Integration of close range photogrammetric surveys in the design process of architectural projects

Emmanuel Alby, Pierre Grussenmeyer, Jean-Pierre Perrin

INTEGRATION OF CLOSE RANGE PHOTOGRAMMETRIC SURVEYS IN THE DESIGN PROCESS OF ARCHITECTURAL PROJECTS

E. Alby[a], P. Grussenmeyer[b], J.-P. Perrin[a]

[a] MAP-CRAI UMR 694, Ecole d'Architecture, 2 rue Bastien-Lepage, 54001 Nancy, France
alby.emmanuel@mail.insa-strasbourg.fr (Architect, Phd student), perrin@nancy.archi.fr
[b] MAP-PAGE UMR 694, National Institute of Applied Sciences, 24 Bd de la victoire, 67084 Strasbourg, France
pierre.grussenmeyer@insa-strasbourg.fr

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ABSTRACT:

The purpose of our study is to test close range photogrammetry as an engineering tool, in an architectural project for two different sites. The first is an urban site in Reims (Champagne, France), where we are studying the conversion of an eight hectares wide waste ground, left vacant following old military barracks. The second is the old malt house of Ingwiller (Alsace, France), where it is necessary to establish the survey of existing buildings, and test the ability of current spaces to spring up again an activity. The two project scales are different: one is urban, whereas the other one is in the domain of building architecture. One must be able to seize their context by a global outline of their study areas, as well as know their dimensions. Such projects requires appropriate analysis tools. Multiple-view photogrammetry can become an additional and effective tool for architectural engineering, through the use of a digital model of existing buildings. The use of a digitized representation in the very early phases of design allows to directly work with shapes and building volumetry, and to choose the working point of view independently of the initial photos. The use of the PhotoModeler™ software package makes it possible to integrate the production of a digital model during the architectural design phase. This study allows us to test compatibility in the concurrent evolution of the digital model and of the architectural project. One must serve the other in a permanent and continuous evolution.

RÉSUMÉ:

Notre objectif est de tester la photogrammétrie rapprochée comme outil de conception dans le projet architectural pour deux sites différents. Un site urbain à Reims (Champagne, France) ; il s'agit d'étudier la reconversion d'un terrain d'environ huit hectares laissé vacant par une caserne militaire. La malterie d'Ingwiller (Alsace, France), où il faut établir le relevé de l'existant et tester le potentiel des espaces existant pour y faire renaître une activité. Les deux projets sont différents: l'un est à l'échelle urbaine tandis que l'autre est à l'échelle d'un bâtiment. Il faut pouvoir saisir leur contexte par un aperçu global des zones d'étude et une connaissance de leurs dimensions. Ceci nécessite d'avoir des outils d'analyse appropriés à ce type d'intervention. La photogrammétrie multi-image, par l'apport d'une maquette numérique de l'existant, peut devenir un outil supplémentaire et efficace pour la conception architecturale. Mettre un modèle numérique à disposition, dès la phase de conception, permet de travailler directement avec les profils et les volumétries des bâtiments mais aussi de choisir les points de vue de travail indépendamment de celui de la prise de vue. L'utilisation du logiciel PhotoModeler permet d'intégrer la fabrication d'un modèle numérique du bâti au cours de la conception. Cette étude permet de tester la compatibilité entre l'évolution en parallèle du modèle numérique et du projet architectural. L'un doit être au service de l'autre dans une continuelle évolution des deux.

1. INTRODUCTION

Architects need three-dimensional supports to help them to formulate their architectural choices. If it was integrated into the design process of architectural projects photogrammetry would widen its field of application and thus enrich the tool pallet of contemporary architects. Establish links between these two activities seems to be reachable for two reasons: the use of architectural photogrammetry (software and camera) is becoming a more common technique, and computer science is increasingly used in architecture agencies.

This paper will present an outline of architectural design operation and of architectural photogrammetry. The odds of the interaction between these two areas will then be mentioned. Finally, we will introduce two architectural projects where using the photogrammetric principles can be considered.

2. STATE OF THE ART

2.1. Research on the architectural design

The practice of design in an architectural project is complex to describe because there are almost as many methods as architects; though they share common points. We can introduce project design as an interactive process between the specification (provided by the building owner) and the architect through the use of graphic simulations. Lebahar defined Graphic simulation (1983) as "*the use of a temporary representation of the problem, of the graphic simulation*

model, in order to express, test, modify, and interpret the hypotheses of the object model before considering them final."
On one hand representation tools are used by the architect to find a solution to his problem (fig.1). On the other hand there is a figuration of the solution. This represents the progress between problem resolutions. An architect often advances in the project design through interpretation of his own sketches: concepts become clear while redrawing continuously starting from the preceding drawing. The conception is the creation of a language that is specific to the architect, enabling him to advance the project. Graphic simulation is then a cognitive cycle.

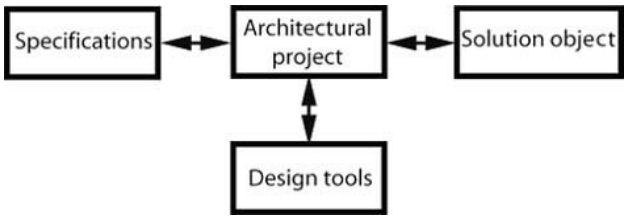

Figure 1. Representation of the architectural design process

The work of the designer is limited by the representation means he regularly uses (plane projections –plan, section – perspective or axonometric view etc). He may be disorientated if these means change (Boudon & Poussin, 1988). Figuration is a way to communicate. It is also a means to convince. The designer can therefore act on the figuration with respect to the witness as well as for himself.

The figuration aspect is quite important. It could be realistic or not. A representation which is not realistic tells about content, about the concept, contrary to a realistic figuration which emphasizes the form. The style of the figuration also takes palace on the message diffusion the representation should give: a sketch can sometimes be more demonstrative than a standardized plan. Consequently there exists a ratio meaning / meant in representation: ratio between what we want to express and the means which are used to do it (Lebahar, 1983).

There are many means to represent a project. The architect must choose one. If he wants to represent his project in a total and realistic way, he will preferably use a 3D view. The point of view of the perspective can be the same one as this of the design. The designer can either project himself from a realistic point of view, or not. There may be an influence of the design point of view on the final object. One should be aware of the liberty the architect has in the choice of his design tools.

2.2. Architectural photogrammetry

There are two fields of applications in photogrammetry: aerial and architectural photogrammetry. Architectural photogrammetry and aerial photogrammetry do neither share the same purposes nor the same requirements. Architectural photogrammetry does not require the same high precision software as the computing units used in aerial photogrammetry. The software used is often based on multiple view technology. Commercial digital cameras provide a sufficient resolution for the major part of architectural photogrammetric applications. Data obtained by this means is adequate for 3d visualisation, but not sufficient for metric documentation. The advantage of this software is that it can run on a PC, allowing the majority of the designers to use it (Grussenmeyer et al., 2002). With this in mind, a test of photogrammetry use with low-cost tools was carried out (Gardiol & Philips, 2001). It aimed at analyzing the precision of outer and inner building survey with low-cost equipment (Olympus camedia and PhotoModeler). The study concluded that it is relevant to use such equipment for surveys of buildings. Although Architectural photogrammetry is achievable at a lower cost, management of the processes still needs to be improved to allow an autonomous use of this tool. This is a matter of technical knowledge transfer between technician and user. What is the role of this transfer in the development of lower cost and lower precision applications (Fraser, 1997)? Two approaches may be adopted: either the tools are automated and users do not need training, or use methods are set up depending on the needs and on the training capabilities.

2.3. First experiences of photogrammetry use in the design phase of architectural projects

A link exists between the representation of the survey and the use of this raw information: "Each convention of representation implies its spatiality, maybe even its own urbanity" (Latek, 1999). Caution should be taken to avoid that photogrammetry hinders the design phase, if this means is used during architectural design. Is it permitted to use documents characterized by their source, or is it necessary to completely adapt representation convention to the beneficiary (Eckstein, 2001)?

The use of photogrammetry for an urban project or for a large project had already been considered. A good example is the conversion of the Hasanpasa gas works in Turkey (Tanyeli et al, 2001), which demands the restructuring of an industrial area. Use of Photogrammetry was planned. The challenge resided in the adoption of a compromise between a precise survey and the larger study area. Aerial photogrammetry was then chosen. The collected 3d data was then imported in a software CAD tool: specific interfaces had to be developed, in order to be able to process the produced data as classical shapes (plane section etc). In this case the design method was modified.

The project (Canciani, 2001) is comparable. A three-dimensional model of town part of Marconi (Italy) was to be built before being used as a support for the urban project.

The architects' design method depends on the project context (Iordanova & Tidafi, 1999). This makes the task very difficult for those who try to translate those methods in the CAD area. A part of the built background can be rendered with help of photogrammetric methods. The representation of this context thus has an influence on what can be interpreted of it. It is useful to connect the information provided by these surveys and existing CAD tools, in order to integrate the photogrammetric surveys in the architectural project process.

3. ADVANTAGE OF BRINGING CLOSER PHOTOGRAMMETRY AND THE ARCHITECTURAL PROJECT

Specifications allow for a clear statement of the problem the architect will have to solve. This problem is the reference on which the solution will be based (Prost, 1992). We thus assume that the problem figuration mode influences the choices of the designer. The design mode may change if photogrammetry is used to provide part of the data that is used in the problem.

In this case the architect would get a digital three-dimensional model to work his project out. The references to architecture are

often indicated as being the central element for the constitution of an architectural solution (Prost, 1992). Thus the availability of a model of the existing buildings seems significant to us.

For Lebahar in 1983, the drawing was the means of acting on the object, and on "himself (the architect) acting on the object ". Nowadays, CAD is an alternative to the drawing and allows similar situations. In order to initiate a building project, one should be able to view it in the final context in which it will be inserted. A building in the design phase does not exist, but its future environment generally does. A representation of the existing context is thus significant. Models at various scales have been used for a long time to visualize three-dimensional architectural objects. Now data processing is developing in the agencies, and we should consider the benefits this 3D visualisation tool brings.

3.1. Virtual model available today

Only what is necessary for the desired final model is modelled during a restitution (using the photogrammetry software), once images have been oriented (fig.2). However, in the case of an architectural intervention, part of the potentialities of a building are discovered at the same time as it is measured. Thus the interest of the model evolves according to its own advance.

3.2. Volumetric 3d model

Data processing proved itself in the area of the architectural drawing. It is concievable that the use of it will extend to the design, even if hand drawing keeps an undeniable role. During this significant stage of the project, several implementation and volumetry alternatives will be tested, and they will be confirmed (or not) by their traditional model representation. 3D modellers are increasingly being used. Consequently a 3d model of the existing becomes essential. However urban 3d models are not yet available for the designers as are 2d computerized plans (Morakot, 1996.). Multi-image Photogrammetry allows a quick and easy making of 3d models (for a smaller intervention scale). In order to carry out this 3D model, the data will be obtained from virtual models and it will be used immediately to model the volumes of the buildings (fig.2). Trying to bring back whole volumes with the photogrammetry software would be too tiresome. A topographic plan can be used as a starting point if it exists (Chevrier & Perrin, 2001), by extruding the lines describing the buildings, and by slicing the volumes, one after the other, depending on the data provided by the photogrammetric model. A 3D model is not an accurate model, it should be used to give the scale of buildings, not to provide details on openings and ornaments.

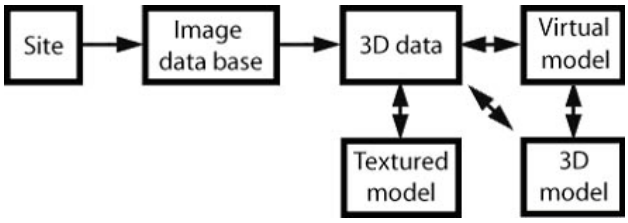

Figure 2. Three possible uses of the 3d data issued from photogrammetry

3.3. Textured 3D model

The textured model (fig.2) directly results from the data-processing tool for architecture representation, as opposed to the 3D model, which comes from traditional model. It allows a virtual insertion of the project in its closer architectural environment. It is possible to choose the point of view, to represent the project in perspective, after inserting it in the 3D model.

The easiness of the proposed tool is one of the critical success factors for the architect to use photogrammetry. This is why a "turn-key" tool must be made available.

4. HOW TO INTEGRATE PHOTOGRAMMETRY IN THE ARCHITECTURAL DESIGN PROCESS

4.1. The architect as photogrammetry user

The architect must use this tool himself. It is one of the success factors for a tighter cooperation between photogrammetry and architecture. Several tools are used alternatively throughout architectural design process. If photogrammetry is directly used by the architect, it becomes a tool which he can constantly use. The photogrammetrist should by no means be excluded from the architectural project process, but photogrammetry principles should be integrated among the architect tools. This is why we do not think a human interface is suitable. Even if know-how is larger, the presence of an intermediate specialist can slow down the process. The project would be jammed if the architect had to permanently translate his needs in order to use one of his tools. Moreover he may not be able to exactly define his wishes as seen in chapter 2.1. To make this tool available to the architectural project, it should be democratized, even at the expense of some accuracy or rigour in the survey. The goal here is not to convince of the absolute need for the use of photogrammetry in the frame of the project but to show which services this technique can return to those who control the principles of it.

4.2. Data processing as a link between the two disciplines

Resorting to data processing is one of first requirements to use the photography survey tool, because the information produced by photogrammetric techniques is of digital nature. Contrary to the computer-assisted presentation, CAD is not very much used yet in architecture but a lot of research is under way, specially dependent on progressing technologies. The introduction of photogrammetry into the architectural design process may also generate demand for CAD for architects who would not have yet found a good reason to adopt it as a working tool.

5. TYPES OF ARCHITECTURAL INTERVENTIONS FOR WHICH PHOTOGRAMMETRY IS EASILY SUITED

In order to use photogrammetry in the architectural project, the built context has to be appropriate. That is why we distinguish between two kinds of projects.

Rehabilitation projects and insertion projects between buildings: their contexts influence the course of the design. The documents used to represent this context are already an interpretation of the place. An elevation only shows a part of information. A picture only shows part of the whole object. Thanks to photogrammetry the entire context is available in digital and global form. Photogrammetry makes a virtual object available to the user, which can constantly provide information about dimensions as well as about materials of the considered object.

Low-size urban projects: when the project scale is a housing block or a small part of a district. It is recurrent to have to refer to surrounding building shapes to maintain the analysis on the project insertion. Photogrammetry may make it possible to provide interesting information for the development of the project, but only if the project scale is not too large.

6. EXAMPLES OF ARCHITECTURAL PROJECTS USING THE PHOTOGRAMMETRIC TOOL

To test the validity of our approach we carried out two architectural interventions of different kinds. During the visits, we had a digital camera (Minolta Dimage F100, 4 Mpixels) and the PhotoModeler Pro 4 software (EOS System) for data processing.

The first example is a preliminary work with an industrial building rehabilitation. The old malt house of Ingwiller (fig.3), a 2000 inhabitants' town in north Alsace (France). This building was built at the beginning of the 20th century and was modified several times. It has not any more been in activity since 1986, when the malt production was transferred to another site. In order to give a new life to this building, it was decided to make the survey of it, followed by a test of the transformation feasibility for such a building group.

Figure 3. Ingwiller old malt house

The second example is a common reflexion at an urban scale. The site of Jeanne d'Arc barracks (fig.4) is situated in the periphery of Reims (France). Reims was a garrison town at the time of the German empire occupation of Alsace-Lorraine. It was thus surrounded by barracks at the beginning of this period (1870-1914). The Jeanne d'Arc barracks is a hint of this time. Strategic interest of Reims barracks disappeared and those will be destroyed.

The two operations have different natures. This enables us to study several possible and various uses of architectural photogrammetry as a tool. One allows to test the possibility to measure with the virtual model of existing (malt house) and the other to use the 3D model and the textured model.

Figure 4. The barracks, aerial picture, current built context.

6.1. The survey

As regards to the malt house, the survey and its representation constitute the major part of the work. It was carried out in a traditional manner (distancemeter). It was long and hard and sometimes some distances were impossible to measure. That is why an additional outer photogrammetric survey appeared interesting to us. It allowed us not only to measure the elements which were only visible from outside, but also several inner dimensions, thanks to the trace of slabs in facade for example (fig.5).

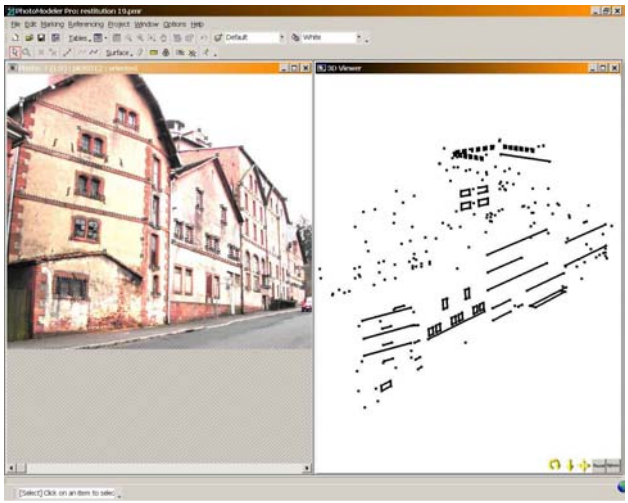

Figure 5. Malt house virtual model. The trace of slabs in the facade and some windows facing the street can be seen (PhotoModeler software).

With regard to the project in Reims, the photogrammetric survey was carried out simultaneously with the site visit by the design team. The ground being large (approximately 8 hectares), it was necessary to define an area for the survey. The site was the center of our interest. It was decided to survey only the buildings that could be seen from the barracks ground. The model for this project was to be directed towards a virtual 3D model. Only the existing limits on streets of the site were modelled. Thus the project could be inserted in a virtual built context.

6.2. Protocol

The malt house belongs to an urban fabric which is not dense. It is thus easy to go around it. That simplifies the convergence of shots. Moreover the building has some elements which can be distinguished at the roof level (chimneys, technical buildings). This is due to its industrial nature. It becomes then easy to link images of all façades. The virtual building of the malt house was obtained by orienting images which have sufficient overlap.

In Reims, the two streets where the survey takes place are sufficiently broad to allow perpendicular façades shots. Unfortunately, one of them is partially hidden by two lines of trees which appear on quite all the images. Interesting buildings are partly masked. The shot axe of selected pictures is as close as possible to the perpendicular compared to the façades. This allows to avoid perspective effects which reduce accuracy. Virtual model images were oriented in several blocks. A single image block is not useful because the virtual model is not a representation of what exists. Moreover it would have been composed of a great number of images, which would have complicated the orientation and the handling of the file (important requirements of material resources). We split the virtual model according to housing blocks. Five to ten buildings were included in each model. Some virtual models were made according to specific needs. It was the case for precise buildings (a tower, an isolated building). The site is represented globally only in the 3D model (fig.9).

6.3. Use of the models

Malt house: once all the necessary images are oriented, the restitution can start. It is not necessary to model all the building.

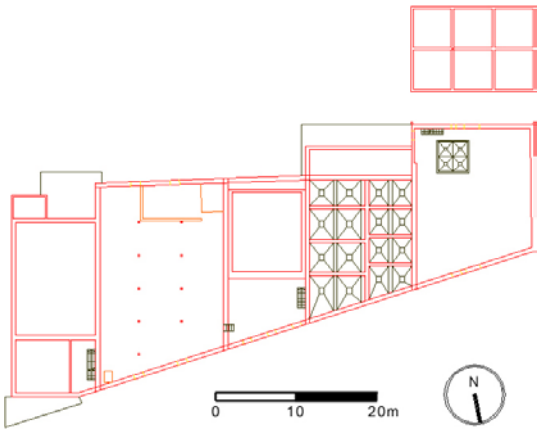

Figure 6. Malt house: survey plan, the oblique angle, in its whole, was designed with help of the virtual model.

Only elements which require details must hold the attention. Ideally, the model should be carried out at the same time as the representation of the survey. In this way it is possible to put the model and the plans in interaction. The model is then related to the plans (fig.6). This is not a goal but a means of perfecting survey plans.

We found the Reims model useful in the volumetric form for dimensioning of the built volumes. Numerous exchanges between Photomodeler and CAD were necessary to build the 3D model, as for the survey of malt house. This project could have required a textured model, but the principle of the common reflexion directed us towards more abstraction for the sights of the project. Concerning the masks caused by the trees, cables and electricity poles, our solution however consisted in orienting an image already used in the model after modification in the publishing software (Adobe Photoshop).

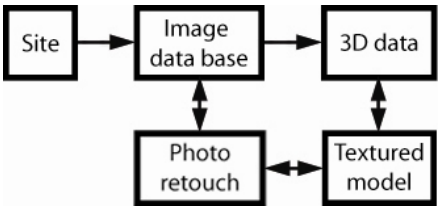

Figure 7. Picture retouch as texture source

The textured model built with Photomodeler uses some of the pictures as texture source. It is sufficient to retouch copies of these images (fig. 7), and then to orient them with the same points as their double. The textured model becomes exploitable for a meticulous project representation (fig.8).

Figure 8. Reims: retouched image, oriented in Photomodeler.

7. CONCLUSION

Architectural photogrammetry, throughout the kind of information it brings, can be made available to architects, as a representation means of existing buildings. The contribution of a virtual model of the context for a project can make it essential. Moreover, if the architect can get used to this technique, the right design process is preserved. The point here is not to conclude on the need architectural design could have for a tool like photogrammetry but to present how the architect can possibility use it. He is free to choose his tools depending on his project practice.

Being an architect and having used photogrammetry as a tool, it appears essential to us to set up users' guidelines for photogrammetry. It should be made appropriate to people without scientific background. Photogrammetry can become an effective and helpful tool for the architect if he is able to manage it.

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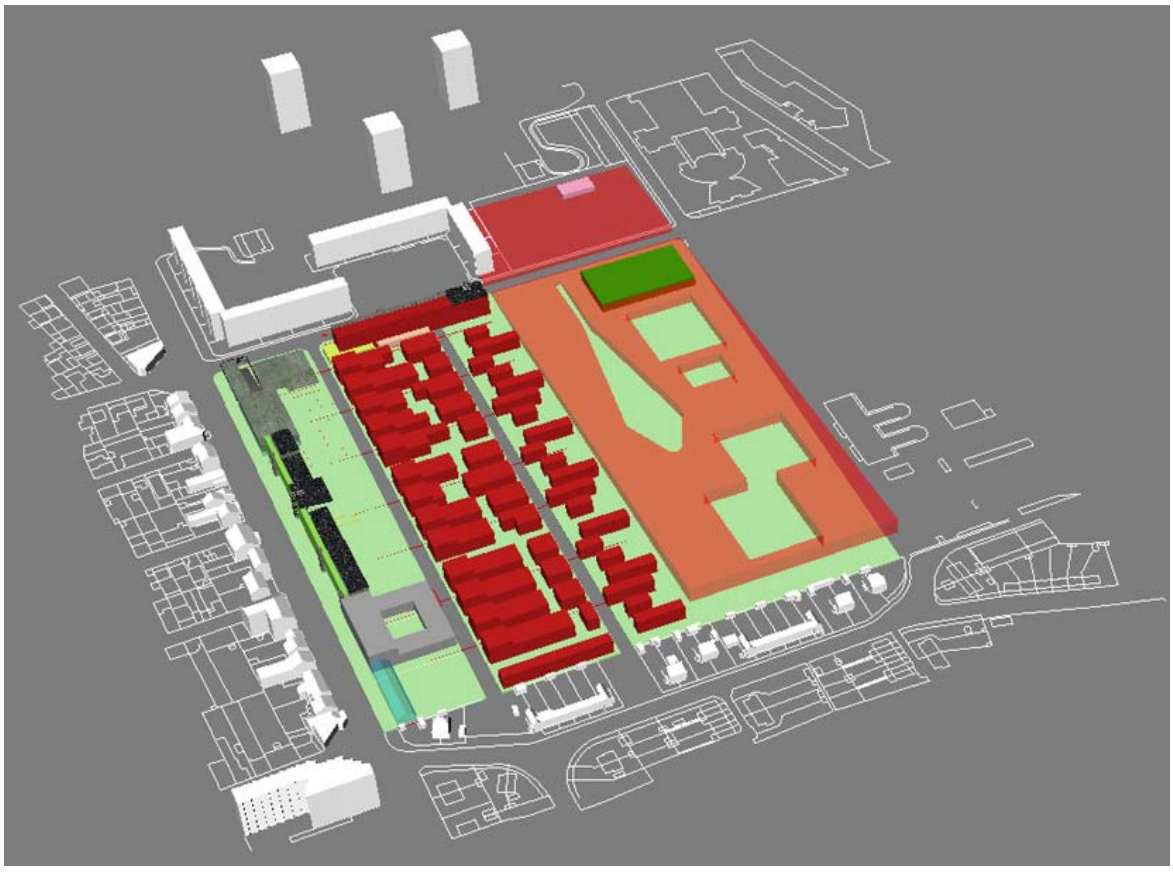

Figure 9. Reims: working 3D model, buildings in white have been modelled from the virtual model