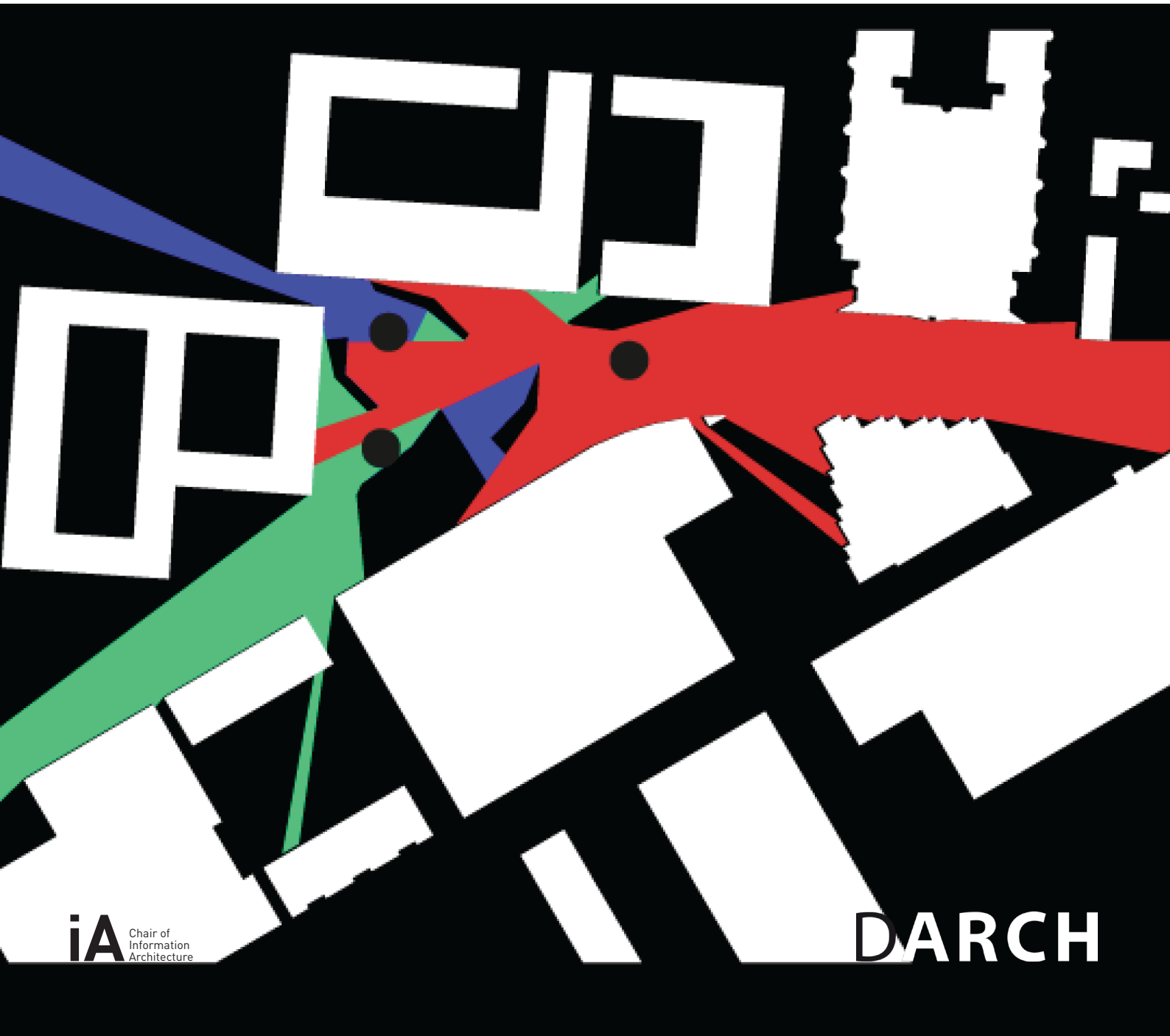
ETH zürich

Documentation of the teaching results from the spring semester 2014

New Methods in Urban Analysis and Simulation

Reinhard König, Estefania Tapias, and Gerhard Schmitt



DARCH

Department of Architecture

Chair of Information Architecture

New Methods in Urban Analysis and Simulation

Documentation of teaching results

Reinhard König, Estefania Tapias, and Gerhard Schmitt

iA
Chair of Information Architecture

Teaching
Reinhard König, Estefania Tapias, and Gerhard Schmitt

Syllabi
http://www.ia.arch.ethz.ch/category/teaching/archive/fs2014-new-methods-in-urban-analysis-and-simulation/

Seminar
New Methods in Urban Analysis and Simulation

Students
Guillaume Stark, Jain Neel, Jing Xi, Lewis Williams, Li Li, Rini Singhvi, Stanislas Chaillou

Published by
Swiss Federal Institute of Technology in Zurich (ETHZ)
Department of Architecture
Chair of Information Architecture
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Switzerland

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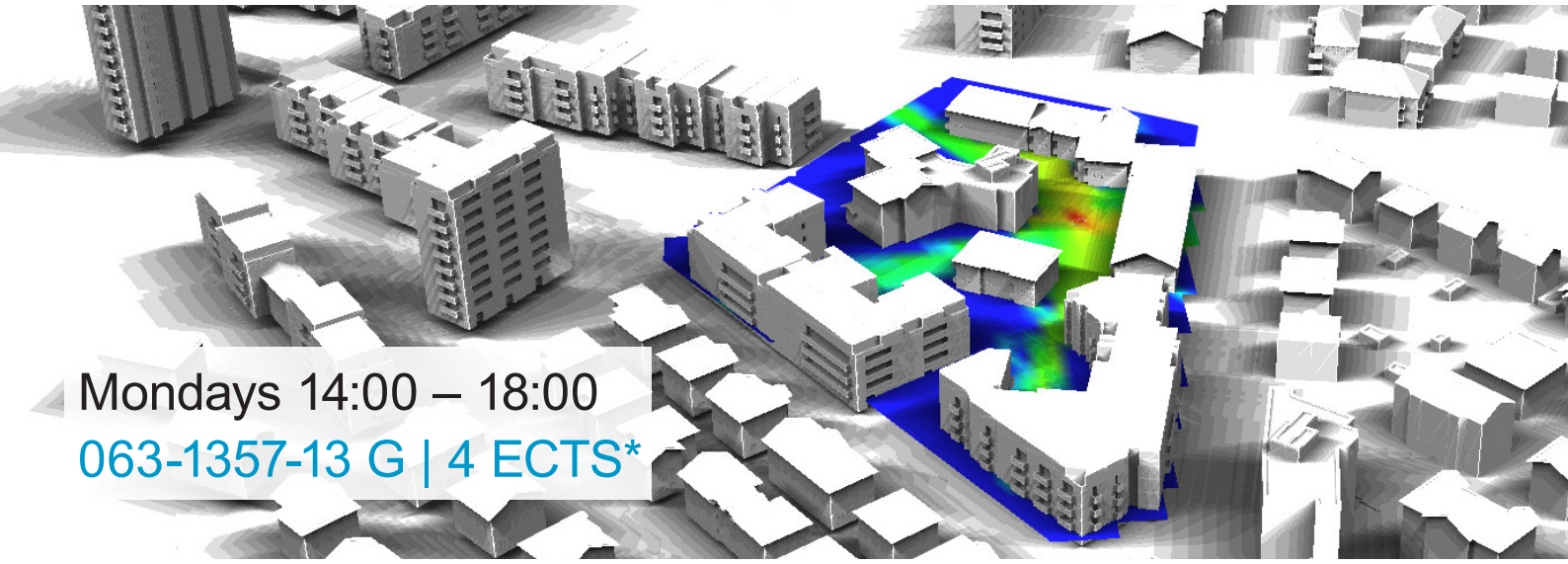
Cover picture:
Front and back side: Guillaume Stark, Isovist and shadow analysis for Max Bill Platz, Zurich

Course Description and Program



Mondays 14:00 – 18:00
063-1357-13 G | 4 ECTS*

New Methods in Urban Analysis and Simulation

A solid knowledge of computational methods is an increasingly important key competence for future architects or urban planners. In this course you will learn how to analyze and generate spatial configurations with advanced computational methods.

In a series of theory lectures we explore how designing and planning of cities could become evidence based by using scientific methods. Various exercises will provide training for your skills in working with state-of-the-art yet office proven design tools (Depthmap, Ecotect, and Rhino/Grasshopper). In an integral project work, you will deepen your knowledge in spatial analysis and simulation methods such as Space Syntax using Depthmap software and environmental analysis with the program Ecotect. In addition you will acquire skills for using analysis methods for generative design processes. Therefore we introduce you into the parametric design software Grasshopper for Rhino 3D.

Based on the methods introduced during the semester, you will learn and understand different effects of planning and design interventions on urban life. At the end of the course you will be able to interpret analysis and simulation results, and to apply correspondent computational methods for your own planning projects.

Where:
Lecture, HIT F22 - Value Lab
Exercise, HIT H12

When:
Mondays 14:00 to 18:00

Supervision:
Dr. Reinhard König reinhard.koenig@arch.ethz.ch
Estefania Tapias tapias@arch.ethz.ch
Matthias Standfest standfest@arch.ethz.ch

17.02.2014	Introduction to the course E1 - Rhino/Grasshopper tutorial
24.02.2014	Generative systems workshop E2 - Generative techniques
03.03.2014	Space syntax I E3 - Convex Map, Axial Map of a small area
10.03.2014	Space syntax II E4 - Depthmap & GIS: Prepare Data -> Import Data –> Analysis methods
17.03.2014	Seminar week (no lecture)
24.03.2014	Space syntax III E5 - Rhino/Grasshopper
31.03.2014	Empirical studies E6 - Collect data (evaluate existing materials)
07.04.2014	Microclimate analysis I E7 - Ecotect Tutorial I. Analysis of a small urban area.
14.04.2014	Microclimate analysis II E8 - Rhino/Grasshopper
05.05.2014	Best practice examples - Guest lecture
12.05.2014	Final consultation
16.05.2014	Final iA critique Combined critique with the other iA courses

* Total 120 h = 4 ECTS
Exercises 25% (documentations)
Presentation 25% (project at the end)
Written documentation 50% (project)

The most recent outline will be found on www.ia.arch.ethz.ch

iA Chair of Information Architecture

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Knoxville, Tennessee

Student: Lewis Williams p.35

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Student: Rini Singhvi p.49

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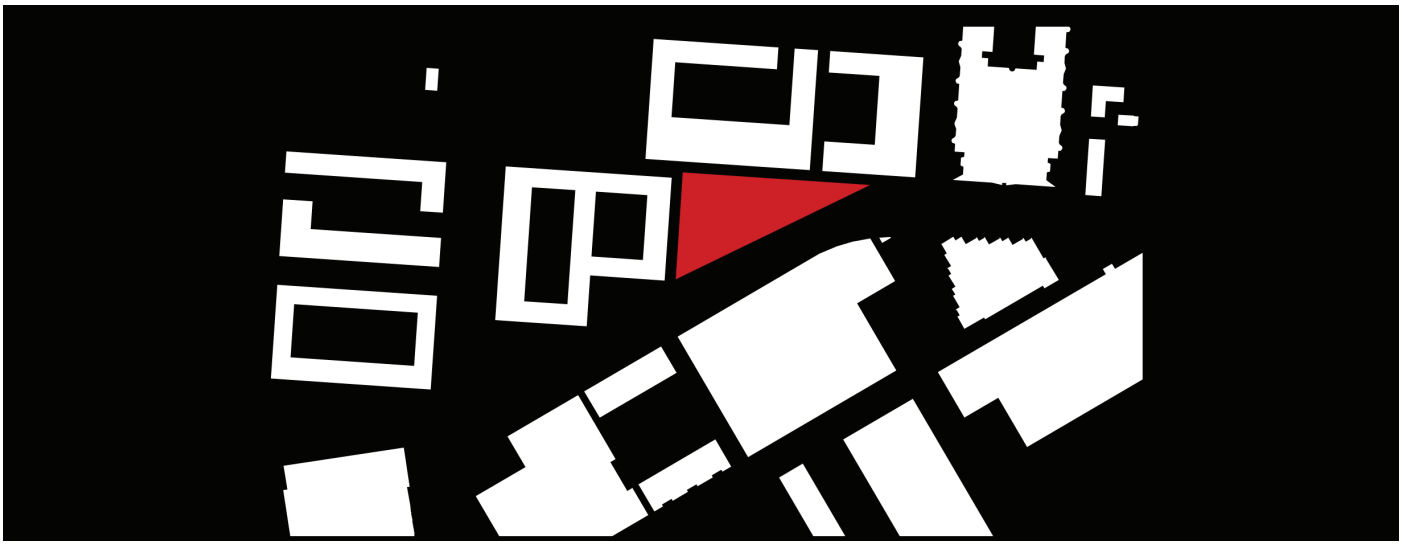
Student: Stanislas Chaillou p.55

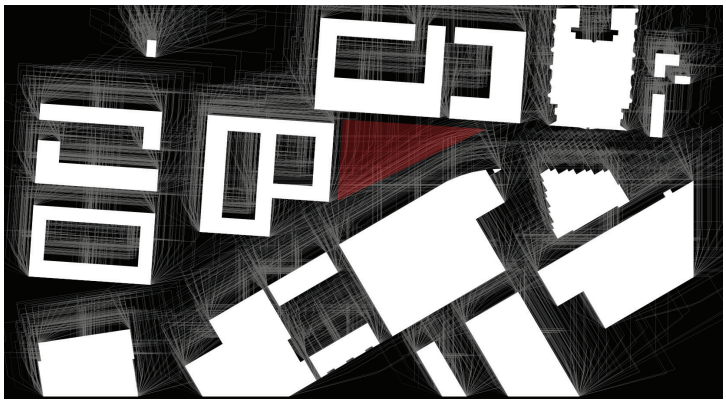
Galvanizing Max-Bill Platz (Zürich-Oerlikon)

Student: Guillaume Stark

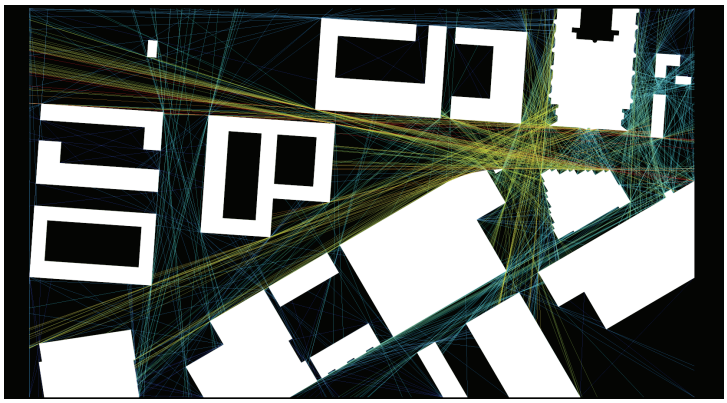


Summary. Max-Bill Platz in Oerlikon has a strange status. It's a triangular square, surrounded by big-scale housing buildings. Although its urban environnment, the Platz hasn't a dynamic. Why? and what could be done in the aim of galvanizing this space are the question that this analysis tries to answer.

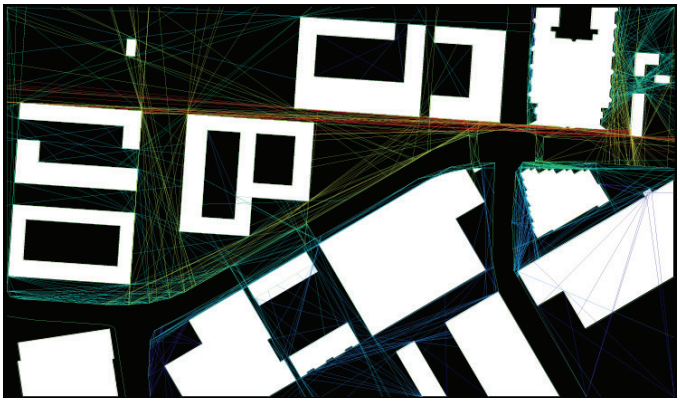
Motivation. As future architects/urban planners, we might very well be confronted to such issues. The idea is to make use of the tools learned in the course in order to suggest an option that would improve Max-Bill Platz dynamic and, if possible, point out the factors that take on the most influence.



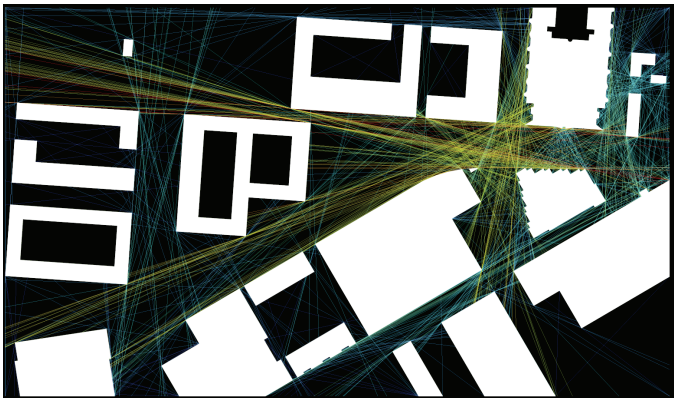
Shadow analysis
[grasshopper, time 21 September] shows that the square is provided with enough light during the day, it also defines the area where an intervention would make sense, considering that people would spend more time in the sunlight.



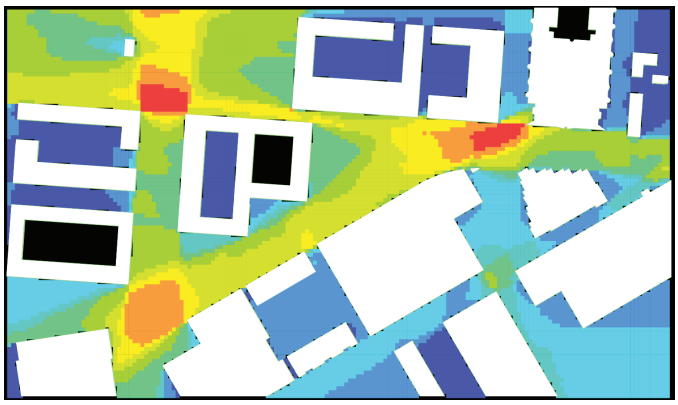
Integration [depthmap, axial map analysis] as it is today, the triangular shape which defines Max-Bill Platz is also defined as a non-integrated area.



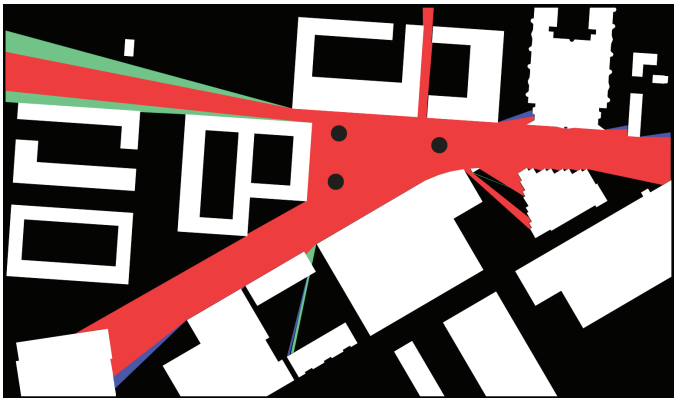
Integration considering the road as a non-walkable space [depthmap, axial map analysis] the road bordering Max-Bill Platz is an important axis for the city and therefore subject to high trafic. As the analysis is based on a pedestrian scale, it makes sens to consider the road the same way as a building. We can see that the square is even less integrated than it was in the previous analysis, although the crosswalks are considered as «gates» through the road.



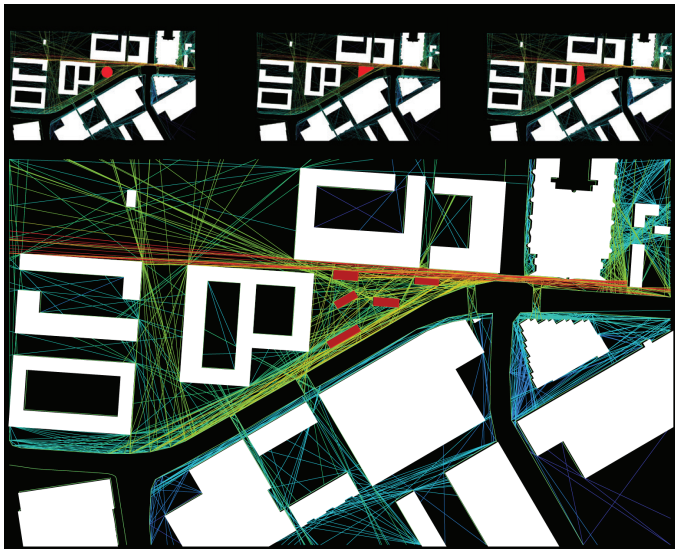
Choice [depthmap, axial map analysis] shows that Max-Bill Platz is not offering a large range of choices, increasing this factor could be a way to galvanize the square.



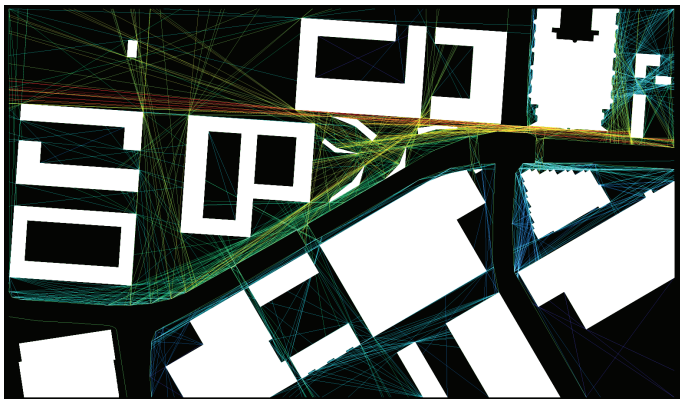
Connectivity
[depthmap, visibility analysis, 3m grid] shows that Max-Bill Platz suffers from a lack of connections, the crossroads nearby seems to act as a pole of connectivity. Shifting this pole or dissolving it could be a way to connect the square to its surroundings.



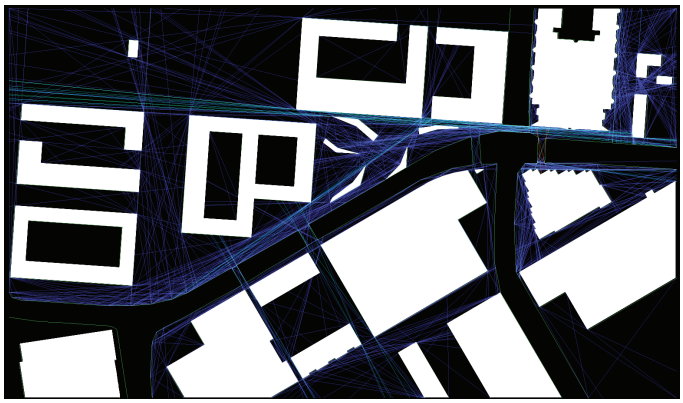
Isovist [depthmap, visibility analysis] what can be seen from the square is mostly the road, which makes it un-attractive for the pedestrians. This analysis reveals that the view factors are also to be taken into account.



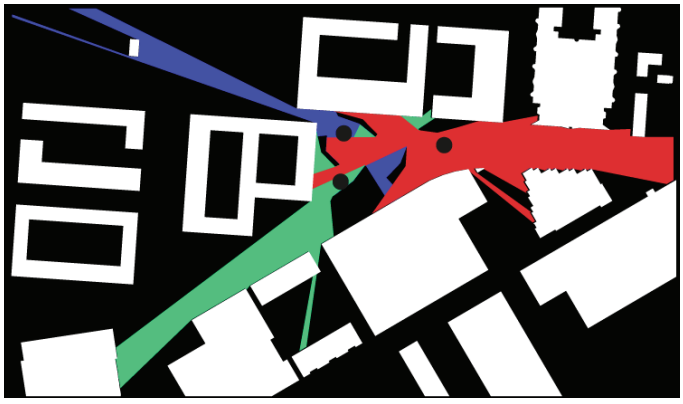
Comparison of the options shows that option 4 has the more potential regarding integration and choice. The several objects give a dynamic to the square, where the other options were helpless.



Integration [depthmap, axial map analysis] this variante shows the best potential, the inclined shape of the five objects provide the square with a heart, which is an important feature for an urban square. It also drives the fluxes and dialog



Choice [depthmap, axial map analysis]
reveals that now Max-Bill Platz offers
more choice, this intervention would create a more vibrating and dynamic space .



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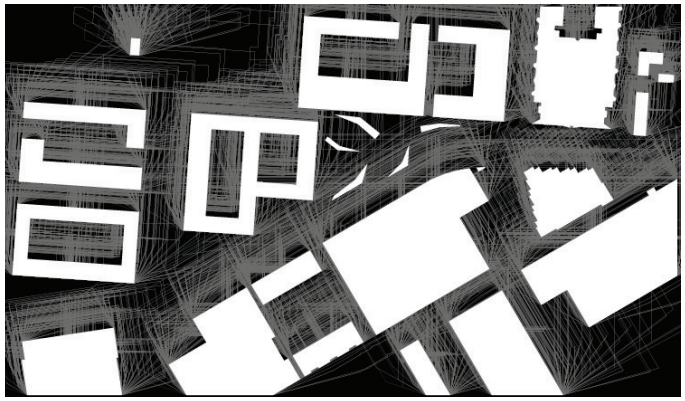
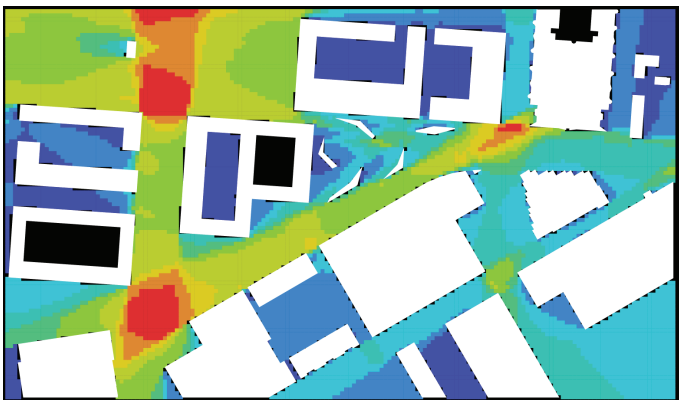
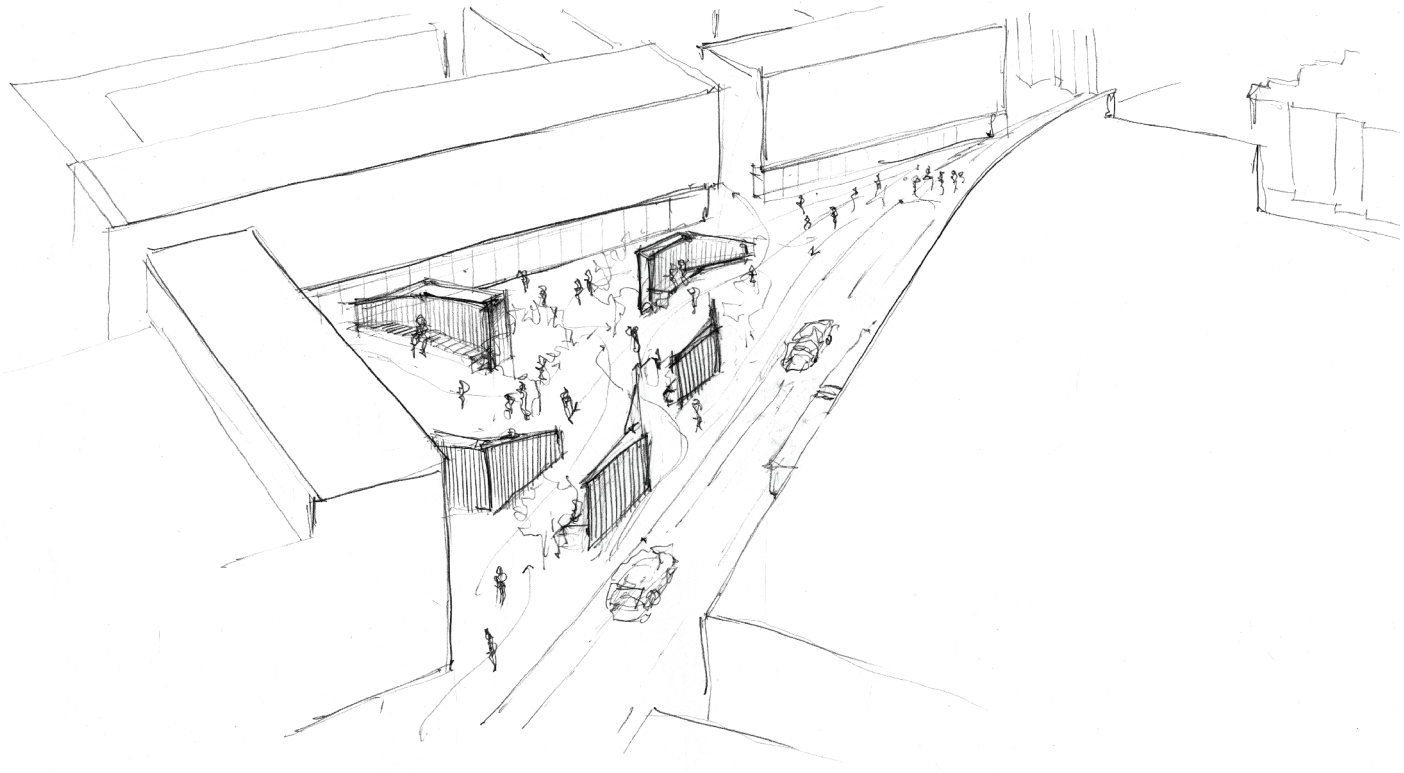


Shadow analysis
[grasshopper, time 21 September] the new space created would still benefit from a good sun exposition, another advantage of this multi-pleobjects intervention.



Connectivity
[depthmap, visibility analysis, 3m grid] compared to the last connectivity graph, the square is now less connected to the trafic. The cross-raod nearby seems to loose its importance, which is good, as it could not be used by the pedestrians.



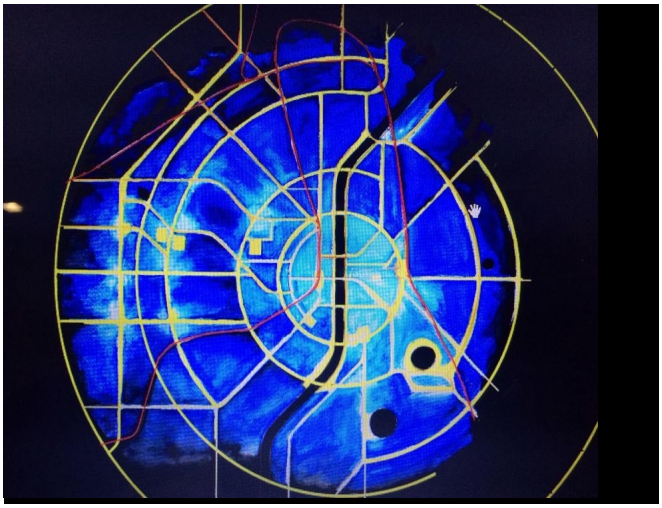
Conclusion. At the beginning of the analysis, the first design idea was very far from the variante chosen at the end of the process. The analysis reveals what's underneath the surface, and actaually open new perspectives for design. The project proposed here could be more refined, by testing more design options, but the basis of the concept are now solid, and this step is hard to aquire. Such analysis could be applied to any project that has an environnment, and it shall now be part of my design process.

Pedestrian Network: Old City of Ahmedabad

Student: Jain Neel

Ahmedabad City

Located on the western part of India, Ahmedabad City has its roots more than 600 years old. Formed and developed by Mughals then, it has been lived in ever after. Hosting more than 6.5 million people it is the seventh largest city in India. It is also a place holding various architectural works by very well known Architects, both nationally and internationally.



OGNAJ
RAKANPUR
JAGATPUR
CHANDKHEDA
GOTA
CHENPUR
KALI
MOTERA
BHAT
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RANASAN
MUTHIYA
PARDHOL
BHADAJ
SOLA
CHANDLODIA
RANIP
HANSOL
NARODA
BILASIYA
HANSPURA
HUKA
GHATLODIA
HERAPUR
SHILAJ
NAVRANGPURA
THALTEJ
MEMNAGAR
VIJAY 'X' ROADS
KATHWADA
BODAKDEV
NIKOL
ZANU
VASTRAPUR
AMBLI
ISKON
GANDHIGRAM
KALUPUR
BHUVALDI
ODHAV
SARANGPUR
SINGARVA
KANBHA
VEJALPUR
VASNA
VASTRAL
KUJAD
MAKARBA
JUHAPURA
MANINAGAR
PIRANA
MEMADPUR
SARKHEJ
RAMOL
GATRAD
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FATEHWADI
GYASPUR
VISHVASPUR
BIBIPUR
VATVA
SHAHVADI
PIPLAJ
SHAIJPUR
VINZOL
GERATNAGAR
DHAMATVANA
FATEHWADI
LAXMIPUR
VANCH
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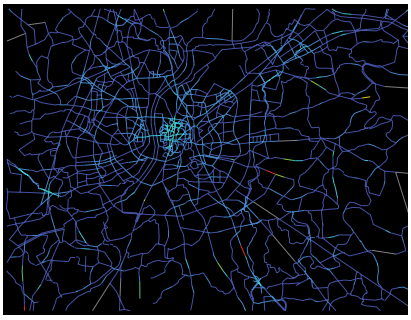
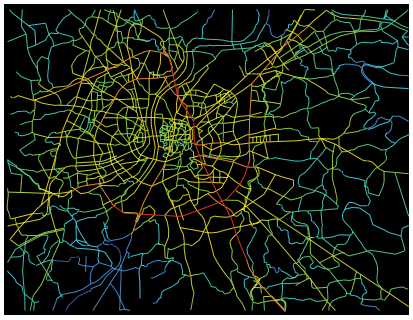
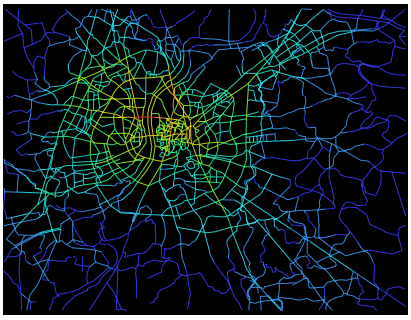
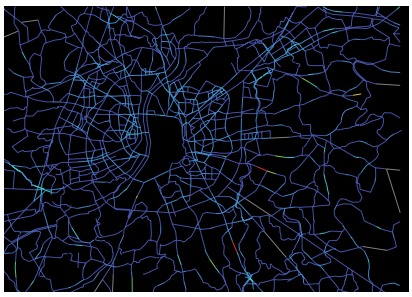
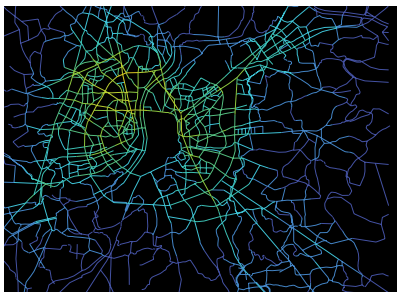
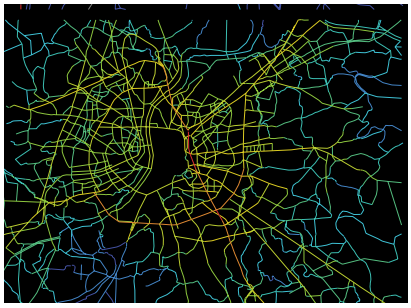
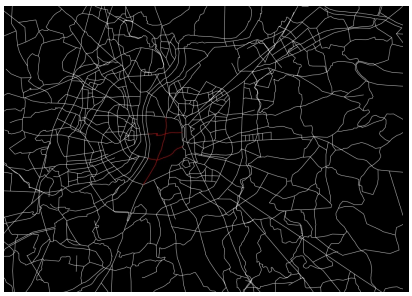
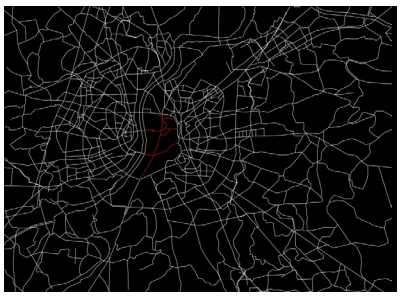
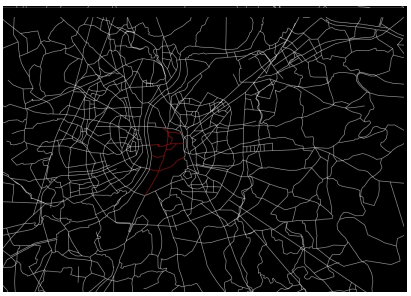
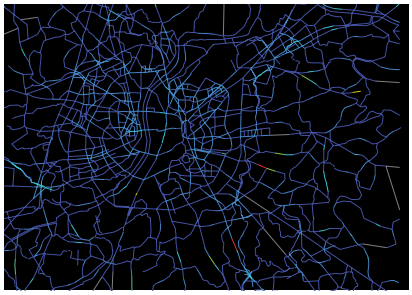
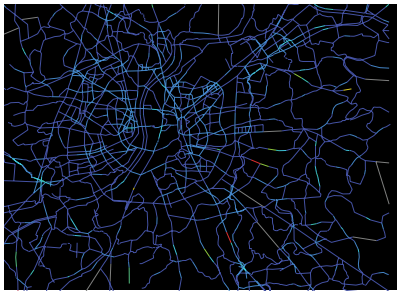
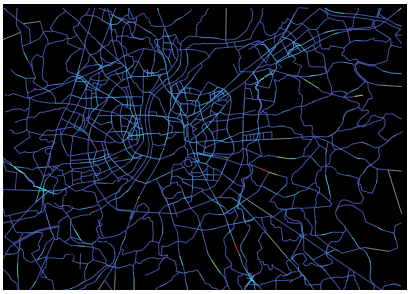
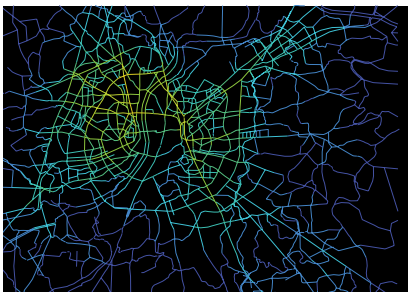
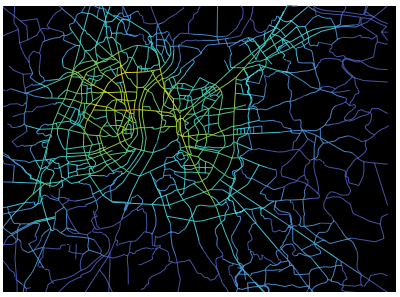
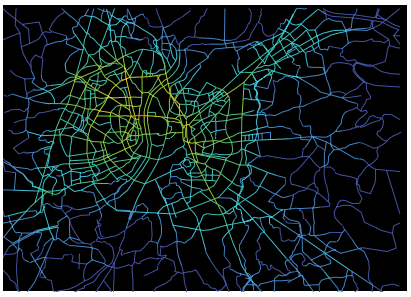
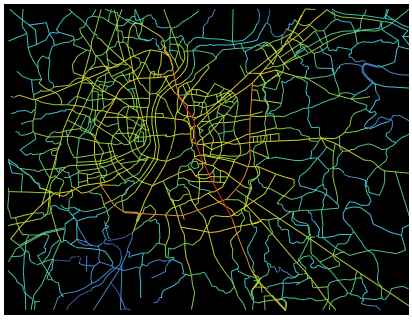
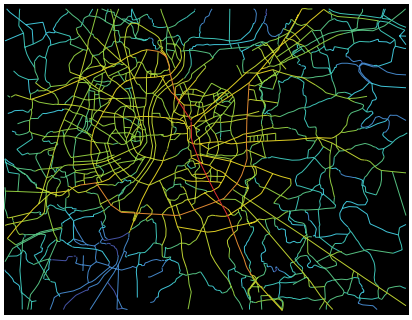
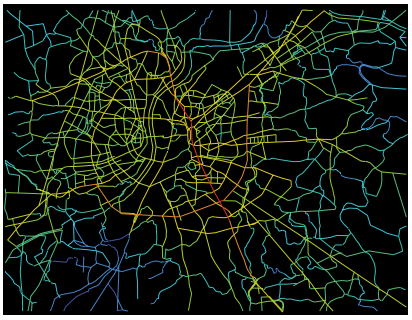
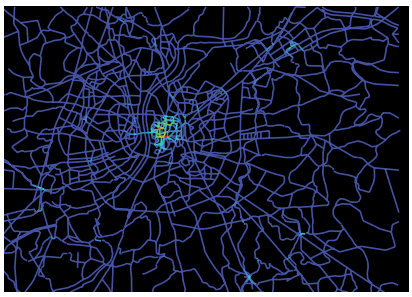
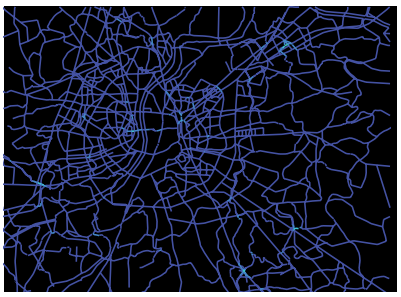
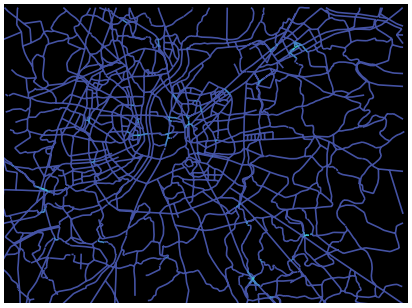
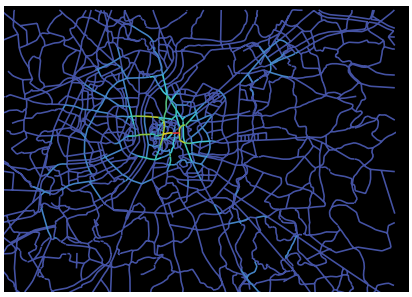
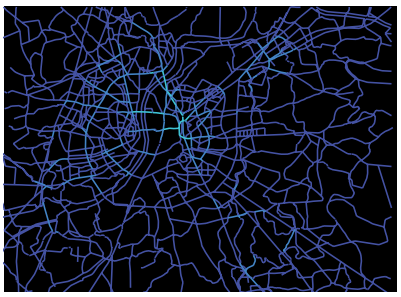
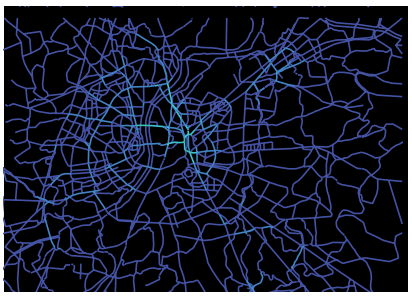
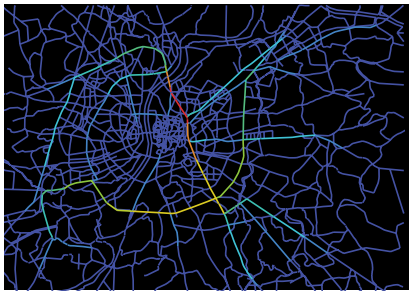
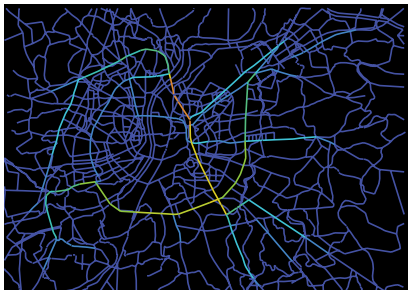
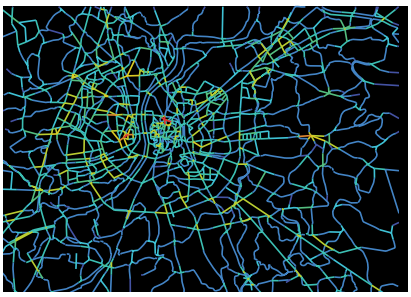
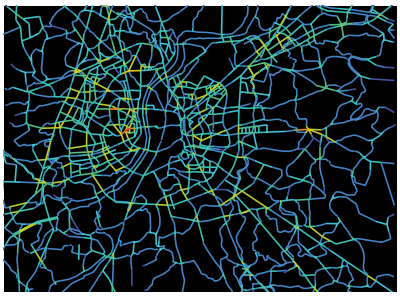
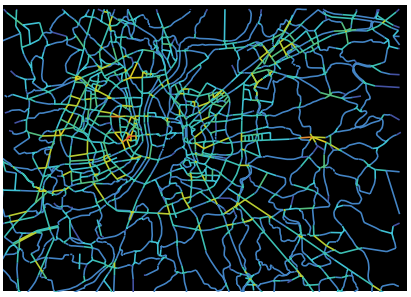
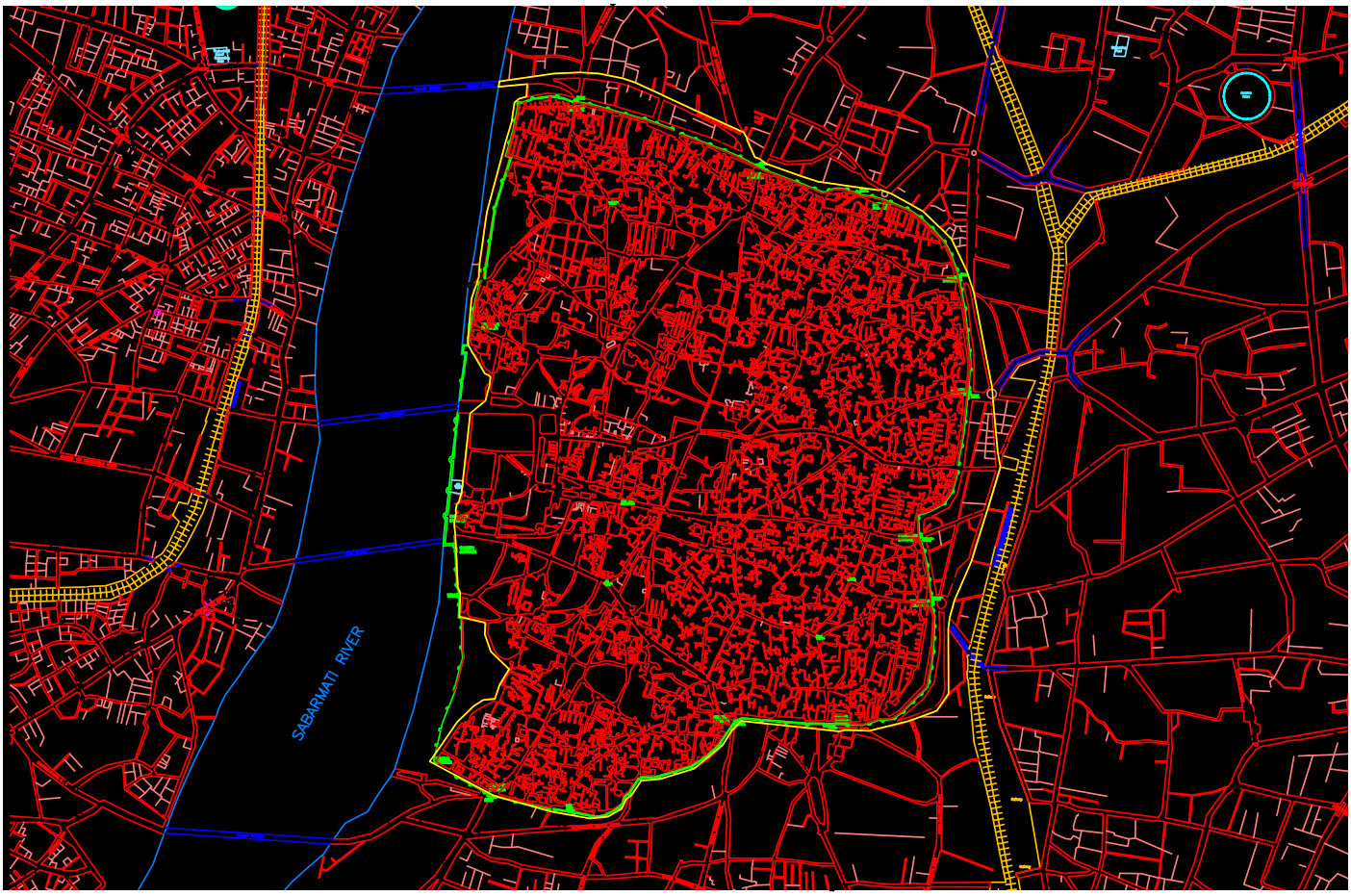
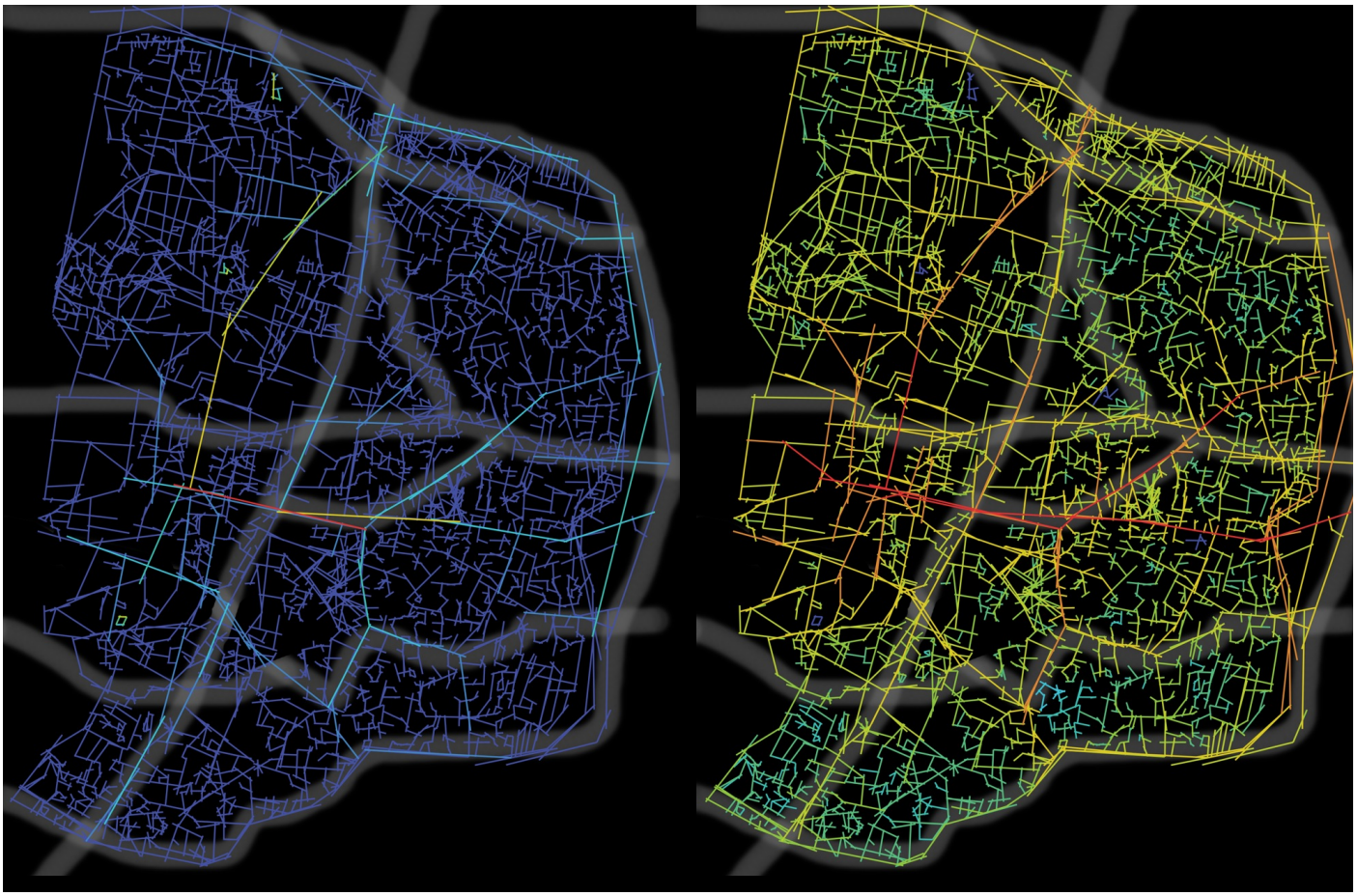
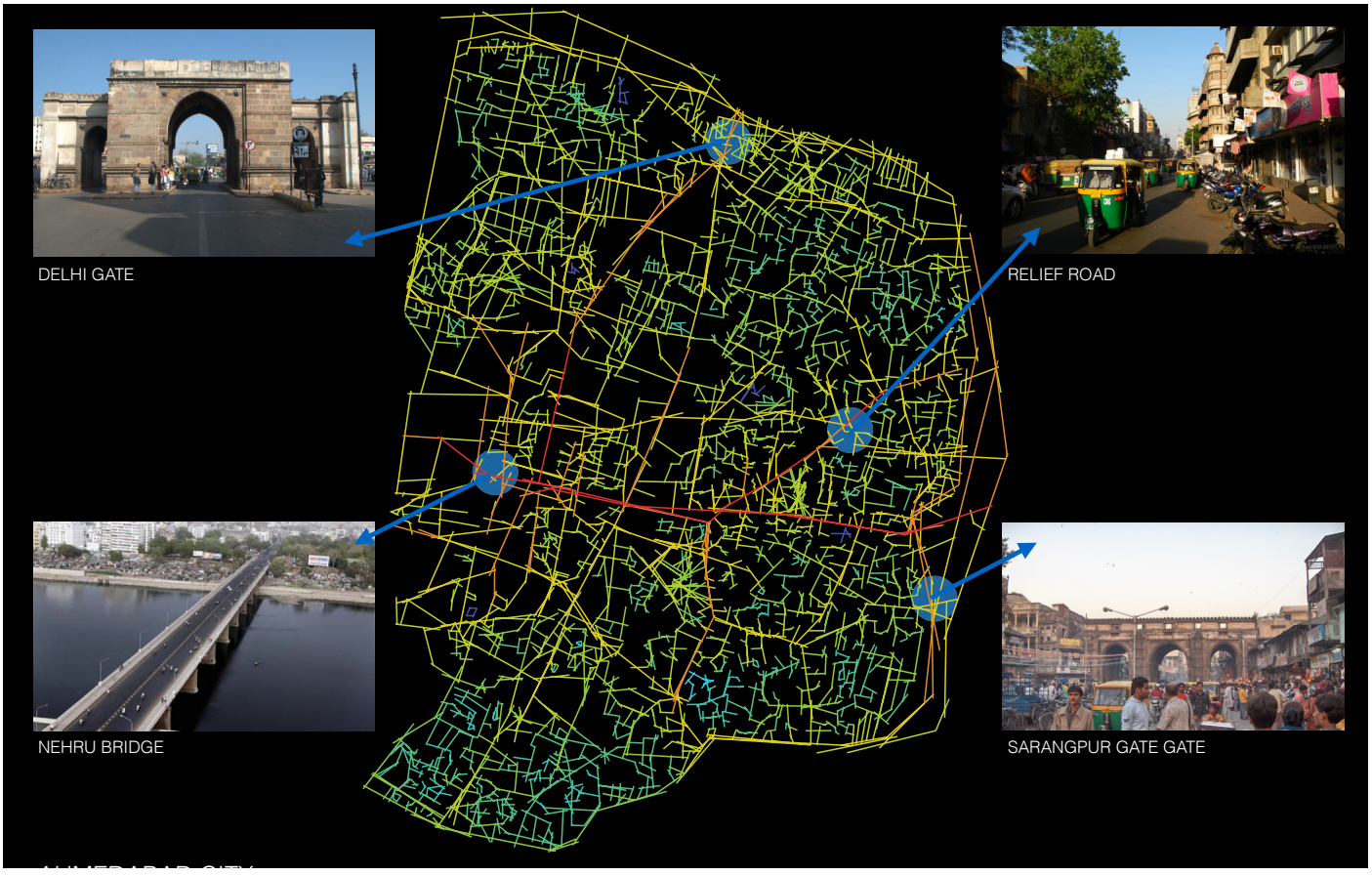

















SABARMATI RIVER




DELHI GATE
RELIEF ROAD
NEHRU BRIDGE
SARANGPUR GATE GATE

“All models are false, but some are useful.” - George Box

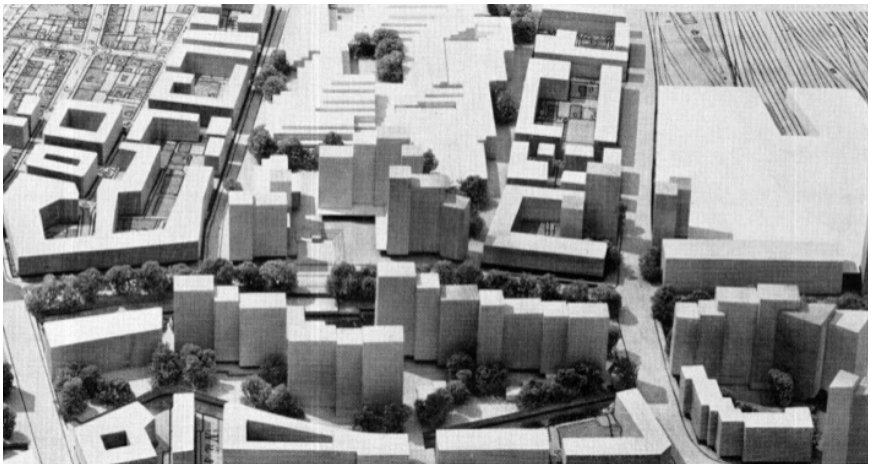
Precise selection of models based on,
Abstraction and Awareness

"Learning only makes us aware how less we know about the whole.”

Kasernenareal: Park oder City?

Student: Jing Xi

Existing Kasernenareal park.



Kasernenareal replaced by cityscape.

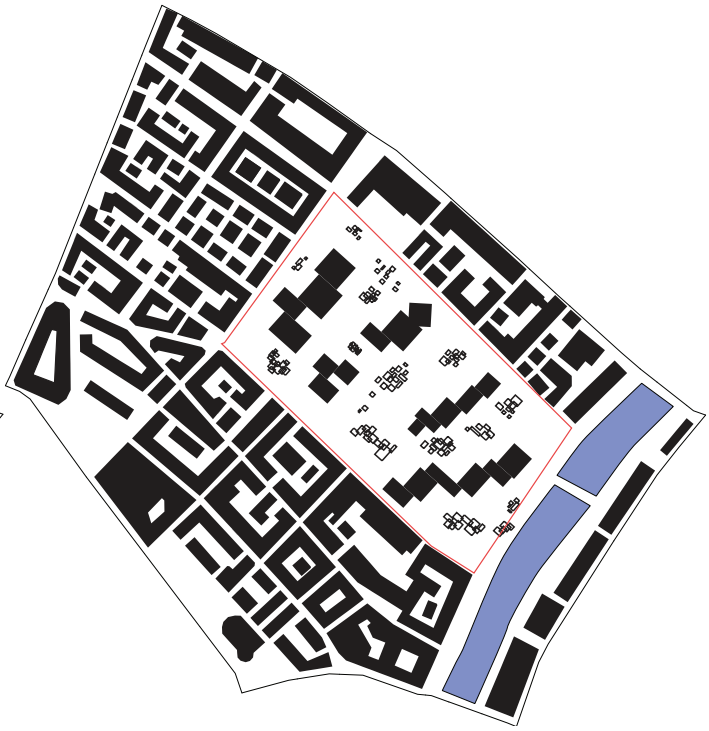
In the city of Zürich, attention has been enthralled on Kasernenareal, a multi-purpose square near the Zürich center. Due to the high land values in Zürich, the public forum has scrutinized the purpose of this park-slash-Kanton-Police-head-quarter space.

Multiple proposals had been made and rejected to re-purpose this space. The two categories of proposals are to either let it remain a park, or to build more urban structure on it. The purpose of this study is to try and answer the question of which of the two proposals is better; is it park or city? The park scenario uses the existing layout of the park, assuming that the future design of the park will have very little added footprint to the site.
In contrast, the city scenario is produced by a visionary and calls for large invasion on the site.

This study evaluates the Kasernenareal as part of Zürich, then it evaluates the local site immediate to Kasernenareal. The evaluation on Kasernenareal between the two proposals will be on pedestrian movements, visibility, environmental impacts and connections of the whole city.

Kasernenareal is not evaluated independently. A few blocks around Kasernenareal is included in the analysis. These are natural barriers around the site in question. The perimeter around Kasernenareal is bordered by Lagerstrasse, which runs parallel to the Zürich Hauptbahnhof, then turns 90 degree towards South. Badenerstrasse boarders the South and the Kreis 4 boundary line boarders the East and include the river Sihl into the study. These boundaries are not chosen so randomly. Langstrasse is an important street in the city of Zürich.

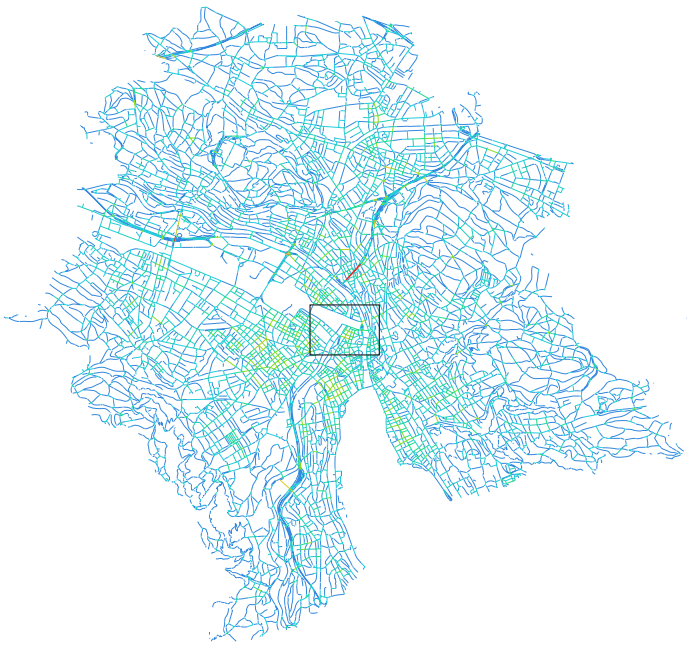
Above: Park plan, within its local boundary.
The park plan used in this study assumes no fences or boundaries around Kasernenareal.

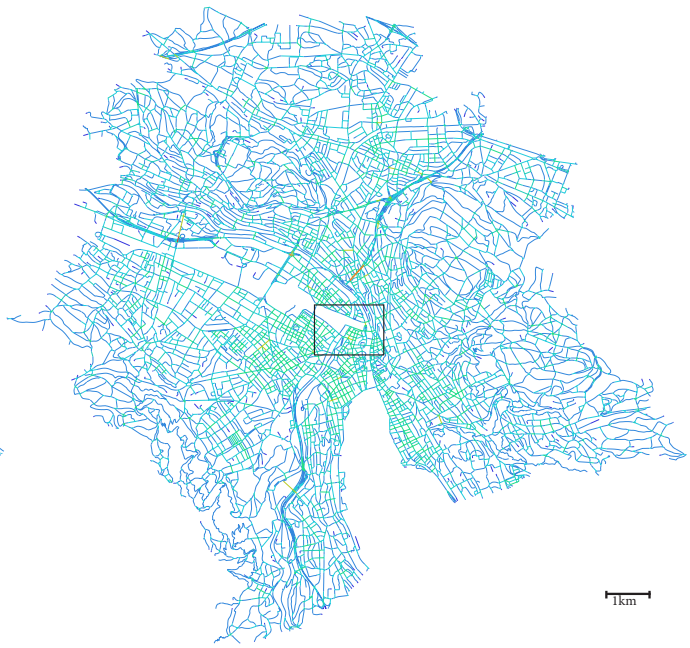


Above: City plan. This city plan is a replica, as proposed by the visionary's perspective model shown on the previous page.

Zürich Axial connections

Kasernenareal is a part of a whole city. The analysis began with a study of the movements of the movement of people throughout the whole city. An axial map was conducted, comparing Park or City design over the site. It was evident that the new paths that are added to the site did not change the analysis maps of Zürich as a whole, and that the changes to the paths affect the movement of people more locally. In the connectivity maps below, one can see that adding the additional footpaths does not mean that the roads around were more linked to others. The analysis shifted to a smaller scale from this point.



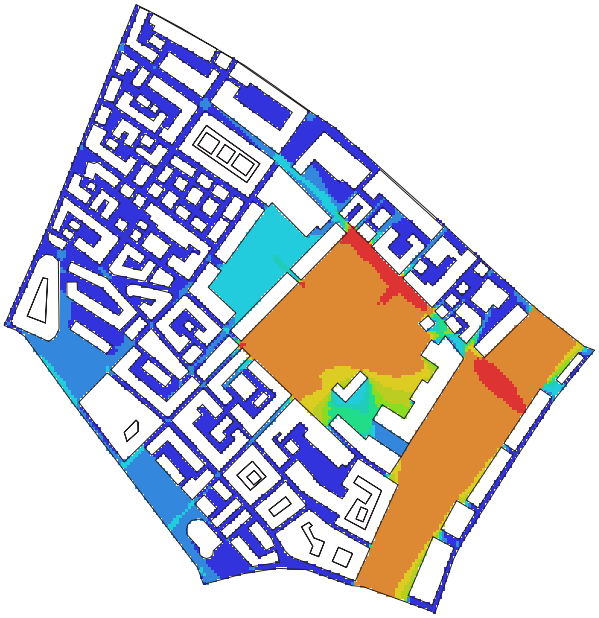


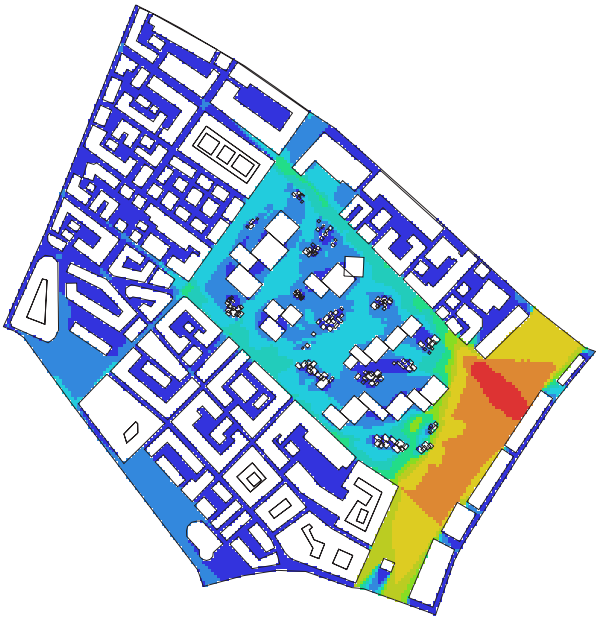
Top: Zürich axial map _ park, connectivity.

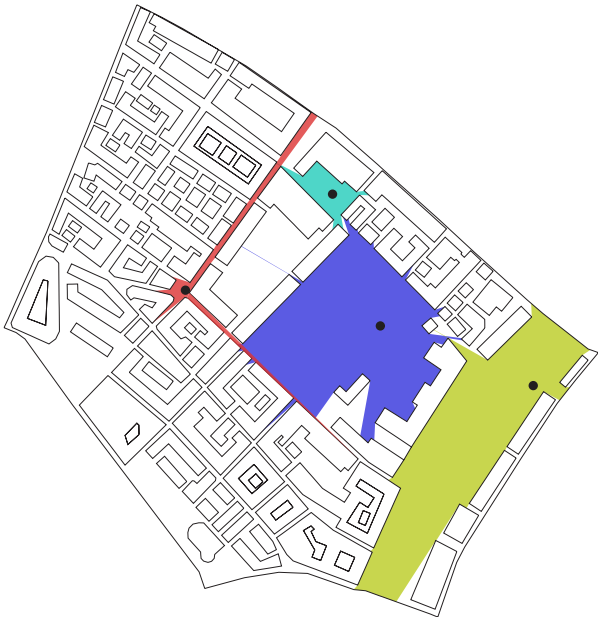
Top: Zürich axial map _ city, connectivity.

Zürich Axial connections

The visibility map below displays the extent to which any point in the spatial network is visible from any other point. The red spots show the most visible of the overall site considered, where the dark blues are the least visible. Four separate points were selected to further understand the changes in view between the two master plans. They show that the view site around the city become more scattered and more sharp due to the edges of the buildings, where the park has larger view ranges. This offers privacy to the people using the space, instead of having an open field. The greenery in the city master plan also reduces the view ranges and makes the views more scattered. The park plan is easier to navigate through than the city plan. This analysis is only a two dimensional study of the space, however, assuming that the towers are quite tall in comparison to the surrounding, it would play a role in what people see above eye level. The park plan reduces people's depth of view.







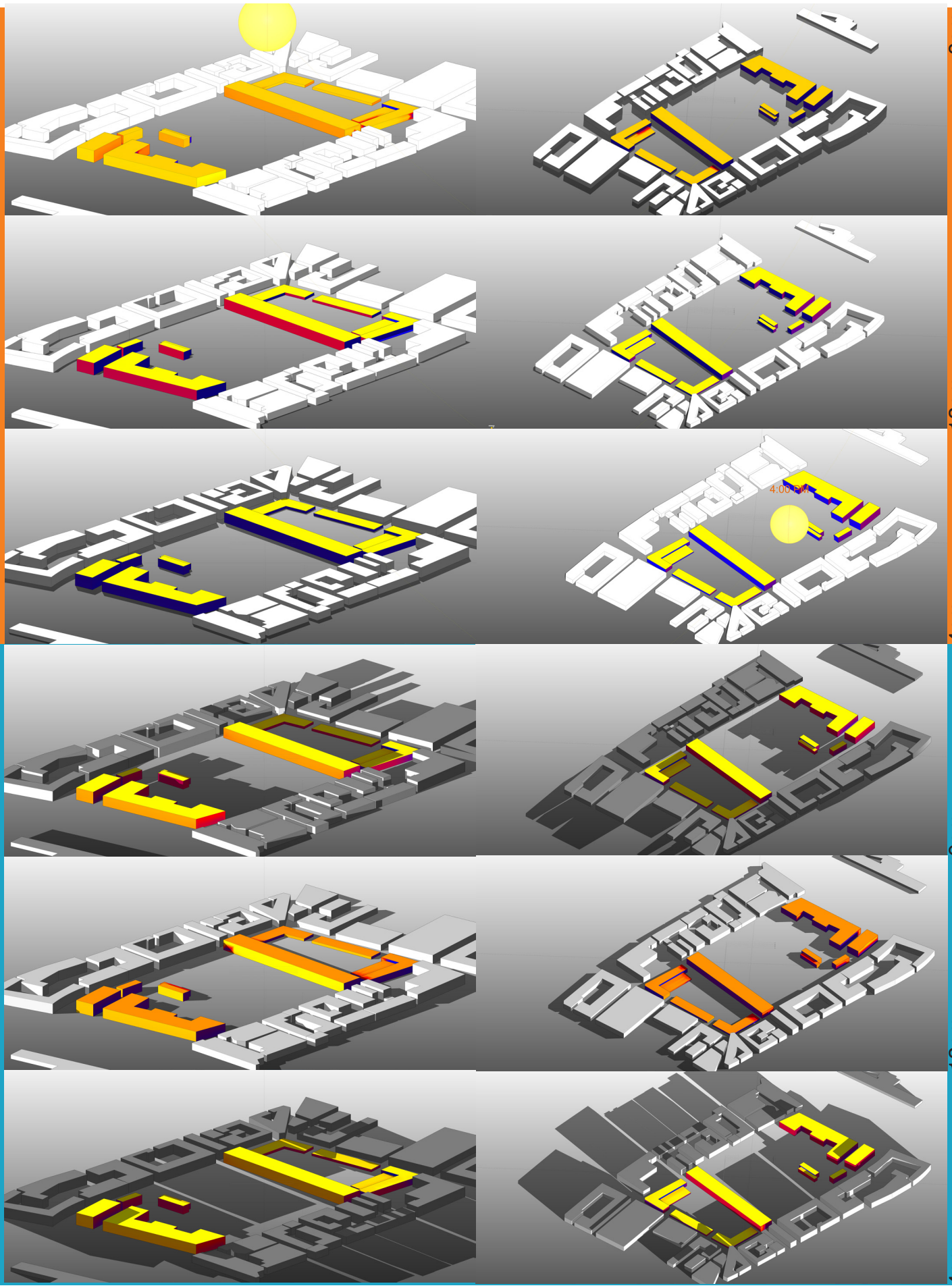
Top: Local visibility map of park.

Top: Local visibility map of city.

Solar studies

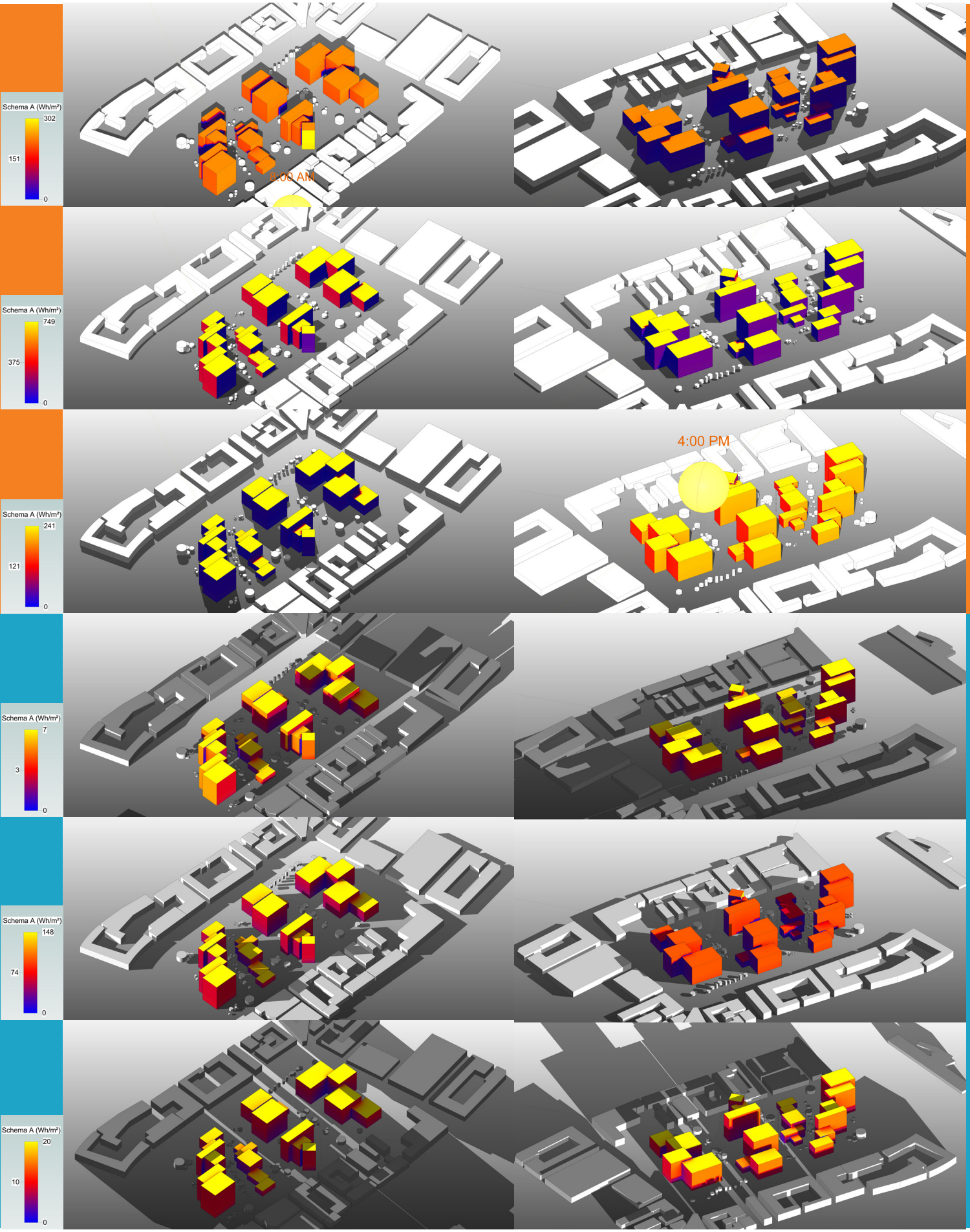
Park solar studies. Viewing from North.

Park solar studies. Viewing from South.



City solar studies. Viewing from North.

City solar studies. Viewing from South.



Summer
During the summer solstice, there are long days. The sun is already very high at 8am, and the site receive a lot of radiation, especially on the East and North-East facing façades. The park master plan is very exposed due to the lack of shading, which could make it less inhabitable during the summer months. However, Swiss people likes sun and the park is supposed to be open. With these assumption, this space does not need further shading, unless for special events.

The city plan shows some shading from the buildings itself. The sky-facing surfaces of the buildings, as well as the ground that is exposed in both park and city plans have high exposure to the sun. In the city plan, the ground level is more shaded than the park plan, which is good for occupancy for the hotter months.

Design considerations for summer
If the park plan is to go ahead, the designers need to think about shading (and sometimes also for rain) for the summer time to make it more inhabitable. In the park plan, at 4pm, the West facing façades receive high radiation, thus, shading is required in the summer.

Winter
The sun rises very late during winter. At 9am, the tall buildings in the city plan casts a lot of shadow in the surrounding, which is not desirable, given that solar radiation helps to heat buildings passively. Also, the shadows of the building masses also cast on themselves. The building will be requiring a lot of active heating during winter due to the lack of sun. However, The roofs receive the most solar radiation during the winter months under the city plans, one can harvest some solar energy from the roofs.

The park plan is open, with a few structures that fits into the surrounding suburb. Studying the shadows, one can see that the park plan has quite low impact on the surrounding compared to the taller buildings in the city plan.

Axial Map

The Integration graphs below shows the least isolated paths that pedestrians tend to take. In the park Integration graph, one can see that the paths indicated A on the map is the least isolated and serves an important pathway for pedestrian travel. Similarly, this path is not isolated either in the city integration map. We can also see that there is a lot of movement on the roads around Kasernenareal. The difference between the park and city integration maps are that in the park axial map, the main traffic is directed through a few very clearly identified lines. However, in the vAxial map of the city, the red lines start to disperse and go away from each other, which indicates more weaving between structures instead of being streamlined to walk on the pavements. The city map shows better use of the space and more pedestrian traffic control.

Top: Local Axial/Segment map _ park, Integration.

Top: Local Axial/Segment map _ city, Integration.

In the attempt to answer the question of whether Kasernenareal should be a park or city, the construct of city connections, views, solar impact and pedestrian movements were studied.
The park plan is not very much different to the current situation, but the city plan proposes a different configuration to the space, which has yield different results in the constructs that are identified.
From the evidence, one can conclude that the city master play for the site does not impact much on the traffic flows on the rest of Zürich, since it is a relatively small intervention within Zürich. The impact on Zürich is much more local.
Within the pre-defined scope of the project, we were able to understand that how pedestrians view the space and feel in the space will change significantly from the park to the city. The park proposal is much less invasive on the surrounding suburb. It shows more open views around the site, which makes it much easier to navigate than the city master plan, which is more closed and obstructive. Since the buildings are is so high in the city master plan proposal, it not only blocks people's views up to the sky, but also casts a significant amount of shadows to the surrounding. This could be problematic during the winter months when sun is scarce in Switzerland, and it could increase heating costs. The size of the buildings is also a problem in summer, since the city master plan proposes to build much more surfaces to cool during the hotter summer months. The city plan navigation also changes the way that people move in the space. The city plan shows that pedestrians deviate from their usual paths on the pavements next to the streets, and increases traffic flows between the proposed buildings.

The city plan is the less optimal option compared to the park. However, there could be a mixture of park and city and to reprogram this space for not only a park, or not only a city, but mixed-use. I would also suggest to future planners to really think about the following points when designing:

- Keeping a sustainable footprint of the buildings
- Making the site easy to walk and navigate around
- Keeping the buildings at the level of the surrounding buildings as not to disturb the heating and cooling of the surrounding buildings
- Think about capturing the solar resource on the open grounds
- The program should be social and encourage circulation to the site

“Park and City” answers the question “Park oder City?”

Knoxville Tennessee

Student: Lewis Williams

Market Square

Centre point of the downtown area
Lies on main city axis
Pedestrian only
Mixed-use space consisting of restaurants and retail on ground level and apartments and offices on upper floors
Primary location of city events and festivals
Emphasis on local shops and restaurants. No franchise stores creates a more unique location

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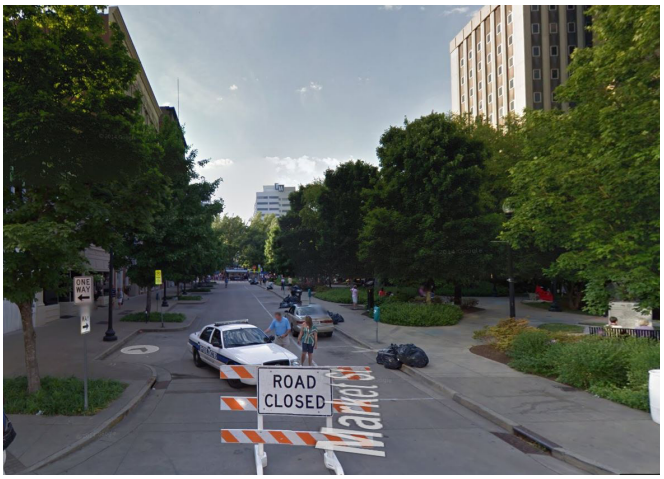
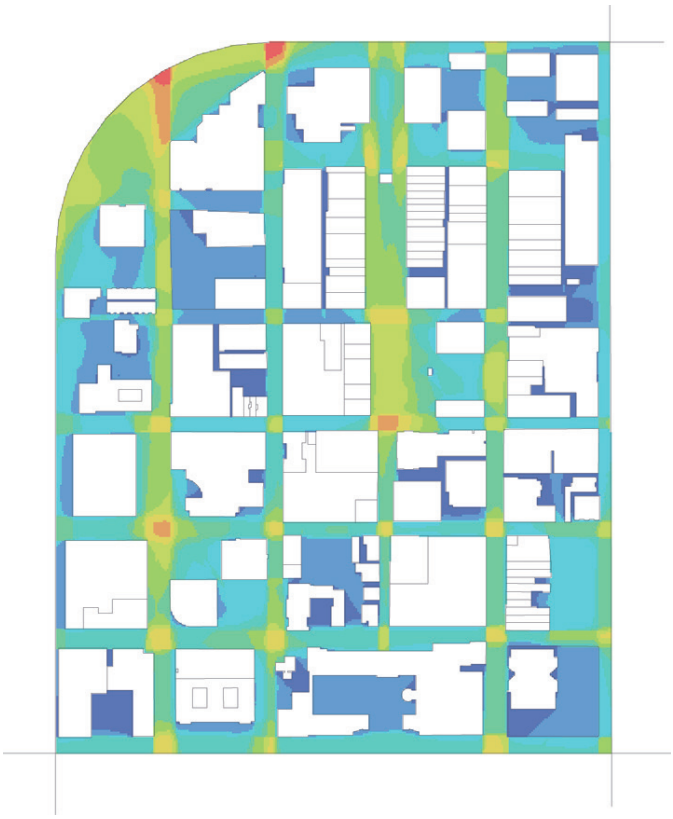
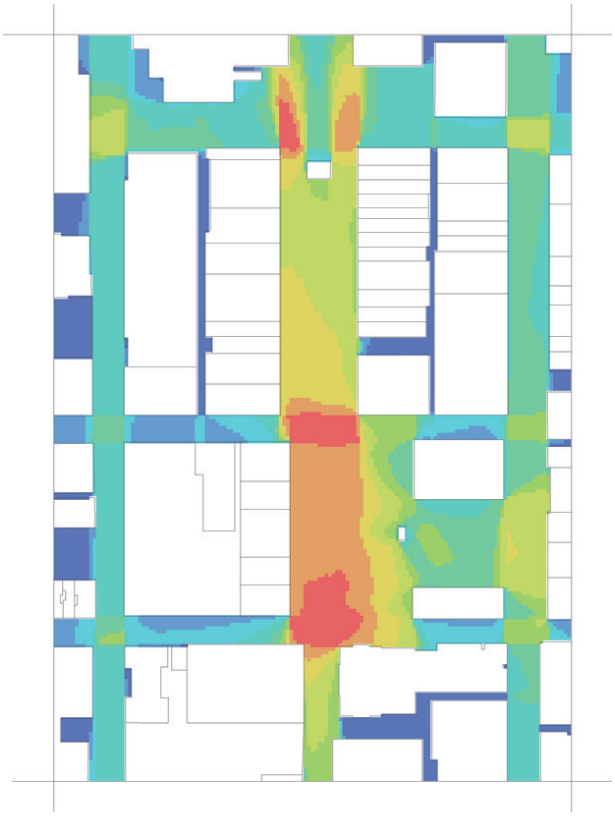


Visibility Analysis of Downtown Knoxville



Axial Analysis of Downtown Knoxville

Visibility Analysis of Market Area



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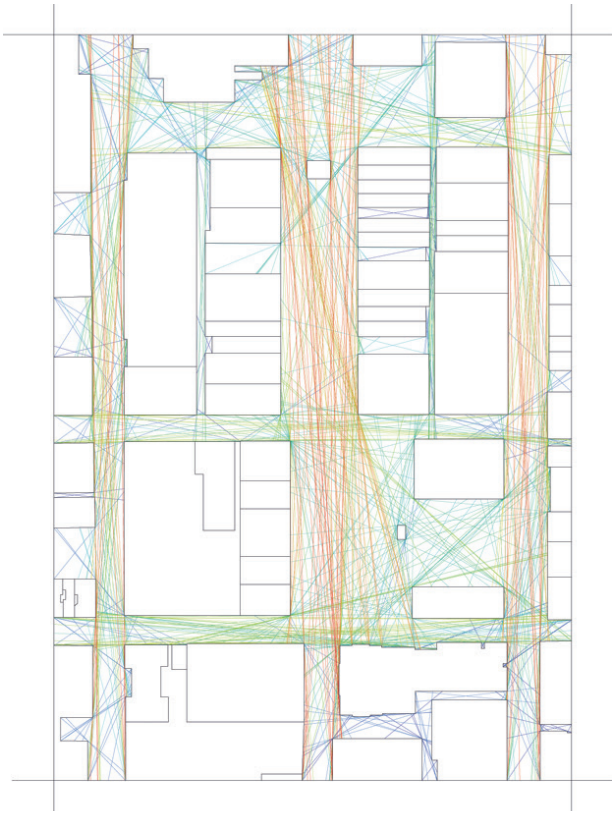

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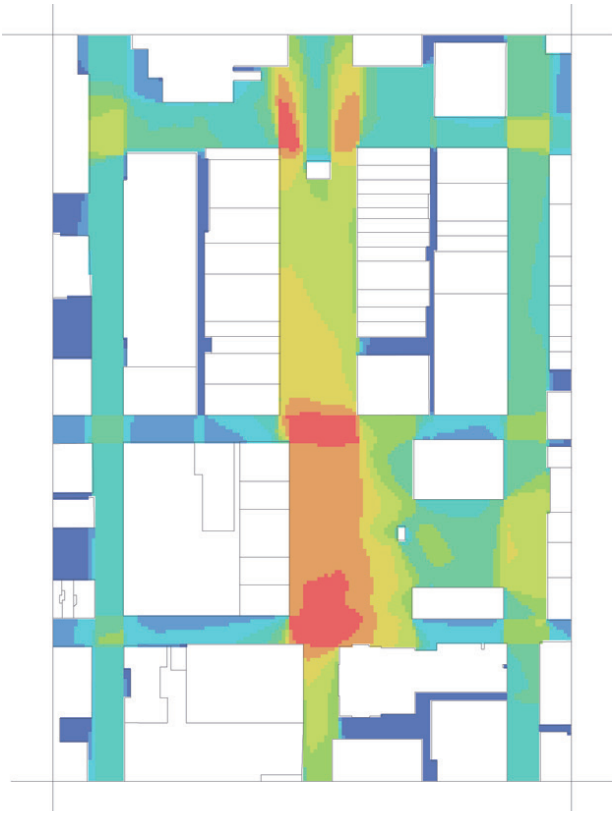
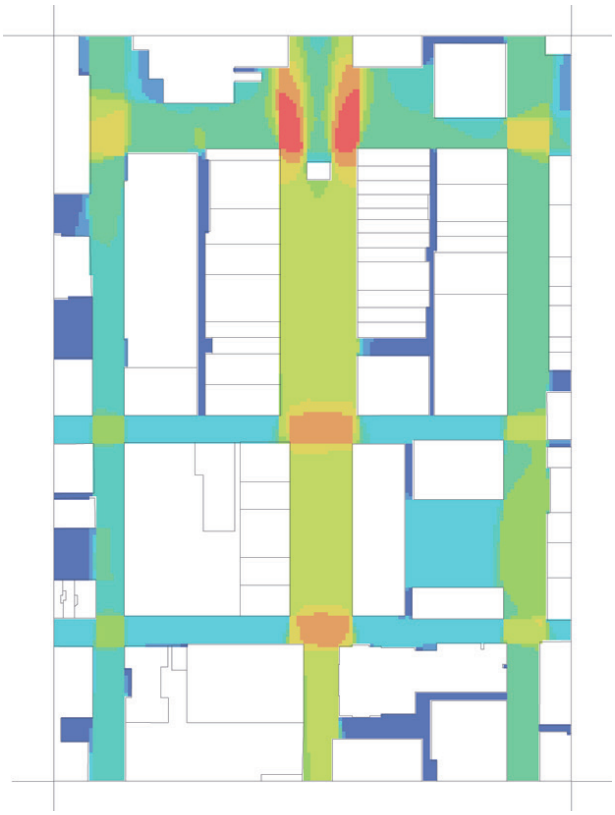
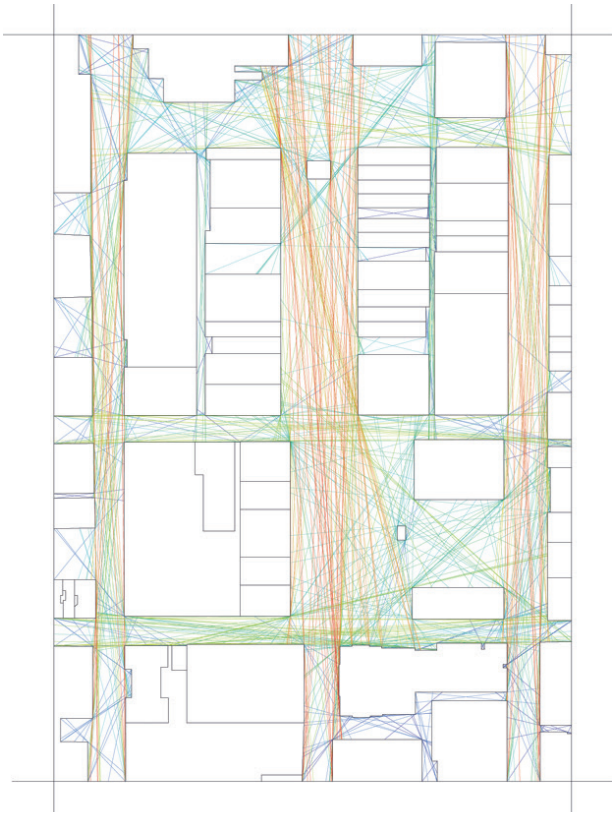


Visibility Analysis of Proposal



Axial Analysis of Market Area



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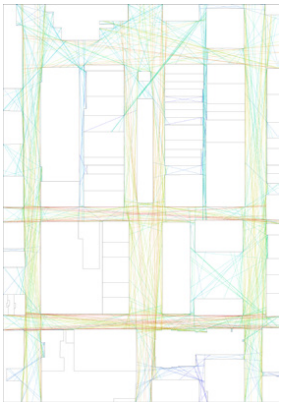
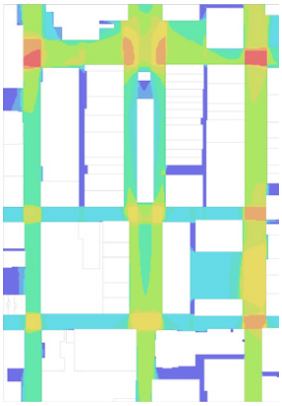
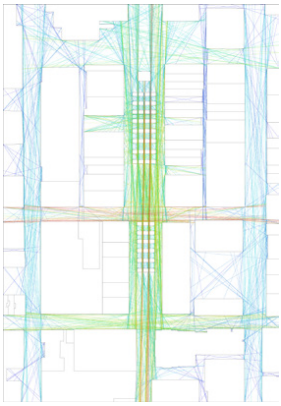
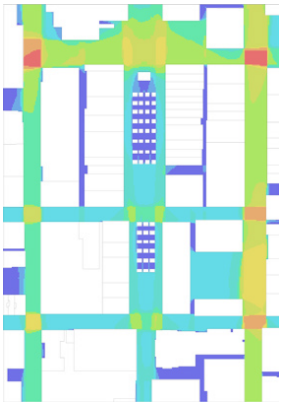
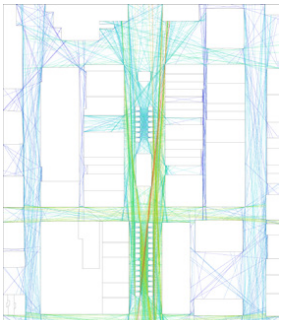
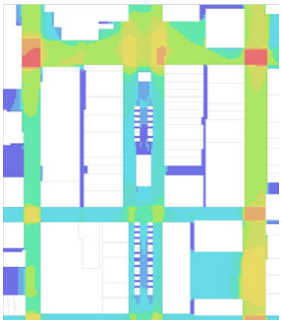
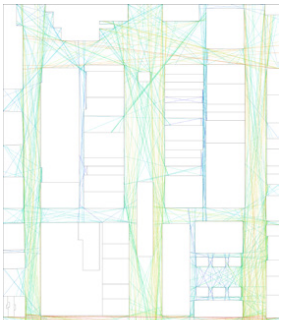
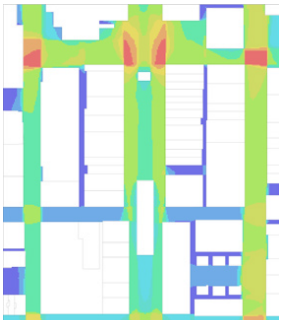
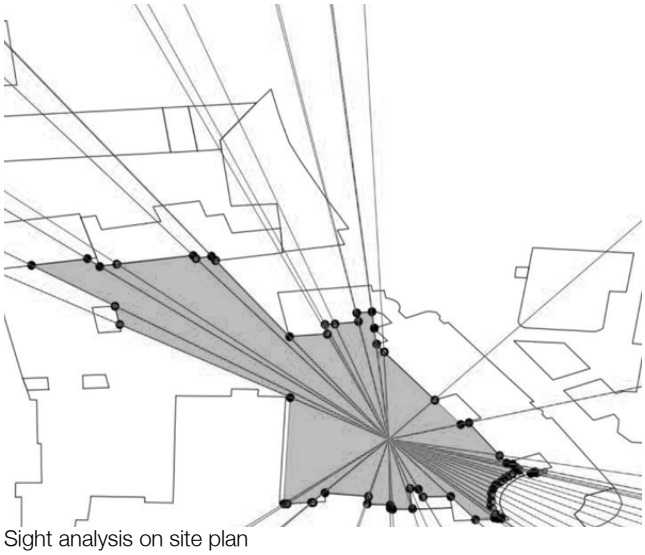









Design with the invisible

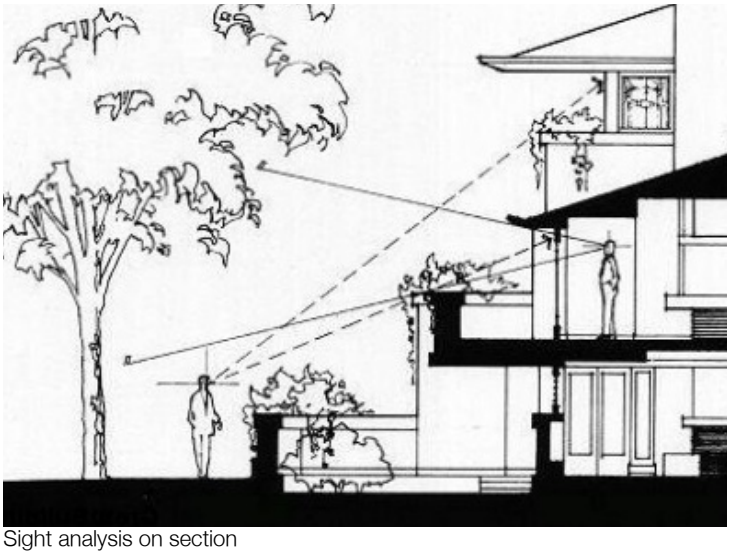
Student: Li Li

Motivation

Sight analysis is very popular in the early stage of the architecture design. It can be used to determine what can be seen from a particular location in the landscape. Conversely, also what can't be seen. Usually, such kind of analysis will be done on the building section or plan. Most of the time, the analysis on 2D drawing is enough for architects to get certain understanding of the environment. However, in some extreme condition, such as crowded urban environment, a precise 3D sight analysis is needed to help the architects to deal with the extreme requirements.



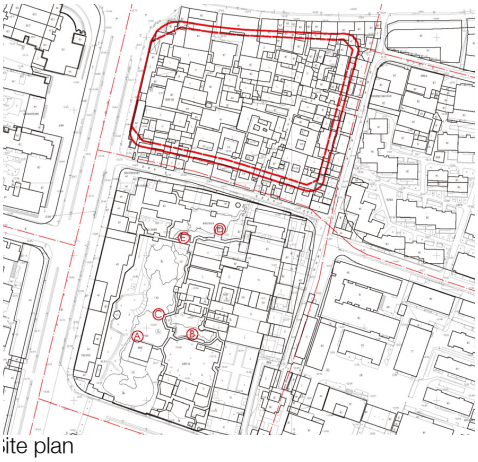
Sight analysis on site plan



Sight analysis on section

Background

In this case, a new commercial building will be built in front of a famous ancient Chinese garden. The developers want the maxim building volume to meet the costs in buying this piece of land. While the government want the height of the new building as low as possible, without disturbing the sight inside the garden. Five critical viewpoints are given, where the new building should be invisible. To research a balance between the two sides, the limit of the volume should be calculated.

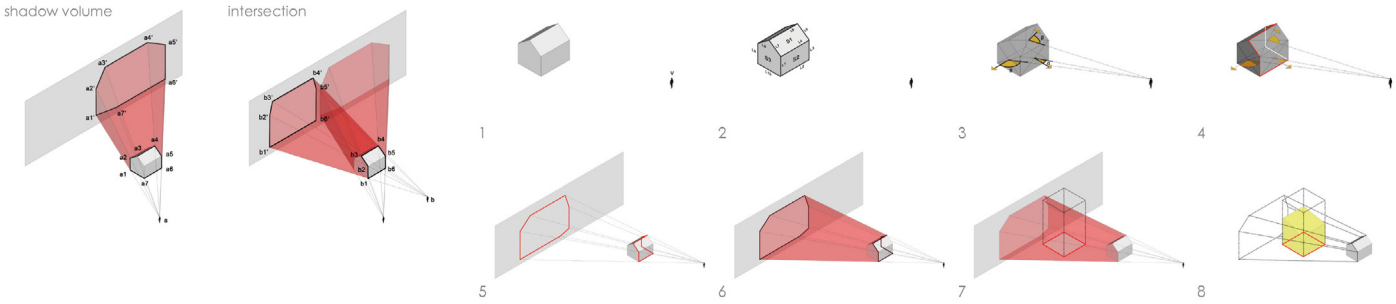


ite plan

Bird's-eye view

Algorithm

The Shadow Volume algorithm was originally developed to calculate the shadows in 3d virtual environment. The objects inside the shadow volume are invisible from the point of the light source. It is not difficult to adapt this algorithm to the sight analysis. The algorithm first find the outline of the objects according to the light source, then project the outline on to a plan behind the object. With the outline and projected line, a volume can be formed.

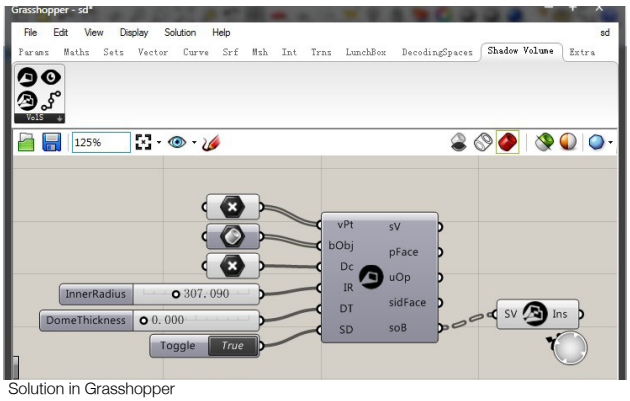


Shadow volume

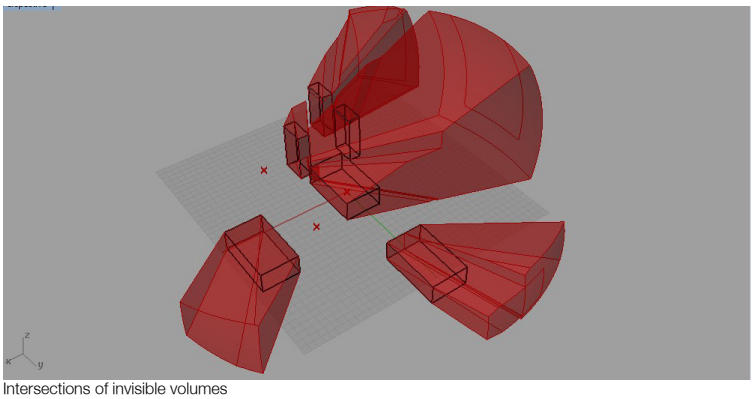
Algorithm

Implementation

Based on the Shadow Volume algorithm, a component for Grasshopper is developed. With this component User can easily generate the shadow volume right behind the building or in distance, volume of one point, multi points or multi points along a path, and create the intersection of the shadow volumes of different viewpoints which means the area where is invisible to all viewpoints. The calculation is done in runtime. So the user can easily compare the results by dragging and placing the objects and viewpoints.



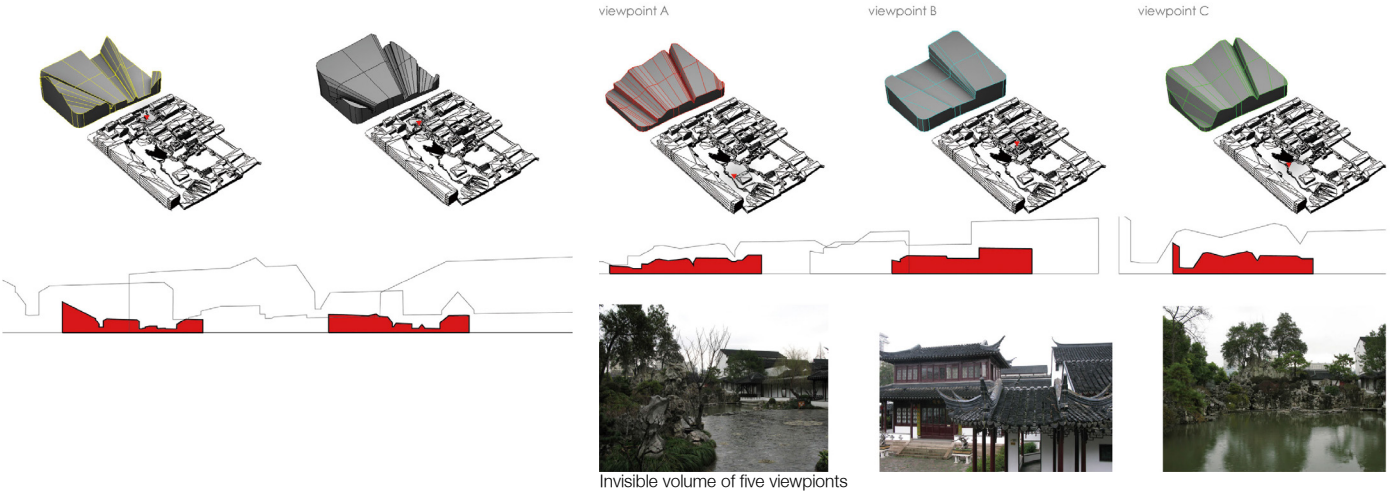
Solution in Grasshopper



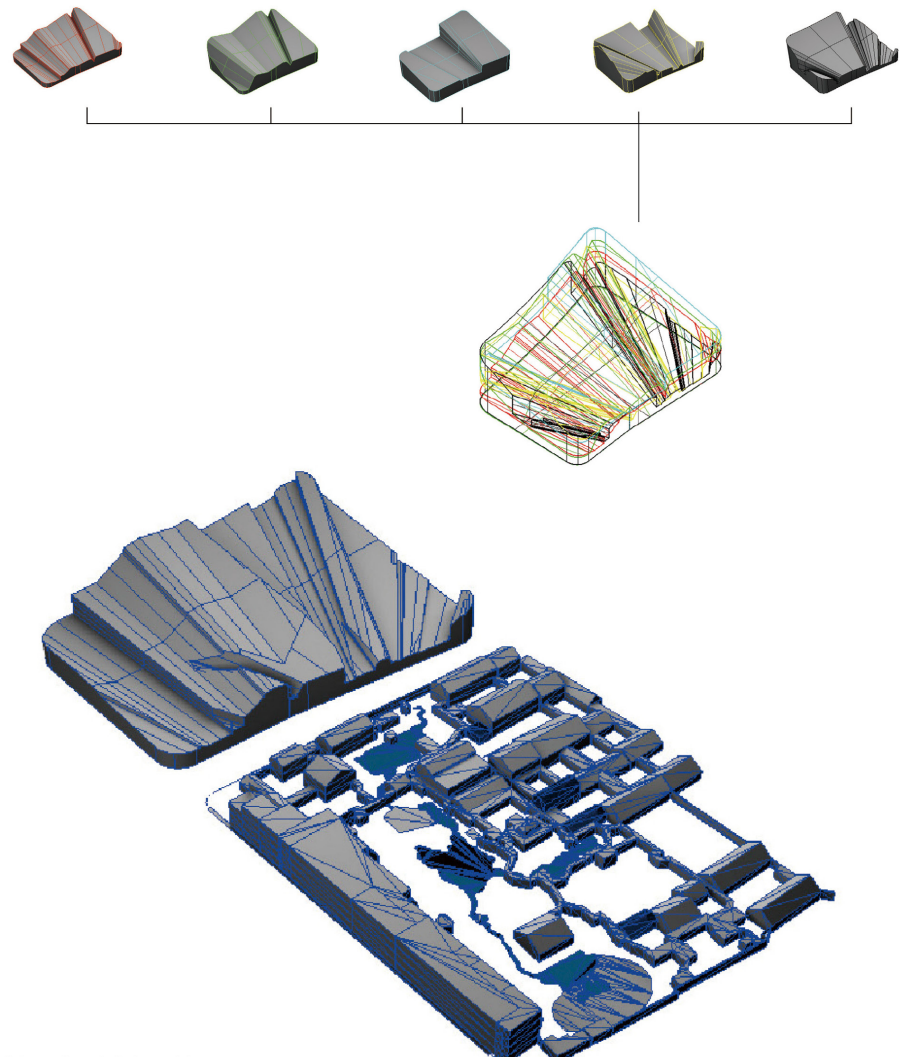
Intersections of invisible volumes

Application:

With this tool, The invisible 3d volume of each viewpoint can be generated automatically. By calculating the intersection of these volume, the invisible area of all the five viewpoints, the maxim volume of the new building, can be created.



Invisible volume of five viewpionts



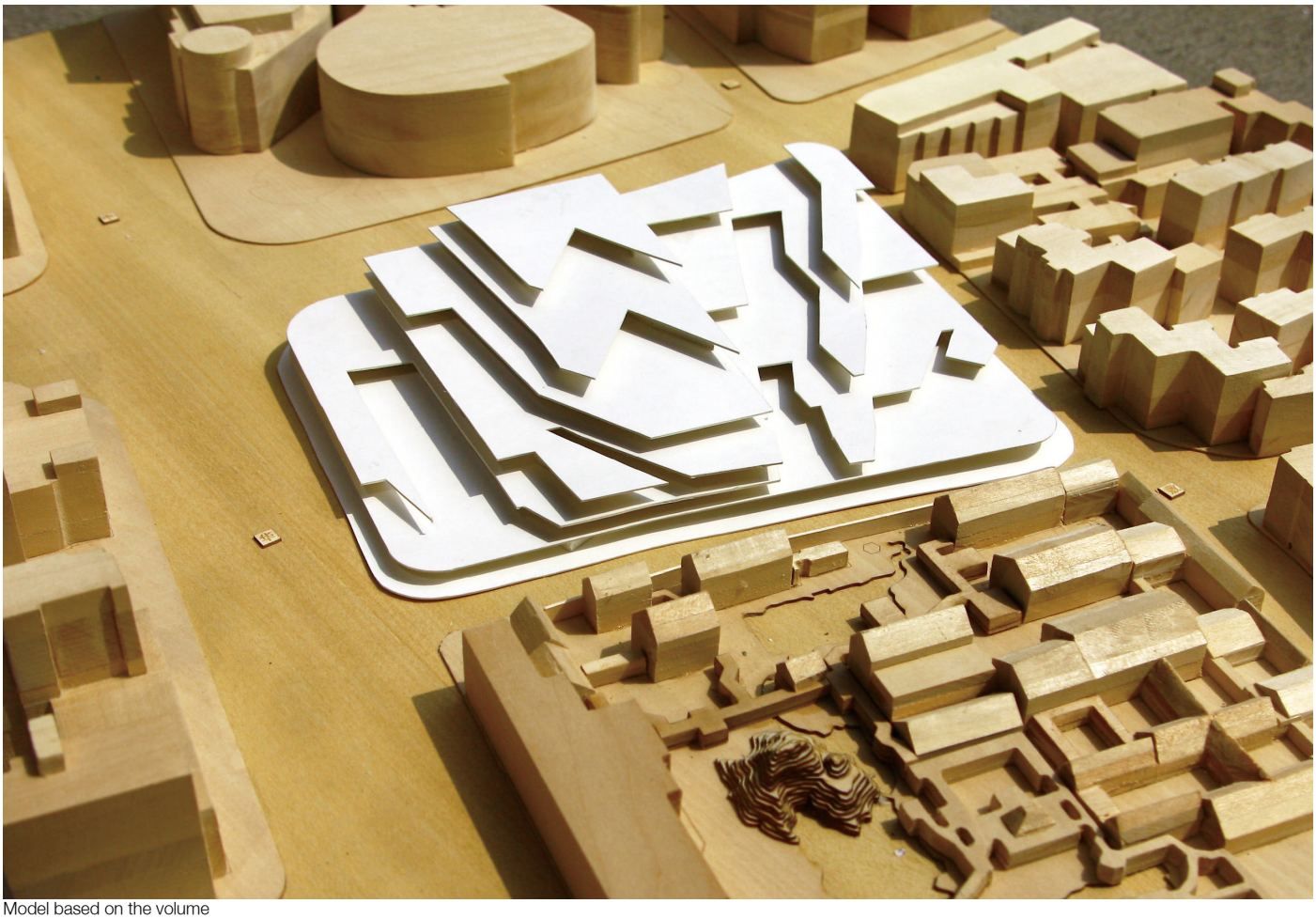
Boolean intersection of viewpionts

Conclusion

According to the storeyheight, the estimation of building area, floor area ratio and the arrangement of building functions can be calculated. Developers can estimate their profits based on these data. Comparing with 2D sight analysis, the 3D approach, can provide more precise and intuitive results. By Integrating this algorithm into Rhino and Grasshopper, which are getting more and more popular among designers, the tool can be easily accessed without additional learning curve and the results are provide in real time when condition is changed.

Future Work

For now, this tool can generate the invisible area, but it is also possible to assign different levels for different invisible areas. So designer can have more choices in decision making.
The intersection of the invisible volumes needs heavy computational power that slows down the calculation speed. So more efficient algorithm should be developed.

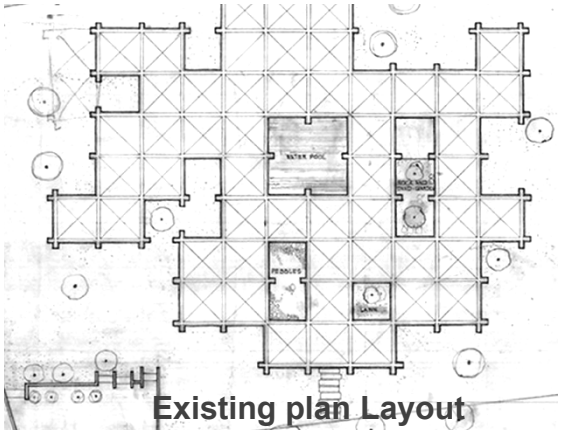


Model based on the volume

Extension of Ghandi Ashram

Student: Rini Singhvi

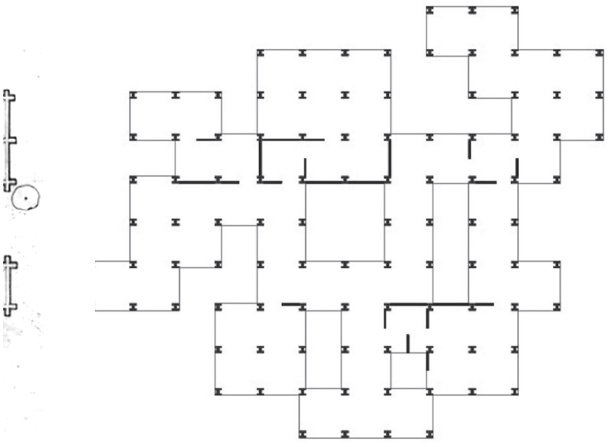
Ground Floor plan



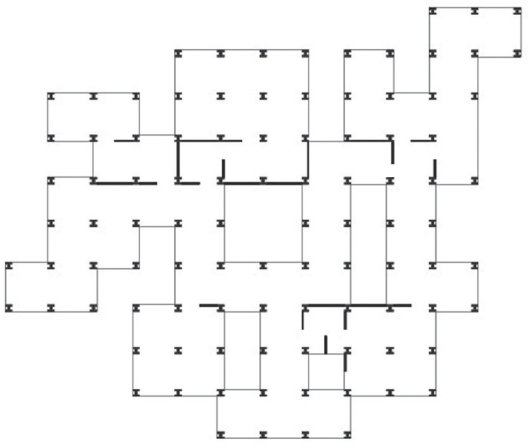
Existing plan Layout

Aim - Project Brief

The Gandhi Ashram is a museum in the city of Ahmedabad, India designed by the architect Charles Correa. The existing plan is a grid of Hshaped columns which forms different exhibit spaces and courts. Hence the aim of the project is to use the same grid and extend the existing campus to make a space for additional room for bookshop and cd-shop. As the brief demanded, the simple rule for building a new space is using existing 3 blocks and adding 6 new blocks to the grid.
But this kind of extension was to be made such that the over-all integration of spaces remains similar to the existing campus. Hence here the analysis run (isovist and axial maps) become very useful in working out various options for this kind of extension and selecting the closest one to the existing.
Due to the existing physical conditions on site, like existence of river and site boundary, the possible available space for extension was derived to be in the upper right corner in the plan and hence two options as shown below were derived for further analysis

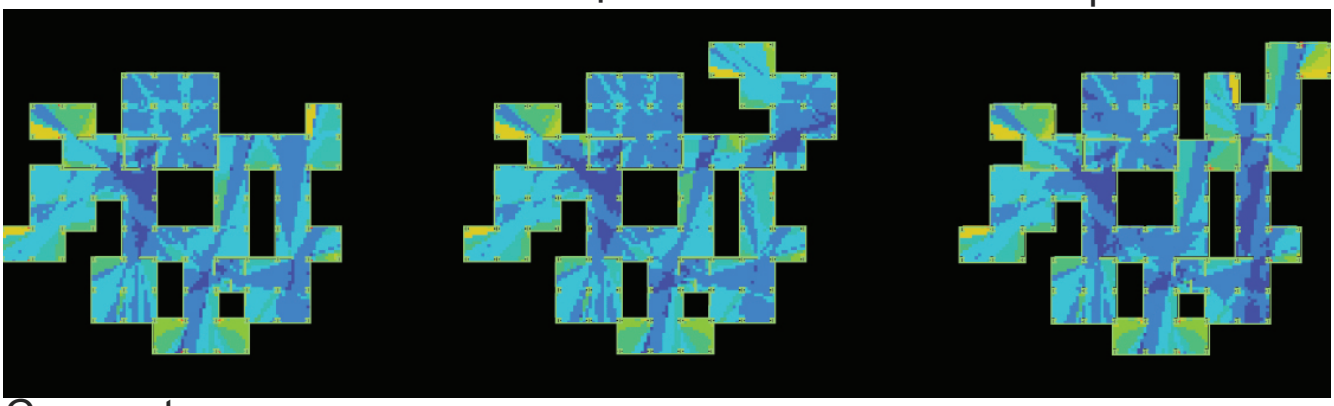


Option 1

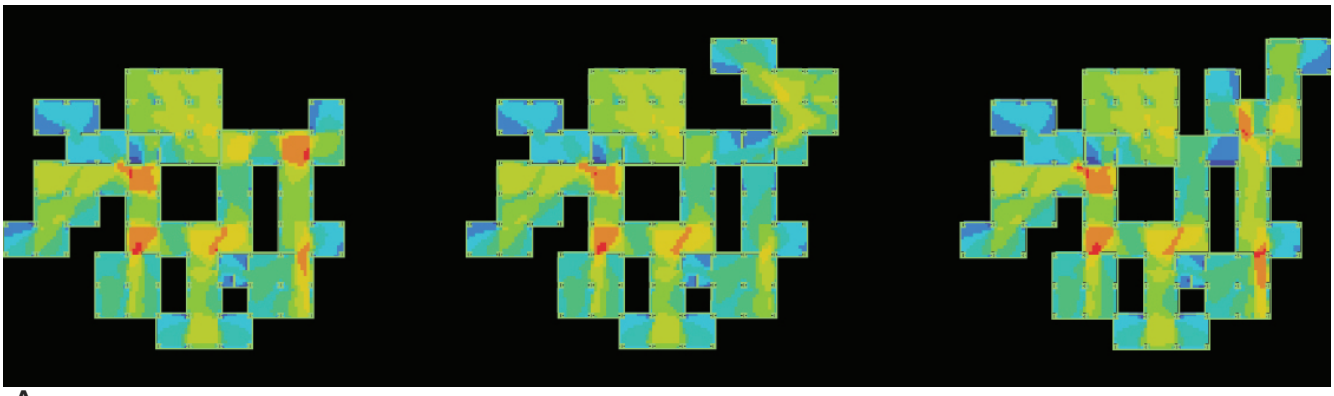


Option 2

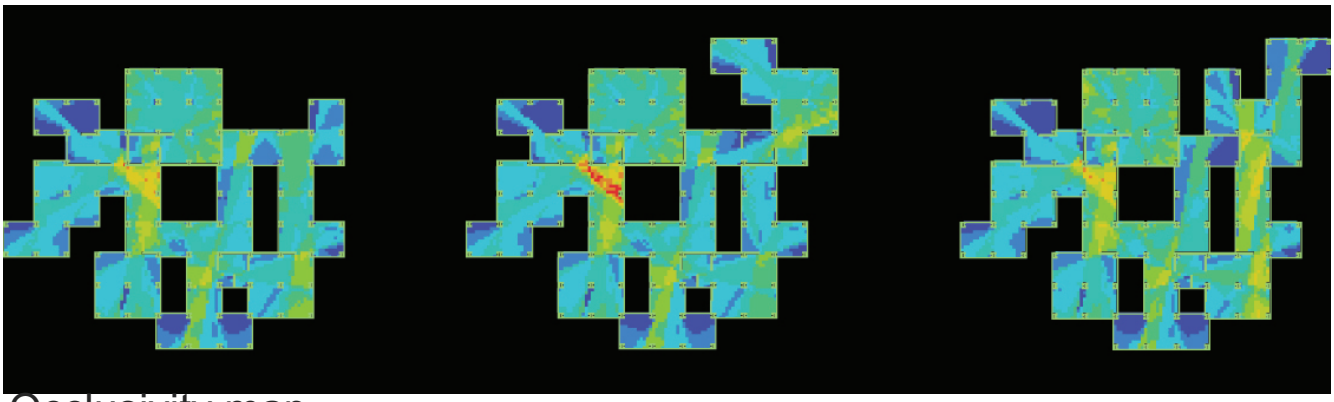
Existing Option 1 Option 2



Compactness map



Area map

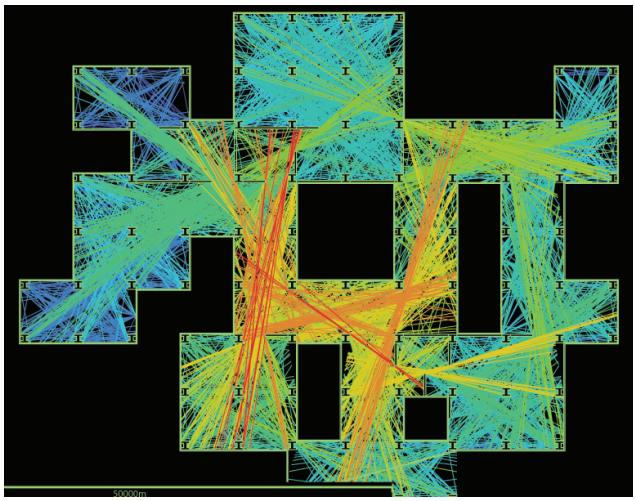


Occlusivity map

Isovist analysis

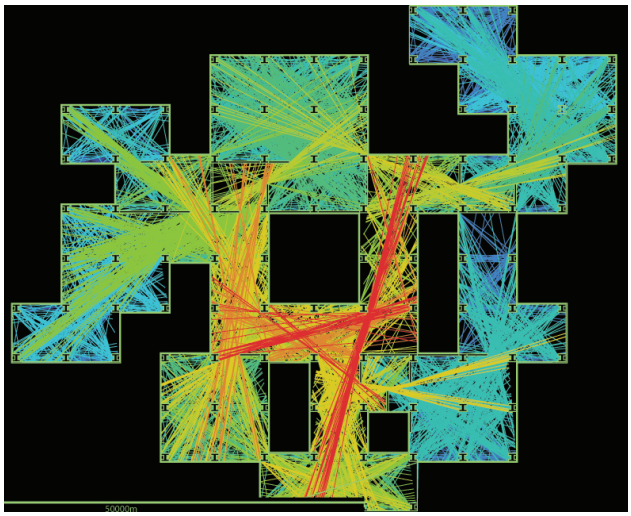
Result of isovist Analysis:
As shown in the graphs on the left, The 3 graphs run respectively as Compactness , Area and Occlusivity helped to compare the results of both the options in regard to the existing plan. For compactness, the second option has two spaces that are most compact which is not similar to the existing plan map. While option 1 is more similar to the existing one. For Area map, option 1 was again a better choice as the central space having the maximum area value as still retained as the original map. For occlusivity map, again the
option 1 shows similar character to the exisitng map. Hence after comparing all three kinds of map, Option 1 was taken further for axial analysis and making further changes if necessary.

Axial Graph analysis



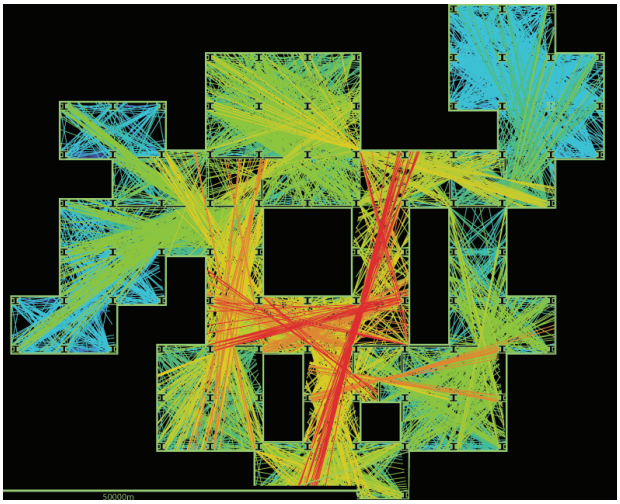
Exisitng Plan:

The above integration map shows that the central area with the pool court and the entrance area are the most integrated spaces. This quality needed to be retained.

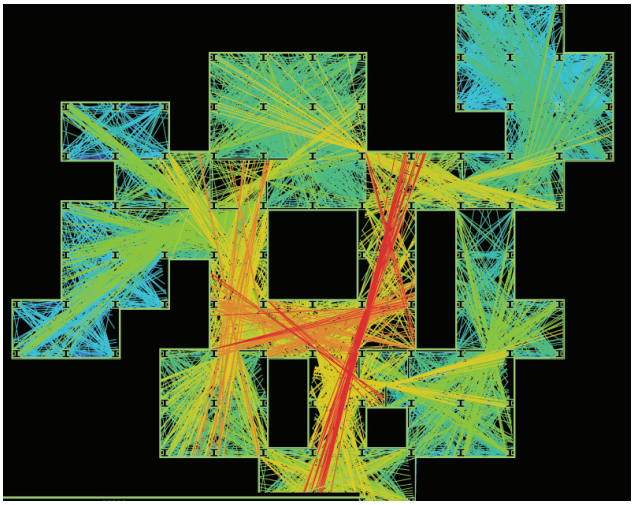


Extension Plan (Option 1):

On running integration analysis map on the option 1 shortlisted earlier, we get to know that the central pool and entrance continue to be the most integrated spaces as in the existing plan.



Option 2:



Option 3:

Further Analyzing option 1 and option 2

Note, in the option 1, the integration in the new room thus created,(on the top right corner), we realize that the integration in this room is not similar to that of others attached to the central space.
Hence we further make changes in the configuration of the blocks to match the integration of this room with those of others. Looking at option 2, we manage to achieve the integration of the internal room thus extended as desired, but again notice that we see new additional orange lines in the lower right room indicating more integration of this space which is what we don't desire.

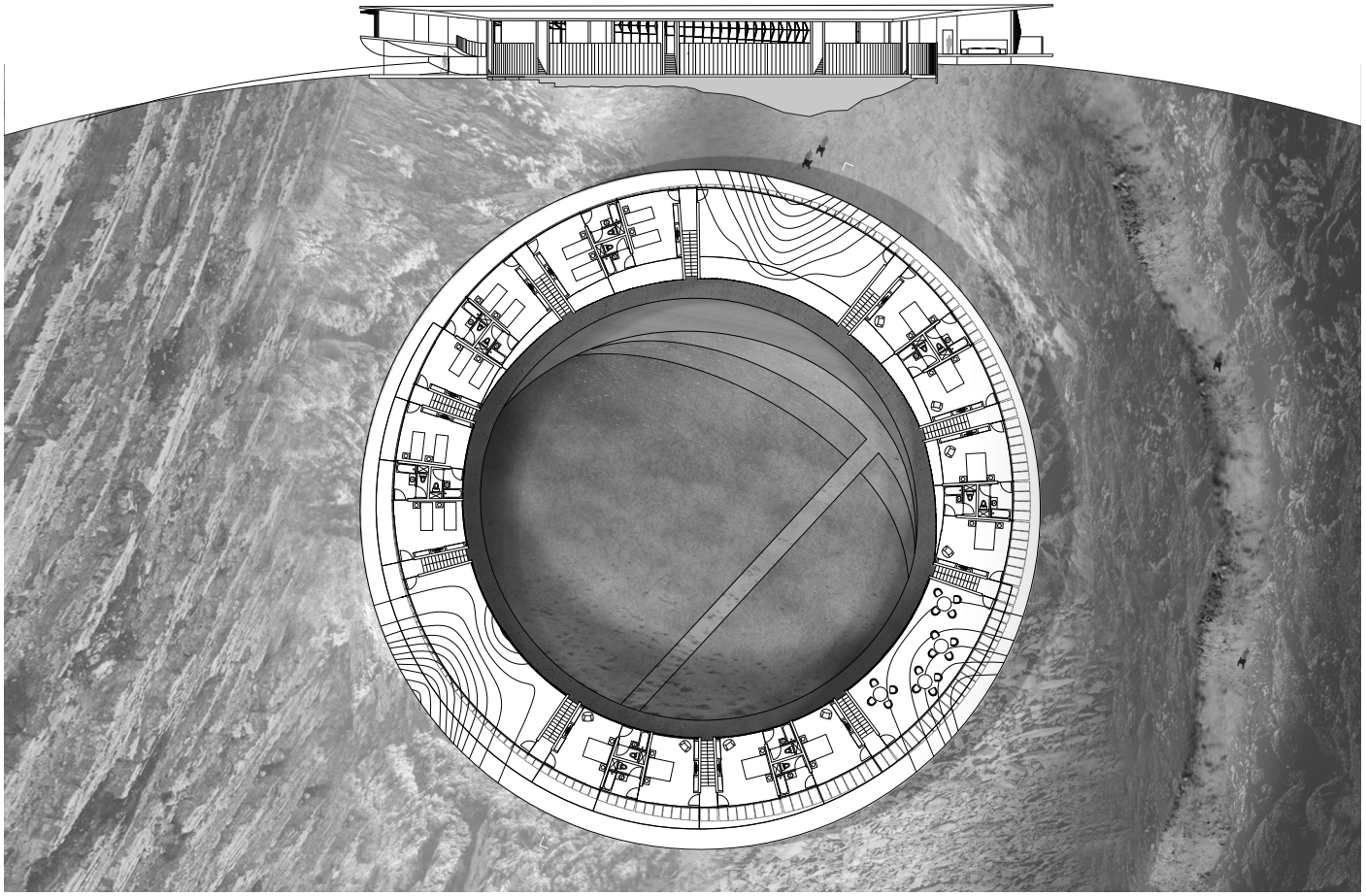
Hence, further on, to correct this, Changes were made in the option 2, as in changing the opening and entrance of the new extended space, to get option 3. Here in Option 3, we have achieved what we were desiring: First, the central pool and entrance lobby are most integrated as in the existing lan, Secondly, the new room thus created due to extension of the exisiting museum, has similar internal integration values as the rest of the rooms attached by the main central space.

A Refuge on Stromboli Island

Student: Stanislas Chaillou

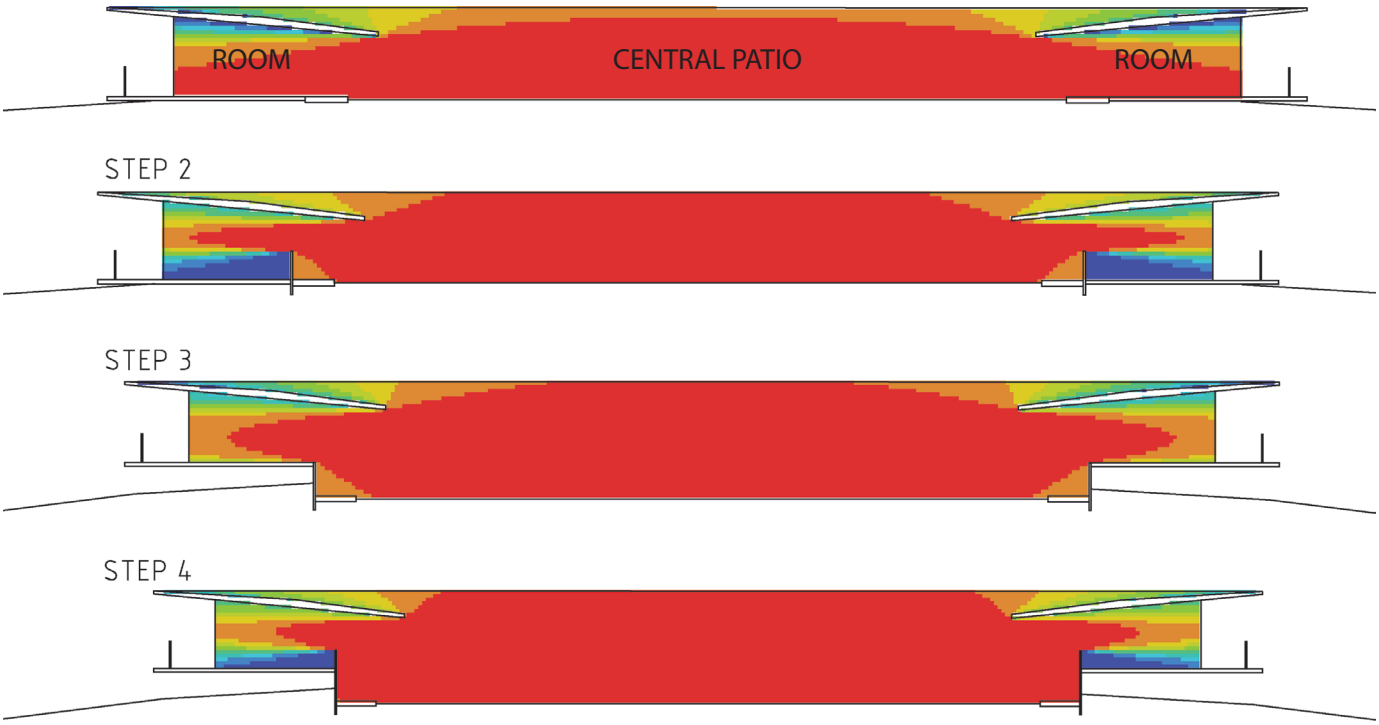
This study is related to my studio project. I had to design a hotel on the Stromboli Island. As an answer, I realised a refuge at the top of the volcano. Because of the height (500 m) the building suers of a to high sunlight exposure. Furthermore, as this rough context implies dicult building conditions, the building has to be rational, compact, but still has to allow for dissociated atmospheres (public spaces, rooms, restaurant etc...).
In a nutshell, this project raises two challenges:

Finding a convenient **threshold between private and public spaces**
Being able to precisely set solutions to **deal with the sunlight exposure**



1/ Dening the threshold Public/Private

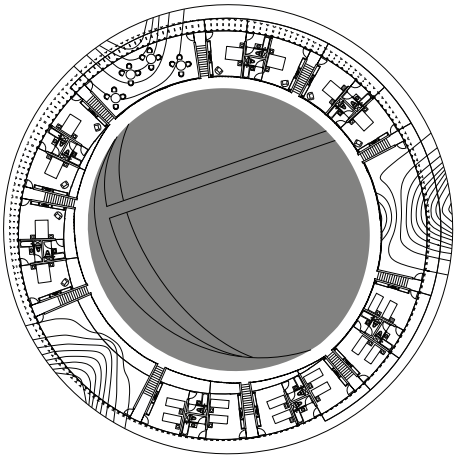
To set an ecient boundary between the rooms and the central patio, I used Depthmap. By analysing the section of the building with the “vision layer”, I was able to analyse the degree of intimimacy generated by my design steps. Here are the 4 steps.

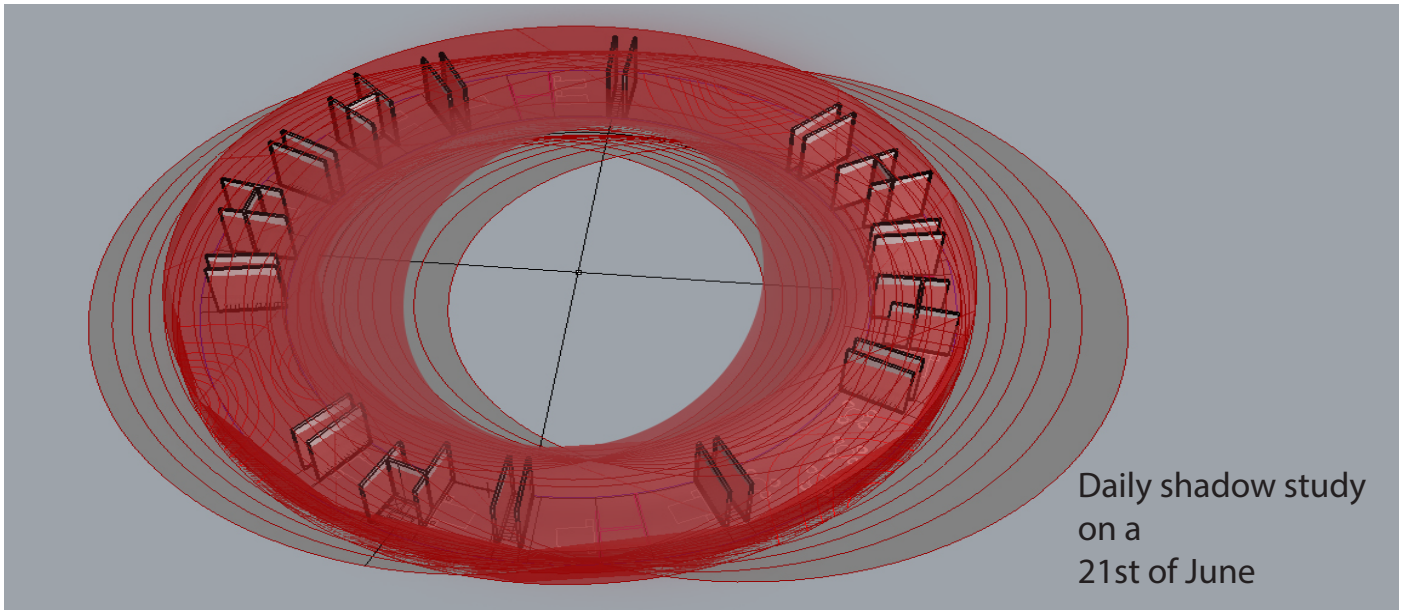


In the last step, the red area is nearly out of the room, meaning that the rooms are protected from the publics sight. The room picture below conrms the analysis.

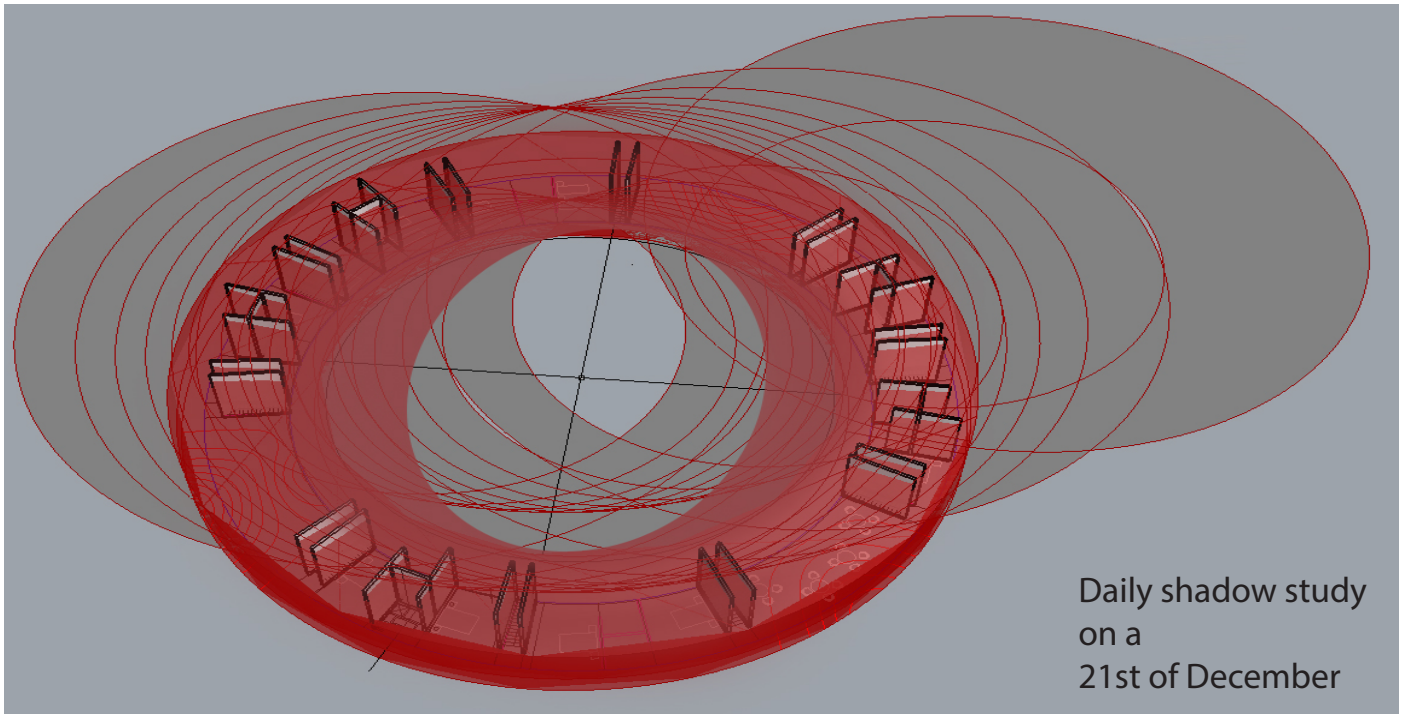
The patio is a crucial point of the porject: each room has a window on it, and the circulation runs around it. By dening a clear limit to the roof we can provide for:

- a shaded circulation
- protected rooms windows
- dierent kinds of light conditions in the patio





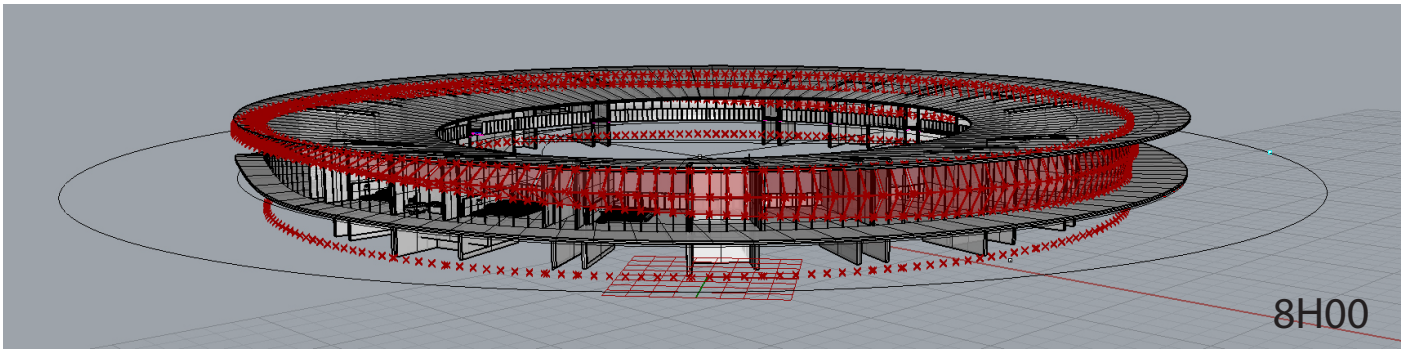
Daily shadow study
on a
21st of June

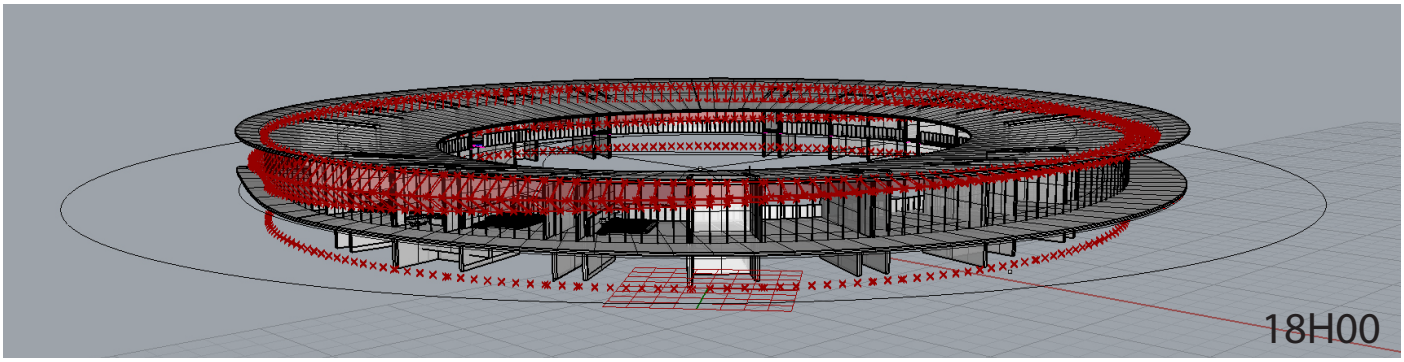


Daily shadow study
on a
21st of December

After modication of the roof limit,
we obtain
dierent conditions of light around the pool, and a
sucients shading to protect the rooms and the circulation.
The picture below conrms our analysis.

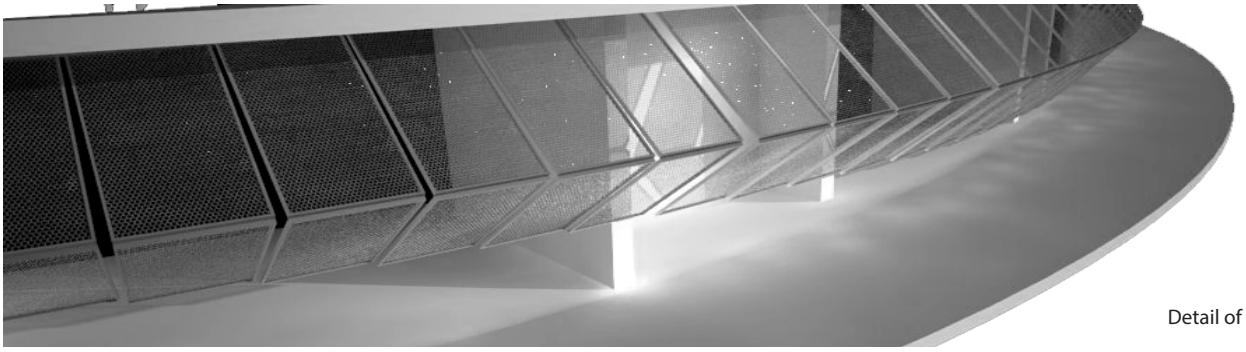
Moreover, the facade is the rst surface to be heated all year long by the sun. It's here a necessity to design a proper system to allow for shading.
Based on the data on the sunpath given by the Geco component, I designed a system of automatic sunblinds. They insure a sucient protection, and adapt their opening to everydays light.





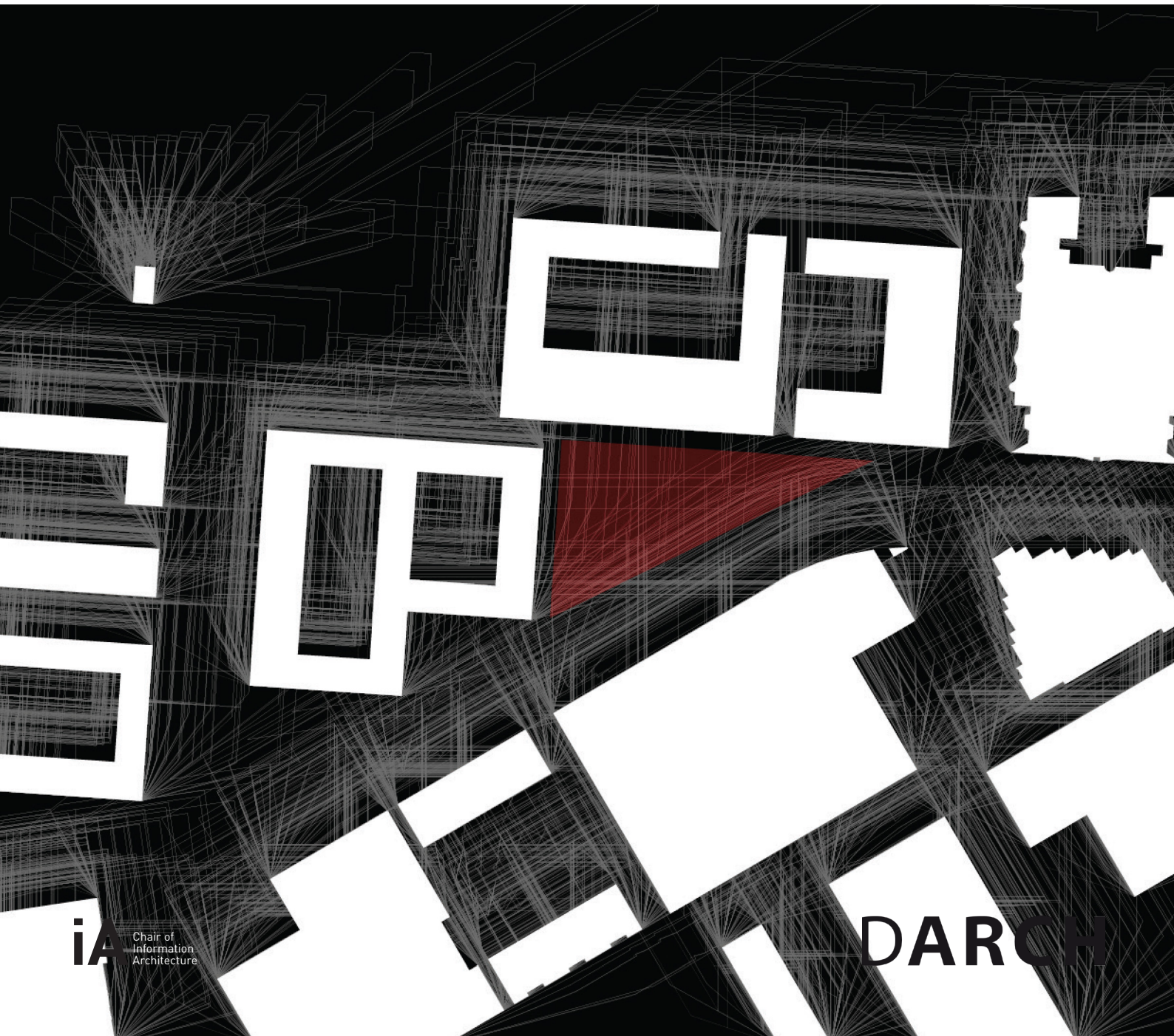
The picture below conrms our analysis: the wall of the room gets shaded, and the sunblinds prevent the light from going too deep into the room.

Light condition in a room a 21st of December at 17H00


Detail of the facade

Conclusion

I managed here to solve issues at dierent scales (views, light, shading etc...) thanks to Geco and Depthmap. I appreciated how Geco helps setting with precision dimensions, and giving relevance to my planing. On the downside, the analysis could be pushed futher. I would have liked being able to embed the energy concern. The sunblinds could then open and close not only to provide shading but also to regulate and master the heat that the building receives and stores during the day. Also depthmap has been a great tool, and the fact of using it to analyse a section has been a revealing experience. On the other hand, the section analysis reduces the number of relevant layers: for instance the layer “integration” makes less sense than in a plan analysis. Can’t we also push depthmap to the axonometry analysis? It could be a way to start dealing with the 3 dimensions at the same time, without running to heavy calculus...



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