of Villa Lehmus. Orth images elaborated from the point cloud obtained from the digital survey performed. The point cloud is entirely navigable and measurable. The acquisition of the colours improves the quality of the results and the amount of information.

Standard elements, such as window frames and use of red bricks were adopted as main design solutions for the entire area, and in practice, they play a fundamental role in the harmony of the whole place. The project of the villa was realized with a simple square-shaped system located in a green site close to the riverbank.

Externally the design of the two flaps of the roof gives a particular and unique character to the image of the villa (Figure 5). The flap from the entrance side is wider and linear, while the side of the garden is narrower and follows a concave metal recess profile. The free roof geometry was a typical element for Aalto during the 1950s. The exterior is in red brick walls combined with white painted parts that better define the volume of the house. A continuity of spaces characterises the inner distribution of the house, both in terms of the physical connection and visual continuity. The ground floor is composed of the living area, with a large dining room and a more private sitting room with a fireplace area. On the first floor, there are four bedrooms located around a common living room with a second fireplace. On the first floor, there is also an open terrace, punctuated by an orderly rhythm of white painted pillars. The essence of the Villa was described directly by Aalto while writing to the Lehmus Family:

The aim has been to create a spatial whole of rooms: a hall, a living room, a dining room, to fit the beautiful surroundings. From the hall the circulation diagonally reaches the dining room and divides the living room into two: a sofa group by the window and a more intimate corner by the fireplace that architecturally dominates the room. The main staircase leading upstairs opens to an upper hall in which there is a hobby corner and a fireplace.
(Jetsonen J. and S., 2012).

The closer wooden sauna is an extraordinary example of log architecture typical for the Ostrobothnia and central Finnish wooden structures in which the traditional construction system is blended with a modern design of the spaces. The volume is simple, a unique rectangular floor plan, located close to the riverbank. The entrance is to the opposite side of the shore even if a secondary entrance is located also from the waterside. The inner distribution reminds the typical circular shell shape, in which from the public dimension, room by room, the person is conducted to a more very private and intimate dimension. The fireplace room offers a wonderful view on the landscape through the presence of big frames.

Conservation and restoration processes, together with the need to create detailed documentation, cannot be just a passive practice dedicated solely to the application of general standards. They should be considered again as a creative act.

Research approach and criteria

According to the *UNESCO's Convention* concerning the *Protection of the World Cultural and Natural Heritage*, today there is an urgent need to define precise and effective strategies for a better understanding of the environment and of the historical buildings in order to guide the new urban dynamics in a more coherent direction[6]. Conservation and restoration processes, together with the need to create a detailed documentation, cannot be just a passive practice dedicated merely to the application of general standards. They need to be considered again as a *creative act* with the aim to rediscover the ethics in the work of the architect surveyor. The strategy adopted by the Action Plan for the Implementation of the World Heritage Convention 2012-2022 clearly highlights the new values:
Credibility has been determined as the most important value in planning the future and ongoing operations [it] requires relying on the best available professional competence when making any choices. […] The objectives also include the establishment of a world heritage system that will remain transparent, fair, responsible and efficient in an ever changing world[7].

For this reason, experts need to approach the new digital tools available in the field of survey and representation and put the processes of knowledge into a new dynamic practice, essential for the protection of the built heritage and its safeguarding for the next future generations. The analysis of a context and its planning need today to assume again a strong *cultural role*[8].
The understanding of an architectural object can only take place through a careful analysis of the tangible aspects and the intangible values through the implementation of all the possible instruments, strategies, actions and expertise. Technology is literally revolutionizing the approach of researchers, transforming

[6] *The objective of the World Heritage Convention is to recognise and secure the value of key natural and cultural heritage sites and ensure their preservation for future generations though cooperation between the peoples of the world. The Convention sets out the duties of States Parties in identifying, protecting, conserving and presenting cultural and natural heritage within their territories and passing them on to future generations. According to the convention, there is a demand for resourced public or private bodies, research and documentation work, and educational programmes and information dissemination*". Ministry of Education and Culture, "Our Common Heritage. For a National World Heritage Strategy 2015–2025*".* p. 6. ISBN 978-952-263-354-5. Finland, 2015.
[7] Ministry of Education and Culture, "Our Common Heritage. For a National World Heritage Strategy 2015–2025*".* p. 8. ISBN 978-952-263-354-5. Finland, 2015.
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theoretical analysis and investigation into something dynamic and more practical. Within digital database, it is possible to link different levels of information putting them in a mutual relation helping the elaboration of new significant considerations. Investigations, inventory catalogues and digital survey support the understanding of the development of architecture, neighbourhood or city, as well as new interpretation of restoration theories[9].
The main scientific question is:
Can technology enhance preservation purposes?
The goal of this comparative study is to find out to which extent the latest laser scanning technology can serve as a tool in smaller and larger historic preservation sites and thus support the aims of the international preservation documents. This study uses the methods of qualitative research in order to the hypothesis that laser technology has drastically improved our possibilities to preserve the fragile wooden architectural heritage. This research proposes an approach in which all the above-mentioned considerations have been put in an interdisciplinary system of documentation. The work approach has highlighted not only the architectural value of the cases, but also it has increased and improved their cultural, symbolic and environmental importance. In both cases in fact, the elaboration of a careful digital survey, navigable and composed by different levels of information and details, has been the first action in order to define a precise 3D model and metrical database able to support different levels of analysis.

Digital survey method for the documentation of the Nordic Heritage
Two main objectives settled the research for defining the structure of the documentation:

- Improvement and development of updated digital survey techniques applied specifically on Nordic Heritage;
- Elaboration of detailed inventories and analysis with the main scope to increase the state of the art concerning the cases analysed.

In both Raksila and Aalto's work cases, the study started with a careful planning of the practical phases involved. Different scales of investigation, which from the general aspects include progressively the details, have produced different levels of analysis and consequently different levels of values. This system of investigation has contributed to the elaboration of a multidisciplinary research that considers the object in its whole material and immaterial configuration.
Three main criterions guided the investigation:

- Preliminary recognition of the area, with archival investigations;
- Definition of objectives, expected results and limits;
- Organization of the practical survey activities.

In Raksila case, the survey has been performed at the urban scale, considering the relationship between historic architecture and new buildings. The strong characterization of the houses has been fully documented by using the laser scanner technology (Figure 6), allowing the creation of a detailed metrical dataset that has produced inventories and typological analysis of the architectural and environmental elements[10]. For the Laanila case, the survey has been performed at the architectural scale considering its surrounding for an accurate description of the landscape as a valuable additional characteristic of the place. The point cloud obtained is composed by all the inner and exterior parts of the buildings

[9] S. Porzilli, S. Bertocci, *3D Digital Systems for the Documentation and representation of the wooden Heritage between Finland and Russia. Survey methods and procedures for detailed analysis*. In F. Bianconi, M. Filippucci (edited by) "*Digital Wood Design. Innovative Techniques of Representation in Architectural Design*", Lecture Notes in Civil Engineering book series, vol. 24. Springer Nature Switzerland AG 2019 Publisher. pp. 565-593. Print ISBN 978-3-030-03675-1
[10] Compare with S. Porzilli, A-M. Ylimaula, *Theory in Practice. Digital documentation in developing effective methods for preserving cultural heritage. The study case of Raksila wooden neighbourhood in Oulu*, Finland in "Tangible – Intangible Heritage(s) – Design, Social and Cultural Critiques on the past, present and the future" International Conference at the AMPS, Architecture_MPS; University of East London June 2018. Proceedings of the Conference: AMPS Proceedings Series 15. pp. 225-234.

with the additional acquisition of the real colors[11] (Figure 7). During the preliminary recognition, it is important to define the activities involved in the process to elaborate operational schemes in order to identify all the different typologies of the data obtained and to understand the achievable results. “Input-Output” schemes, tables and lists have helped the researcher in the organization of the work giving important insights in the elaboration of cross checks and transversal implementations (Figure 8).

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Figure 6. The case study of Raksila neighbourhood in Oulu. Overlapping of the point cloud in false colours on a real picture of the place.

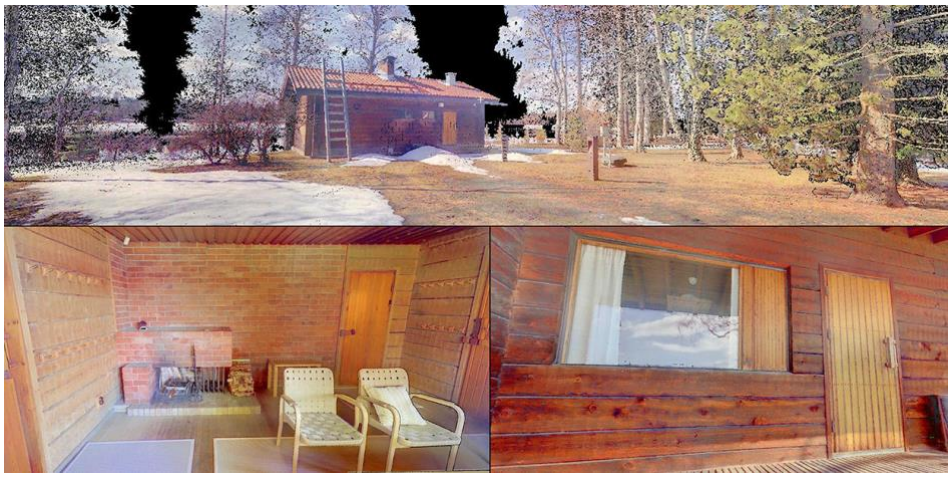

Figure 7. The Laanila Wooden Sauna in Oulu. Pictures of the point cloud obtained from the digital survey. The point cloud is entirely navigable and measurable. The acquisition of the colours has improved the quality of the results and the amount of information.

[11] The laser scanner used, a Z+F Imager 5010X, has an internal camera, that is used for capturing spherical pictures of the surrounding from each scan position. This tool gives the possibility to obtain a photo documentation of the place scanned and it allows the software to re-colour the point cloud with the real colours extracted from the pictures acquired.

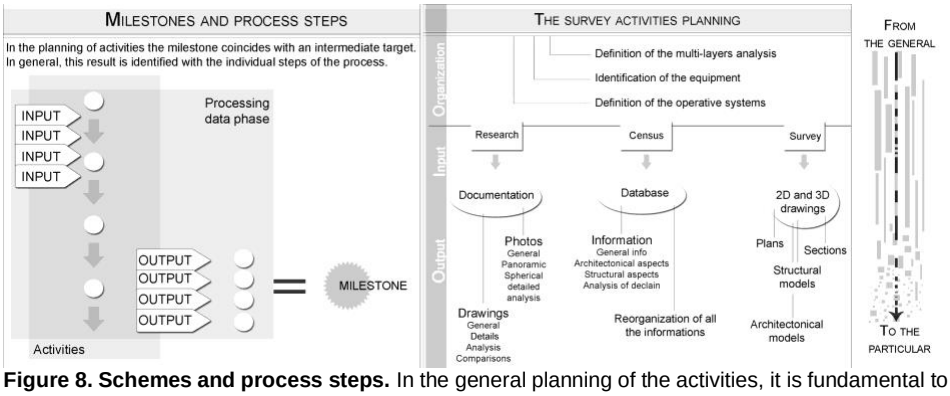

Figure 8. Schemes and process steps. In the general planning of the activities, it is fundamental to understand the types of “input” and "output", the objectives to pursue and the expected results in order to define procedures and integrate the different relevant methods.

During the second and third steps, the identification of the different objectives and expected results helped the recognition of the scale of investigation and the organization of the practical activities that, in general, go from the general aspects includes progressively the details (Table 1).

From the general	⟶	To the particular
Analysis of the existing sources	Goal setting (elaboration of the main purposes of the research)	Structuring of activities with an “input-output” method. Each activity generates results (=output) which should represent the “input” of the next phase
Analysis of the context (territorial scale)	Survey of the architecture (architectural scale)	Analysis of the details (detail scale)
Identification of the of the authenticity of the place	Analysis of the architectural values	Documentation of the particular elements

Table 1. Organization of the activities. The process of recognition and management of the activities follow a method, which from the general goes to the detail deepening each task of the work.

According to the defined objectives, the second part of the work has involved the practical activities on field focused in collecting updated information and metrical data:

- Laser scanner survey, from which obtain a complete point cloud of the architecture and its environment;
- Topographic survey, in order to georeference the point cloud and allocate different parts of point clouds in a mutual geometrically and georeferenced correct position. The topographic survey helps also in the reduction of the error during the registration phase of wide areas;
- Direct survey by using simple tools for measuring details and parts which cannot be surveyed by the laser;
- Photo Documentation for the elaboration of the photo-maps of the facades, sections and floor plans;
- Photo modelling reconstructions, by using the possibility to reproduce from 2D photos 3D models with the so-called *structure-from-motion* process;
- Census activities, for the creation of descriptive inventories and technical atlases of the buildings investigated;
- Additional activities: landscape analysis, studies related to environmental and cultural aspects by using interviews and external supports from other specialized technicians.

For both the cases, survey activities have produced a big amount of data and an updated documentation, characterized by different typologies of information:

metric databases of the point clouds, vector 2D drawings, 3D models and thematic maps produced by the combination of the different levels of information.

Figure 9. The private entrances of the houses in Raksila. Picture from Teuvo Pakkalan Street.

The laser survey of Raksila has been developed by moving the instrument along the streets following an open path with a *zigzag* movement (open polygon). Each block of houses has been surveyed in all its four sides except for the inner areas characterized by private gardens (Figure 9). At the same time, a massive photo documentation produced descriptive photographic archive, divided and organized in specific folders with the use of a codification system. The codification of the folders followed the code system already used by the Municipality of Oulu for the classification of the buildings.
The photo documentation has been performed by making pictures all around the volume of the house and then concentrating the analysis to the details. The inventory for each building has been elaborated on site by using premade tables on sketch notes. All the information has been then put in mutual dialogue through the support of a 3D model. This step produced thematic maps and interesting consideration for the understanding of the place with its intrinsic dynamics (Figure 10).
The case study of Villa Lehmus and the wooden sauna have been developed at the architectural scale. In this case, the instrument has been moved trying to produce closed paths/polygons around the rooms. This procedure allows the reduction of the error during the registration phase[12].
For all the case studies, a precise organisation of the scan positions was defined in advance in order to set the practical activities and quantify the amount of work/hours necessary on field. This procedure is recommended because it gives a real and practical understanding of the work and obligates the surveyor to elaborate in advance all the needed strategies useful to carry out the research and to obtain the expected results.

[12] The term “registration” represents a technical way to indicate the operation of connections of the singular scanwords made during the re-processing of data after the laser scanning operations on field.

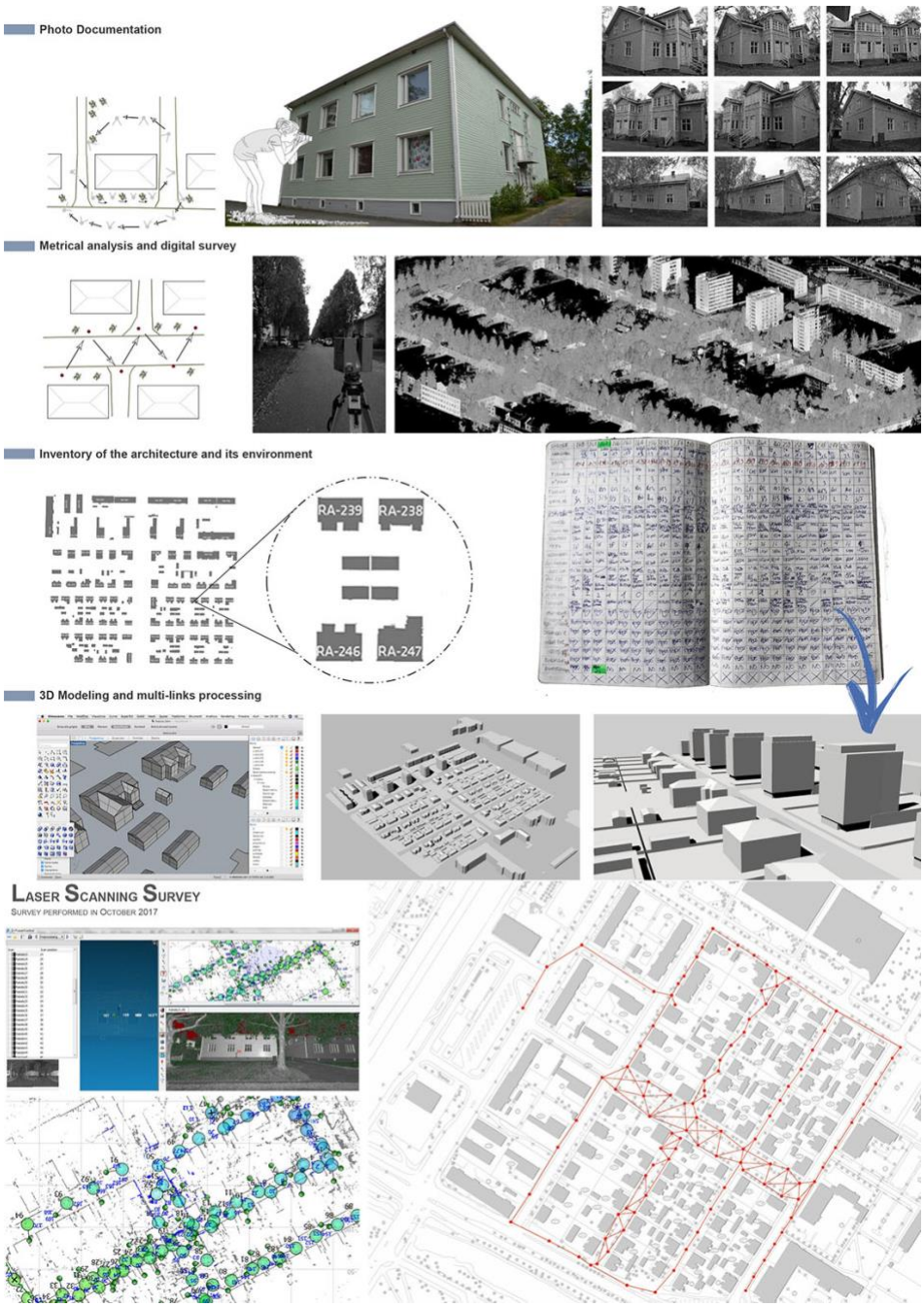

Figure 10. Synthesis of the activities carried out for Raksila case. The analysis started with the laser scanning survey, supported by an intensive photo documentation. The census for the elaboration of the inventory of the architecture uses the same codification system adopted by the municipality of Oulu. A 3D model elaborated during the postproduction has represented the box in which put different information in a mutual dialogue.

Specific factors determinate the organisation of the scan positions, the main are:

- The presence of obstructions, which obligate the surveyor to move the instruments into different positions in order to avoid the possibility of missing data;
- The necessity to create the right connections between external areas and inner parts;
- The necessity to survey the object investigated with the highest resolution, avoiding, when possible, shadows and holes in the point clouds.

For all the cases, the instrument used is a terrestrial 3D laser scanner Z+F IMAGER® 5010X able to perform works with high resolution both outdoors and indoors. The machine has an incorporate GPS system able to estimate on field the current scan positions along the work. This item support the recognition of the scan positions systematically and track the movements while carrying the device to the next position. It is a sort of “registration” on field that helps the registration algorithm finding the correct solution. In any case, the registration can be verified in post-production phase and can be corrected in order to decrease possible errors (Figure 11).

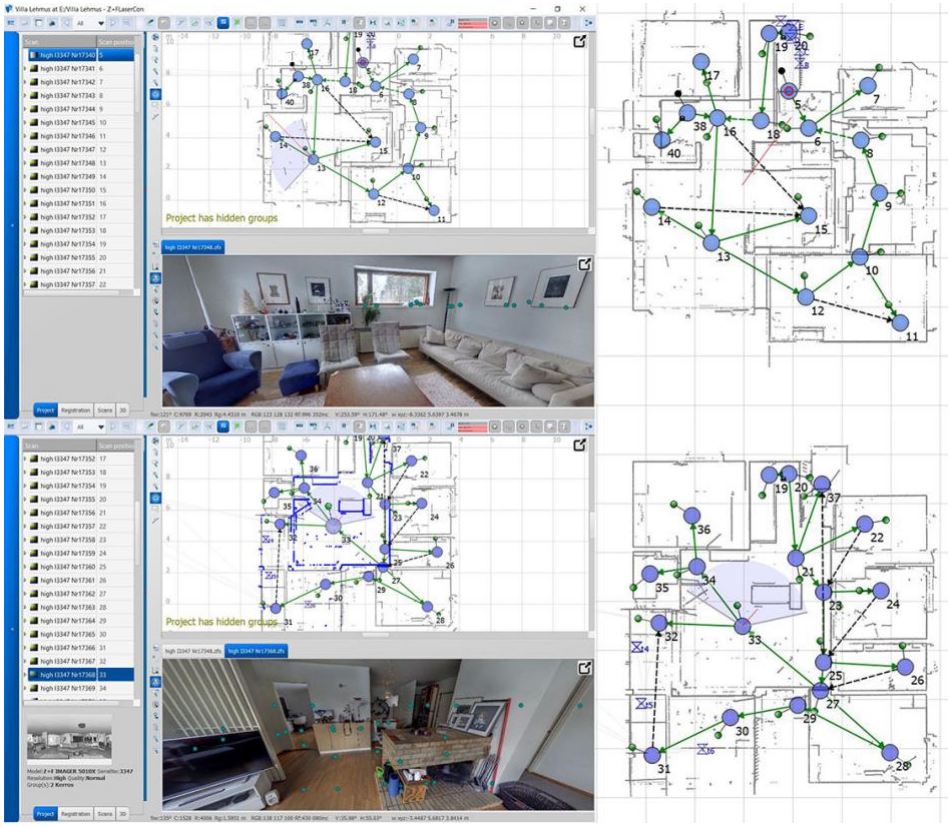

Figure 12. Images from the software ZF Laser Control used for the registration of the point clouds. The window of the programme gives the possibility to visualize altogether the list of the scan words (left side), the top view of the area surveyed with the scan positions with blue balls and a 3D visualization of the singular scan with the application of the true colours. The model is measurable and navigable by double clicking on the blue balls. Each scan has a progressive number and the green links identify the path used by the surveyor during the activity on field.

The registration process in post-production phase has been based on three different methods:

- Use of targets: they are specific points, which give the possibility to elaborate geometrical links between different scan words during the registration operations. The target needs to be visible in all the scans involved in the process of registration. With ZF lasers, it is possible to use black and white paper targets, metallic orientable targets on tripods, or sphere targets.
- *Cloud-to-cloud* alignment system: this method can be used only when wide surfaces are acquired by different scan positions. The software used for the registration gives the possibility to make a geometrical pre-alignment of two scans just by moving and overlap a scan to another one. When the pre-alignment is done, the software can proceed with the accurate final alignment recognizing the same surface in both the different scans. This method needs to be done with attention and only in

those situations where the point clouds have enough areas for overlapping each scan to another one;

- Automatic alignment by using Autodesk Recap: This software elaborates geometrical registration by overlapping common surfaces. The software can calculate the precision of the registration giving to the surveyor all the necessary parameters useful for a careful evaluation of the result. For this reason, the operator is the last who can accept and start the process. After accepting, the operation cannot be deleted.

In some cases, the three methods are used concurrently in order to increase the level of accuracy and for reducing the geometrical error (Figure 12).

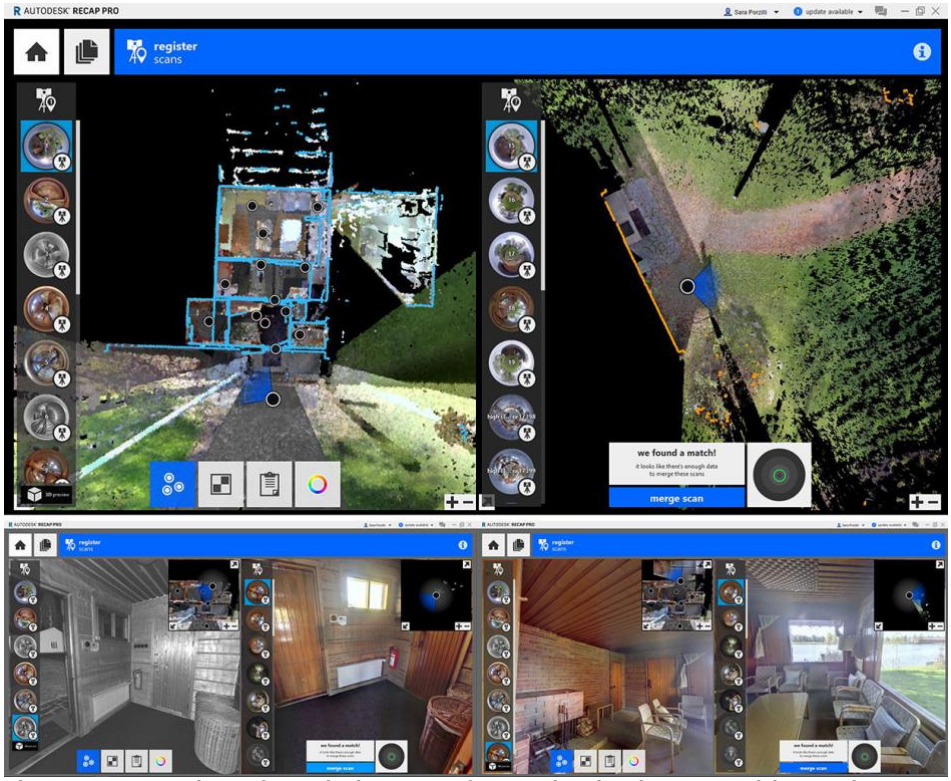

Figure 12. Screen shots of Autodesk Recap software related to the survey of the wooden sauna in Laanila. The programme allows the visualization of the list of scans on the left side, the navigation in 3D through the central window and a general recognition of the whole project through a view map allocated on the top right part of the screen.

Results obtained: How digital documentation can support the identification of values and help the preservation?

The work done on the two cases has produced new insights on digital survey system and an inedited knowledge regarding the place documented. The postproduction phase has produced 2D and 3D drawings, exploring the potentialities of the latest software and their methods of application. Each case has now an updated technical documentation composed by:

- Raksila Project. Documentation and survey of all the street fronts of the neighbourhood. Analysis of the architecture and its environment for the elaboration of updated environmental sections (metric scale 1:50). Census and inventories of the buildings with detection of the characteristics related to the main structures, architectural elements and details, state of conservation with recognition of possible damages. 3D model of the whole area in order to link the information collected in the census analysis with the singular building represented in 3D.

Environmental sections have vector CAD drawings and photomaps of the buildings elaborated thanks to a detailed photo documentation. The resolution of the photomaps is 1:20.

- Aalto's works of Villa Lehmus and the wooden sauna. Documentation and survey of the entire building from both exterior an inner parts (Metric scale 1:10). Analysis of the architecture with detailed drawings, constructive details with direct measurements (metric scale 1:5). Elaboration of a photo documentation for each room and for all the exterior facades. Elaboration of the point cloud with a specific software for allowing an interactive navigation through the rooms and through the external areas (Figure 13).

The application of different analysis to the same object of investigation has created an interdisciplinary work. The elaboration of cross-themes generated the identification of new interesting insights and features.

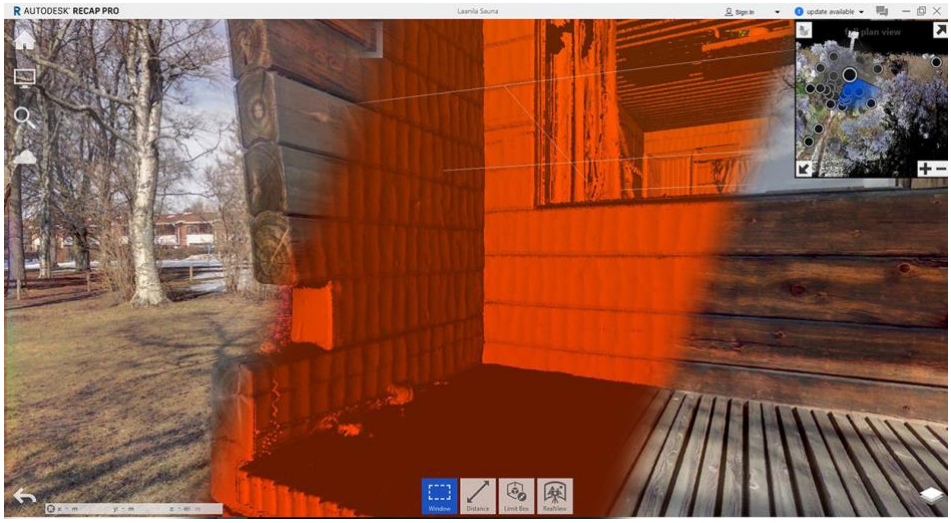

Figure 13. The wooden sauna designed by Alvar Aalto. Different levels of visualization of the point cloud by using Autodesk RecapPRO software. Note the high resolution of the digital survey of the surfaces. In the point cloud it is possible to appreciate the hand craft work which has been done on the logs. Overlap of three different visualization. From the left side: real picture, false colours, real picture applied on the point cloud.

The application of different analysis to the same object of investigation has created an interdisciplinary work. The elaboration of cross-thematises generated the identification of new interesting insights and features of the entire place (in the case of Raksila) as well as of a singular architecture (for Villa Lehmus and the wooden sauna).

For Raksila case the elaboration of all the street sections, combined with the census activity have produced a precious framework of the actual situation of the urban area. 2D drawings and information contained in the inventory have been linked through the elaboration of a 3D model, with the role to be a sort of box containing all the information (Figure 14).

The elaboration of the sections started with the creation of the cut planes on Cyclone software, which is specifically dedicated in the handling of point cloud databases. From the point cloud, orthogonal images (i.e. orthoimages) were produced in order to get a representation of the fronts in real scale and without any distortion produced by perspective visualizations. The vector redrawing has been elaborated through the use of software as AutoCAD and ArchiCAD, on the basis of the ortho images correctly positioned on CAD space. The next part has been devoted at the elaboration of the photomaps of the facades by using the real pictures collecting through the photo documentation on site (Figure 15).

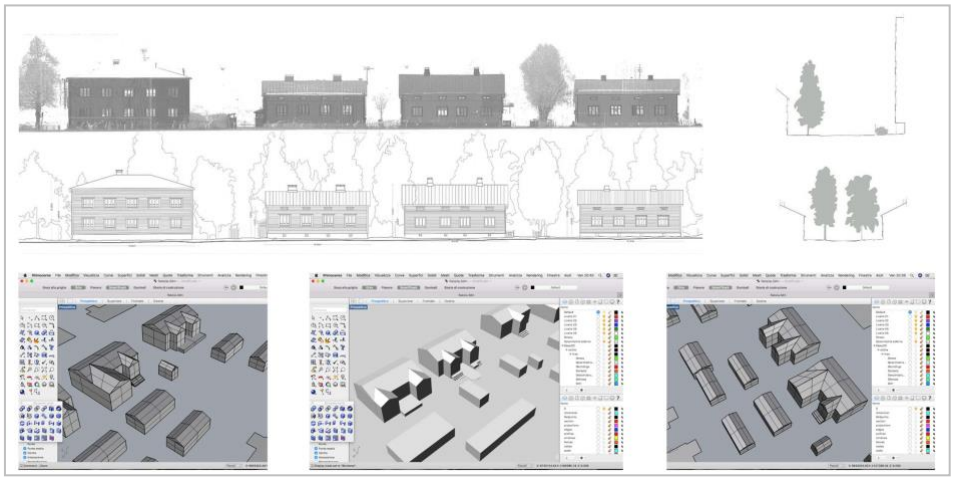

Figure 14. Work in progress for Raksila case. From the point cloud, it is possible to produce 2D CAD drawings and link them to 3D models by using different software.

Figure 15. Description of one street front of Raksila neighbourhood. CAD drawings allow the check of measurements. Photomaps define the real image of the place and give information on colours. The map redrawn from the point cloud has been enriched with the description of the green system of trees, paths and roads with identification of different materials.

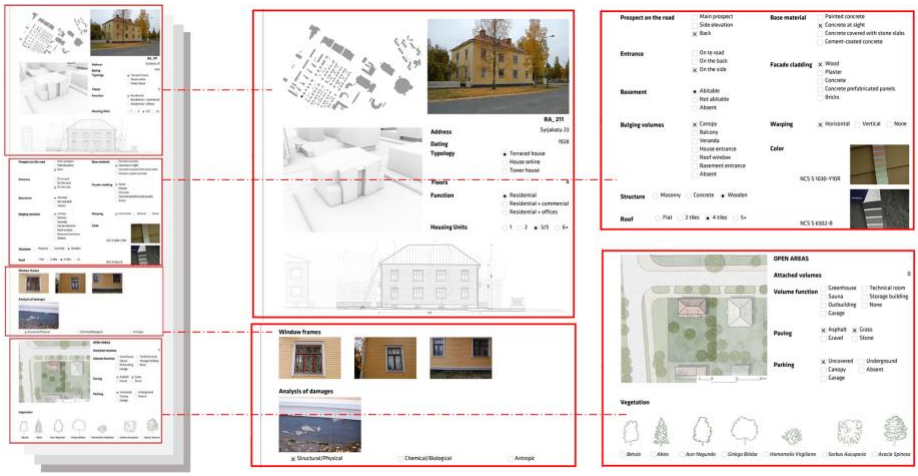

Figure 16. Example of digital inventory for the description of buildings in Raksila. The record card includes all the information collected on field through the survey, CAD drawings, 3D modelling, investigation on site and historical info.

All the information produced created a detailed descriptive card for each building able to give different levels of specifics. Each building is recognized by a specific

code, which has been adopted by the already used codification system used by the municipality of Oulu. For this case, the card has been designed in vertical direction and it is divided into four parts. From the upper part there is a general recognition of the building with its identification on the map, a view, volumetric 3D representation, 2D Cad drawing of the main front and general info. The second part is related to the architectural and structural details, from the typology of the material used, until the description of frames. Third part is composed by images related to details and possible presence of damages. The bottom part is dedicated to the description of the private garden around each building, fixing the number and distribution of the secondary volumes and trees. For Villa Lehmus and the wooden sauna cases, the approach has been similar, considering the different metric scale. The digital survey constitutes the metrical database from which elaborate all the updated documentation. The restoration requires to analyse in detail all the elements, structural details, architectural solutions, electrical and water plants up till the finishing works, i.e. floors and tiles. An inventory and catalogue of all these elements has been defined by using the same method and approach explained in the Raksila case (Figure 16). Each element is identified by a specific code in which it is possible to recognize the specific floor and room. A general map guides always the identification of the specific place inside or outside the house helping the understanding of the catalogue. For this reason, the codification system represents an extremely important element in this process.

Digital documentation and the Madrid Document for an Integrated Conservation

The research activity presented starts from the need to find and refresh a renewed link between the theoretical documents on restoration and the everyday practical activities of architects and experts involved in the processes of protection of heritage. Analysing the current situation of the legislation in the field of restoration and conservation of the heritage, the difference between theoretical statement and detailed explanation of the practical procedures appears evident. The theoretical part is quite comprehensive[13]. However, the application of these Principles is still not easy. Of course, the awareness has grown, but the use of integrated conservation f.ex. has led to different interpretations in many countries.

1883	The Italian Conservation Charter, Camillo Boito
1931	The Athens Charter
1932	The Italian Restoration Charter, Gustavo Giovannoni
1938	Instructions for the Restoration of Monuments
1964	The Venice Charter
1972	The Italian Restoration Charter
1975	European Charter of the Architectural Heritage
1975	Declaration of Amsterdam
1987	The Washington Charter on the Conservation of Historic Towns and Urban Areas
1991	The Florence Charter on European Heritage
1994	The Nara Document on Authenticity
2008	Charter on the safeguarding of Palestinian historic towns and urban landscapes, Bethlehem
2011	The Madrid Document

Figure 17. The main charters and international documents consulted. The refers to the main documents analysed in the ambit of the restoration and protection of heritage.

All of the documents listed in figure 17 put a special emphasis on several different aspects, but they all deal with the issues of recognizing and evaluating the tangible and intangible heritage.
These international charters and documents are published in order to preserve the historical built environment and the landscapes for the future generations. As in preservation and restoration activities, mere inventory of the building heritage nor the technical building surveys can ignore the maybe most important part, the value assessment. And as soon as values are discussed, also disagreements

[13] In this list, only the main documents are mentioned.

appear. This is not the only field where value paradoxes exist. In the preservation activities there are material values as well as inalienable values. In architecture, the value of art is not just the price, which is paid for it. Otherwise the restoration of the Parthenon f.ex. would not be possible. So, some values transcend above time and place. Moreover, those we cannot catch with the most recent technology, not to speak of laser scanning. Nevertheless, this avant-garde technology is very suitable for enhancing the technical condition assessment and thus opening our eyes also to a wider value assessment. This is one addition to the toolbox of historic preservation and restoration.

The Madrid Document (2011) linked to the research

Eight articles divided in thematic subjects compose the Document. Each one is divided into variable number of subparagraphs. Below are some of the most interesting parts that have been analyzed while performing the practical activities of the research. All this work started by sharing the fundamental ascertainment explained in the foreword of the second edition:

Too many of the heritage structures and buildings of the twentieth century are at risk. They are threatened by a general lack of appreciation and recognition, and all too often they are pressured by redevelopment or unsympathetic change.

- ***Art1.*** *Identify and assess cultural significance.*
  Identification requires always a type of documentation able to investigate even all the most detailed aspects of the heritage. New technologies, digital software and an interdisciplinary approach to the object investigated can help the elaboration of high quality analysis as shown above, offering accurate and precise description of all the necessary elements that will guide the elaboration of the technical solutions.
    - *1.1: Use accepted heritage identification and assessment criteria.*

Within the process of recognition and analysis, it is necessary to identify all the characteristics of the heritage. Some of the characteristics to be recognized were originality, typology, authenticity, identity, narrativity and reversibility. The research presented tried in fact to build up an inclusive method in which historical documentation is linked with the actual state of the place.

    - *1.2: Identify and assess the significance of interiors, fittings, associated furniture and art works.*

For the analysis of Villa Lehmus the laser scanning survey and the navigability of the point cloud give the opportunity to have a realistic and complete description of the whole building including also its furniture and art works. They are all visible, represented with real colors and measurable with the help of simple toolbars available also in the free versions of the software used.

    - *1.3: Identify and assess the setting and associated landscapes.*

The documentation of a place involves also its surrounding and landscape. Laser scanning survey is able to acquire detailed information of architecture as well as represent vegetation and open areas. In the cases presented, the analysis has always included the presence of the external areas through the elaboration of detailed environmental sections and inventories of the green areas.

    - *1.4: Proactively develop inventories of the architectural heritage of the twentieth century* […] *through systematic surveys and inventories.*

The research has explored the benefits of digital inventories testing specific software. For Raksila case *Filemaker* software has been used that gives the possibility to design detailed card. List of values, organization of the sheet paper and disposition of the information can be all handle and the compilation can be done by using a tablet straight on field.

- ***Art2.*** *Apply appropriate conservation planning methodology.*
    - *2.1:* […] *Adequate research, documentation and analysis of the historic fabric are needed to guide any change or intervention.*

The importance of research and documentation is expressed earlier in this article Even if there are many business companies capable of performing digital survey and documentation, still a theoretical investigation of the sources is essential in order to create an updated and careful analysis of our Heritage.

- *2.2: Use a methodology that assesses cultural significance and provides policies to retain and respect it, prior to commencing work.*

The *cultural significance* of a heritage passes only through the identification of its tangible and intangible elements. Starting from careful analysis of the historical and archival material, the analysis of the cases presented have deepen the actual situation, investigating wide scenarios of different level of information.

- *2.3: Establish limits of acceptable change. For every conservation action, clear policies and guidelines should be established before starting any architectural intervention.*

The analysis presented addresses the elaboration of planned activities of investigation and documentation in order to elaborate guidelines and consolidated methods for the elaboration of successful conservation actions and policies. The limits of acceptable change differ from city to city, but co-operation with the city has been part of this research.

- *2.4: Use interdisciplinary expertise.*
- *2.7: Archive records and documentation.*

Nowadays a restoration project requires the synergy of different experts. For this reason, the research has been able to produce and organize the documentation, which gives the possibility to be consulted and explored by all the experts involved in the same process. The order of the information acquired, the type of files and ways of storage, the elaboration of a codification system for the identification of the elements, they all contribute to the search for information by a large scale of users.

- ***Art3.*** *Research the technical aspects of twentieth-century architectural heritage.*
  - *3.1: There is a need to research and develop specific repair methods [...] Original/significant materials or details should be recorded if they have to be removed, and representative samples should be stored.*

Through survey investigation and re elaboration of the data acquired it is possible to fix precious aspects of a heritage especially in case of removal or modification. A metrical database such as a point cloud constitute a real situation existed keeping a tridimensional, measurable and reliable recognition.

- ***Art9.*** *Promote and celebrate twentieth-century architectural heritage with the wider community.*

For the cases illustrated, dissemination of the research material has represented an important task of the process. For the Raksila case a public meeting with the inhabitants helped the dialogue between the municipality and people from Raksila. All the entire research was presented through videos, posters, people had the chance to understand the value of the place in which they are living, and at the same time, they became active partners in the process of protection this heritage.
Concerning the case of Villa Lehmus, the owners, interested in a restoration project on their villa, got a full description of their house, supported by updated archival information and technical drawings available for the technicians and the architects who will develop the project.

Conclusion

This conducted project has confirmed that today technicians and experts involved in the protection of the built heritage have a strong and powerful new set of equipment ready to support and improve their operations. The study of the

architecture and its environment, the need to acquire the knowledge of a place through archival studies and historical analysis increase and put additional essential demands to the digital survey operations. According to the advancement on digital technology, also guidelines and methods for preservation need to be updated and implemented by explaining in a more effective way the contribution that digital methods can offer to documentation.
There is an important challenge to the research in operating within these principles, which are listed in the international documents mentioned above, this challenge concerns also the supporting technicians and operators involved in different restoration and preservation activities. We need to remember, that the mere technology does not rescue our built heritage. It also needs international principles, restoration philosophy and common sense.
Today the main damages to our heritage are created by the lack of education in understanding the cultural context[14].
Historical memory and preservation of a heritage passes also through a collective validation of the cultural significance that a heritage brings with itself. For this reason, the three strategic pillars adopted in Finland through the *National World Heritage Strategy 2015–2025* for the heritage protection are so fundamental in our everyday work:

- The value of the world heritage sites;
- Networks of stakeholders;
- Activities creating new outcomes

With the consciousness that today *"the current and future world heritage sites and their universal value form a sustainable and fundamental pillar for the strategy. It is also supported by the ever-expanding, responsibly operating network of stakeholders and the increasingly diverse activities that create new outcomes[15].*
This research intends to promote the importance of the triangle theory-practice-action trying to benefit as much as possible from our digital era. Spreading a documentation such as those produced with the two cases presented, will hopefully contribute to the common awareness of our cultural values, of our heritage and thus also of the importance of its protection.

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[14] As declared in the foreword of the Madrid Document (2011). Web reference: http://www.icomos-isc20c.org/madrid-document-archives/
[15] Ministry of Education and Culture, "Our Common Heritage. For a National World Heritage Strategy 2015–2025*"*. p. 18. ISBN 978-952-263-354-5. Finland, 2015.

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