

Digital Simulation of the City for Three Millions Inhabitants by Le Corbusier

Geometrical analysis, electronic reconstruction and video animation

Alberto Sdegno¹

¹Department of Architectural and Urban Design, University of Trieste

¹(<http://www.units.it/sdegno>)

¹sdegno@units.it

Abstract. *The research that is presented describes the geometrical analysis and the digital reconstruction of one of the most important designs by Le Corbusier: the City of Three Millions Inhabitants; it represents one of the most impressive solutions of the idea of Future City done during the XX Century, and a lot of its architectural elements are now part of contemporary buildings. The aim of the research was to understand the main morphological aspects of it and compare the different solutions made by the author during his life, starting from the first public presentation in occasion of the Salon d'Automne in Paris (1922) and to reconstruct the 3D digital realistic-textured model of it, in order to realize the video that describes the whole project of the city; the research was done at the Faculty of Architecture of the IUAV University of Venice.*

Keywords. *Le Corbusier; urban design; digital reconstruction; simulation; video.*

The Description of the City

The City for Three Millions Inhabitants was, without any doubt, the biggest and most important not realized project by Le Corbusier. During his life the architect tried to define a lot of urban and architectural plans - some of them partially constructed, such as the one for Chandigarh - but the idea he developed since 1922 remained unbuilt. In the case of this project we have to consider that it was born for the present time and not for the future: in fact he really thought that it was possible to realize a similar design, in order to have a new town in which try to verify all the problems of the contemporary life. We have to notice also the relevance of the representation of

this idea: a particular typology of presentation was in fact used by him, drawing a large diorama of 100 sq m in order to express the revolutionary concept.

It consists in a strictly geometrical scheme, that considers the main area as the business centre, with high skyscrapers of glass façades, reflecting the scene in a dramatic way, a small airport in the middle, a series of *Immeuble-Villas* all around composed by variable units based on that presented in Paris in 1925.

It is difficult to describe the complexity of the solution without the help of some drawings. In particular it is possible to find some squares that organize the geometry. The general scheme shows a main rectangular configuration and a square rotated

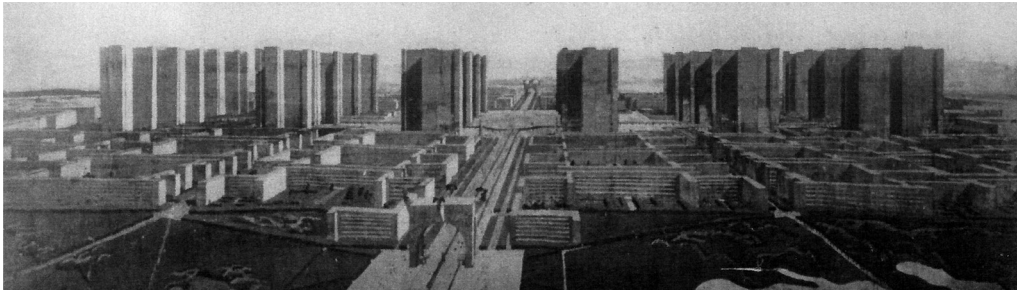


Figure 1
Le Corbusier, *Diorama of the City for Three Millions Inhabitants*, 1922.

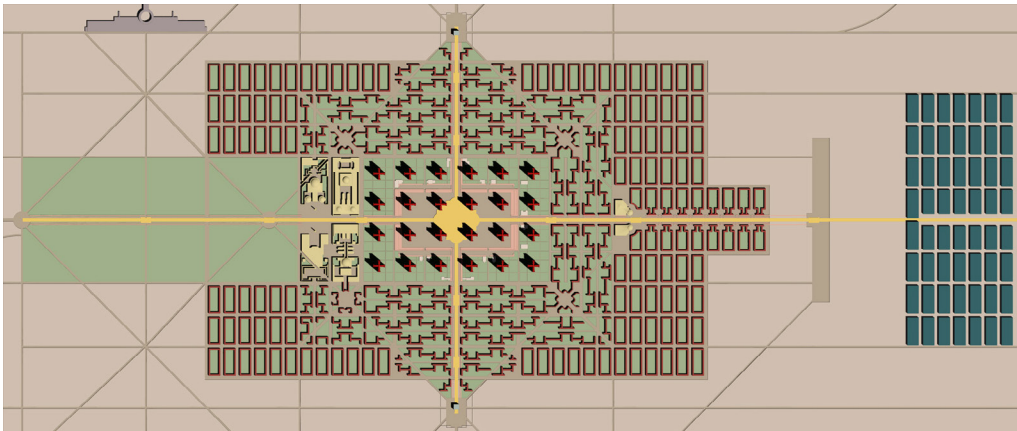


Figure 2
Geometrical analysis of the project plan (elab. M. Marchiori)

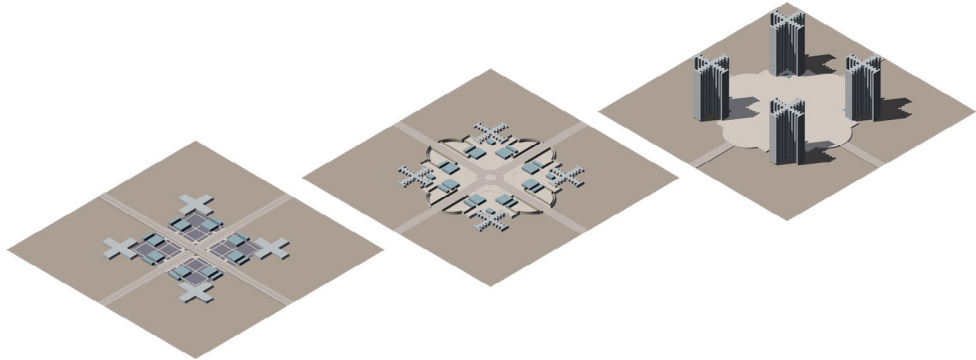
of 45 degrees superposed to the preceding form. The streets are generated from the intersection of the composition, creating the public spaces such as the gardens. In the middle there are 24 skyscrapers, surrounding a small urban airport. Some interesting sketches are presented in the *La Roche Carnet* which Le Corbusier gave as a gift to Raoul La Roche, friend and patron of the architect. In it we can find quoted line drawings, that allow us to start the reconstruction, and the genesis of some forms. For example, the plan of the skyscrapers is 150 m large instead of the 200 m solution he proposed some years after, and the main area is based from the design of Michelangelo for the Saint Peter Church in Rome. Some portals similar to triumph arches are placed at the beginning of the large streets in order to give more

monumental aspect to the access to the town.

The Complex Geometry of the Cartesian Skyscrapers

The skyscrapers are the most visible objects of the whole project. The historical genesis of their conception is in some sketches traced in 1915, during a conversation with Auguste Perret, for whom Le Corbusier worked some years before. In these drawings we can find the main idea of the project: high towers put on a large green park. The architect took the form of the crossing buildings by Perret, but gave a different configuration. In fact Le Corbusier introduced the Greek line in the plan profile, to give more stability to the structure, to have the best distribution of the

Figure 3
Geometrical schemes of the
skyscrapers plan (elab. M.
Marchiori).



space inside and to capture the natural light. They are composed of 60 floors and are 220 m high, and they are used as administrative offices for the City. In the centre there is the concentration of important roads of different typology: such as underground, highways, railways and a small airport just in the middle, for urban flights.

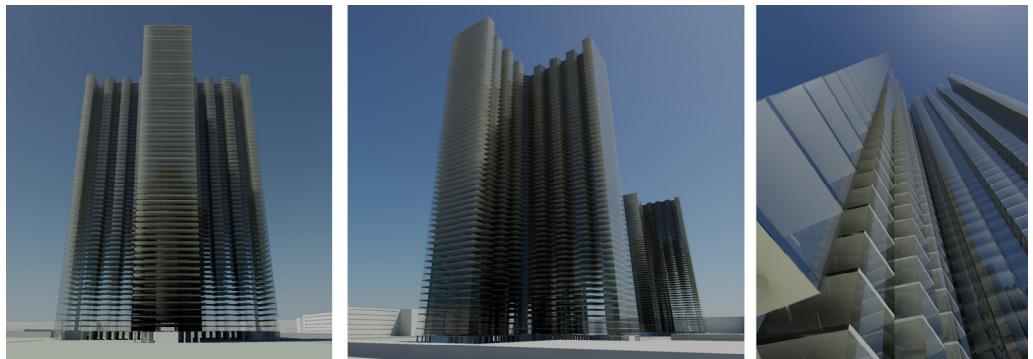
But the most significant aspect of these towers is the external perception of them. In fact a complete mirrored walls run all around every building transforming the big structure in a light volume, reflecting the sky and the panorama. “Immense prisms, but brilliant” was the synthetic expression used by him that explains very well the new conception of volume for Le Corbusier. This peculiarity was a real problem during the phase of the digital reconstruction

and simulation, because we needed a lot of time to render in high definition the scene with Global Illumination algorithms, due to the recursive reflection of light on the surfaces of the volumes.

Different typologies of urban housing

All around the office buildings there is the development of the urban housing. The main ones are those called *Immeuble-Villas* and the *lotissement à redents*. Although we have a great variety of solutions of them during the life of the architect, the relevant difference is in the configuration of the main volume: the first one is a compact building with a green park inside. The typology of the single unit is based on the study he did on the Certosa of Ema in Tuscany,

Figure 4
Digital reconstruction and
simulation of the skyscrapers
(elab. M. Marchiori).



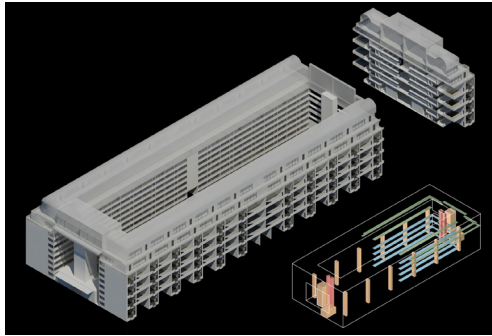


Figure 5
Isometrical representation
of the Immeubles-Villas and
scheme of the paths (elab. M.
Marchiori).

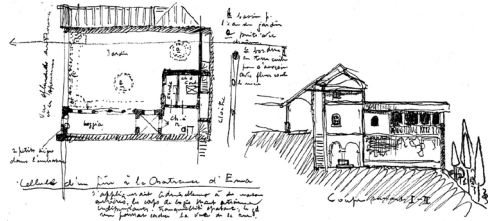


Figure 6
Sketches by Le Corbusier of
the Certosa of Ema.

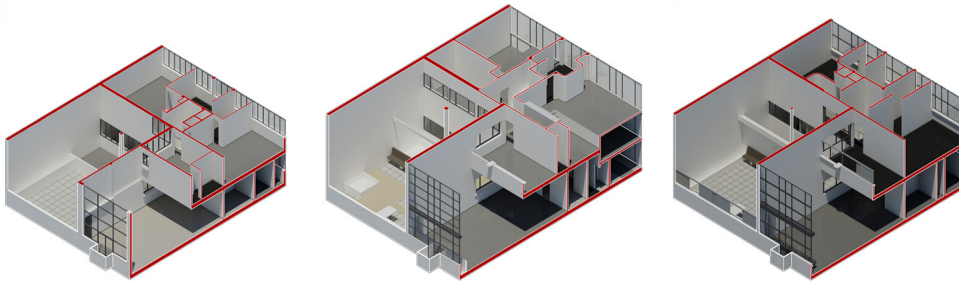


Figure 7
Isometrical representations of
three different versions of the
unit, between 1922 and 1925
(elab. M Marchiori)

organized on a L-scheme, superposing two levels.

A corridor runs in the court, allowing people to reach every single cell. A private garden is put inside every unit, transforming it in a isolated country house. Horizontal and vertical paths create a particular rational distribution, and indirectly generating two very different façades: the external one, more open to the light and to the City, and the internal one, more closed.

Between 1922 and 1925 Le Corbusier developed five versions of this unit, with small changes. But the main distribution was preserved. We can find, in fact, a large terrace near a dining-room and a living-room, the kitchen and the bathroom, and some rooms upstairs.

This idea of house was presented at the *Exposition des Arts Décoratifs* in 1925 in Paris, where Le Corbusier constructed the *Pavillon de l'Esprit Nouveau*.

The words of the author describe in the best way his conception in the book by Le Corbusier and Jeanerret P (1964): "My intention was to illustrate how, by virtue of the selective principle (standardization applied to mass-production), industry creates pure forms; and to stress the intrinsic value of this pure form of art that is the result of it [...] and to demonstrate that these comfortable and elegant units of habitation, these practical machines for living in, could be agglomerated in long, lofty blocks of villa-flats". Attached to this cell-unit was an annex in the form of a rotunda containing detailed studies of town-planning schemes and two large dioramas, the first one is that of the City of three millions Inhabitants, the second one showed the Voisin Plan for the centre of Paris.

Very different from the *Immeuble-Villas* scheme is the *lotissement à redents*. In this case, in fact, the

Figure 8
Sketches by Le Corbusier and
volumetric diagrams of the
cells (elab. M. Marchiori).

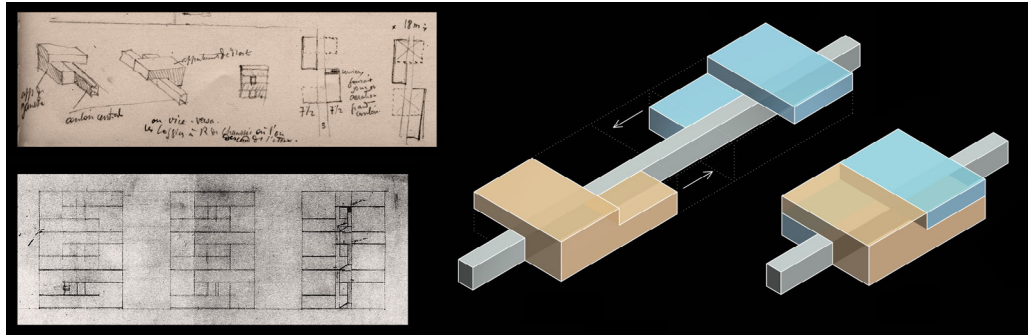
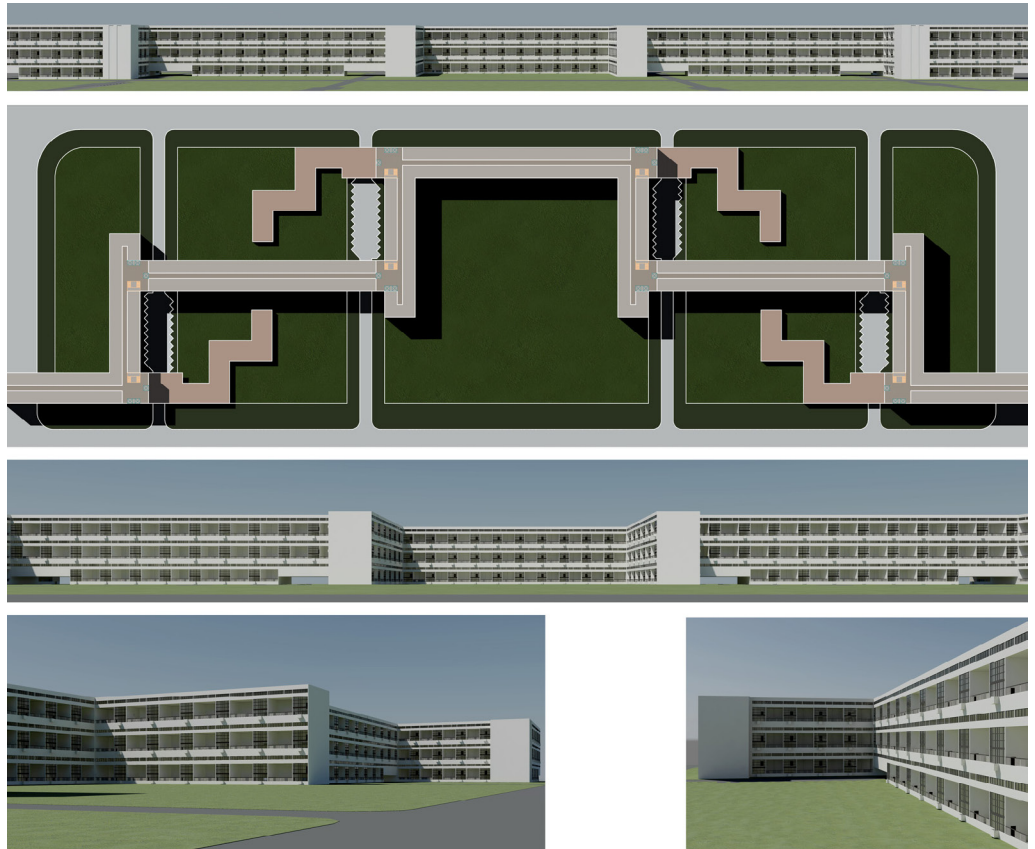


Figure 9
Rendering of the final simulation
of the lotissement à re-
dents (elab. M. Marchiori).



configuration is composed as a block open on a garden. As the preceding one is well described, the housing *à redents* are represented only in volumetric form, showing the articulation of the buildings. Only in 1930 Le Corbusier, in occasion of the project of the *Ville Radieuse*, will try to resolve in a practical way the organization of this structure, defining a corridor between the two cells of habitation.

The final scheme presents perpendicular blocks that run connected one to the other. The recursive façade changed its aspect only thanks to the presence of some blocks in the beginning of every single part. Although we are not sure of the exact idea of Le Corbusier, because of the lack of information we said, we can consider this hypothesis as one of the most similar to that thought by the architect.

The Digital Reconstruction

We started from the general geometrical conception described in the beginning of this paper, based on the rotated 45 degrees square and its diagonals, that

defines all the main streets of the City. We found also another square that, with its golden section, generated the main rectangular structure of the City. Then we have reconstructed the twenty-four “Cartesian” skyscrapers, using the solid modeling extrusion primitives, and applying to the surfaces the material that simulates mirror effect. In this case a lot of time was dedicated to the calculation of the rendering of every single frame, due to the mirror simulation. Some years after Le Corbusier showed this idea in a video titled *Bâtir*, directed by Pierre Chenal, in which the architect took in his hand a translucent scale model of the skyscraper. We considered also these images as reference for the digital simulation. A further step was the comparison between the two solutions of *Immeuble-Villas*, the 1922’s and the 1925’s one.

The last step of the digital reconstruction was the modeling of the “rues à redents”. In his book *The city of tomorrow and its planning*, the architect mainly talked about the paths around the building, and the configuration of the streets for cars and pedestrians.

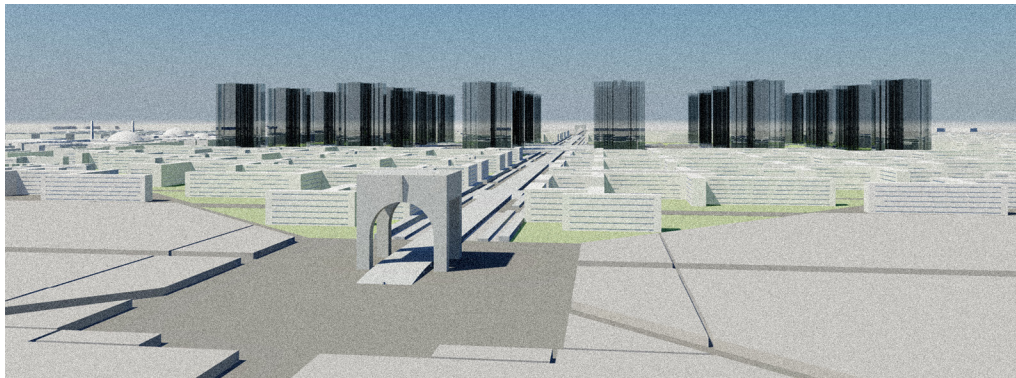


Figure 10
Rendering of the City for Three Millions Inhabitants
(elab. M. Marchiori).

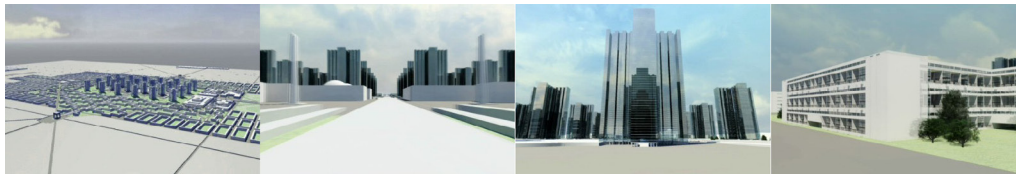


Figure 11
Single frames from the video animation (elab. M. Marchiori).

The most famous realization of this kind of architecture were undoubtedly the *Unité d'Habitation*, a big isolated parallelepiped, in which all the function of the modern town were concentrated. In the case of the City for Three Millions Inhabitants the blocks were connected among them with some aerial tunnels, over the streets.

A lot of other elements were presented in the general drawing of the city plan, such as theatres, public spaces, cinemas, schools. But there are no much information about the real volumes of them. So the only way to give an idea of them was to use the exterior perspectives done for the public presentation of the project, approximating them in comparison to the other well known structures. The final digital model of the city occupy 170 mb of spaces and was created with blocks.

The Simulation of the City and the Video Animation

The last step of the work was the simulation of the city, using rendering algorithms. We used two kind of representation: an abstract visualization, to show sectioned models and geometrical schemes of configuration; a photo-realistic figuration to try to understand the impact of the buildings on the whole city.

As we said before, some problems were determined by the great presence of mirror surfaces, that reflected also the other mirror façades, in a recursive way. Then we decided to create an animation to represent a virtual tour on and inside the city. For the final video more than 20,000 frames were generated with a flythrough and walkthrough techniques, using 60 hours of calculation. The frames were post-processed superposing Le Corbusier's drawings of the design, to verify the correspondence of images. Two were the models used for the simulation. A volumetric model – with colors, about 100 mb – for a general visualization of the city, to use in a bird's eye representation; a very detailed one – with maps, about 400 mb – to see the architectural spaces, and

the effects of lights and shadows applied to the volumes. As the project was elaborated by Le Corbusier without a contextualization, we decided to give a general indication of the geographical site in order to have a natural simulation of sunlight. Due to the dimensions of files, it was impossible to investigate the lighting in different period of one year, a month or a single day. We decided to find the best possible solution and use it during the whole duration of the animation. The research was not yet presented, and we have planned to develop it in order to simulate some interior rooms of the main buildings, that are already studied in the form of the abstract representation.

This research started at the Faculty of Architecture of IUAV University of Venice, was partially developed during the graduation thesis of Mara Marchiori at the same institution, having as supervisor Alberto Sdegno, then it continues at the Department of Architectural and Urban Design of the University of Trieste.

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