



UNIVERSITAT
JAUME I

Location Indoors

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Final Degree Work

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Supervised by: Joaquín Huerta Guijarro, Full Professor



To Laura, my very close friend for being my encouragement and my (beer) company and to my father for being my support even without really knowing what I do.

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First of all, I would like to thank my Final Degree Work supervisor, Joaquín Huerta, for his dedication and support with all my doubts.

Secondly, I want to thank Juan Camilo Gómez for his patience answering my mails, solving license problems and missing files.

I also would like to thank Sergio Barrachina Mir and José Vte. Martí Avilés for their inspiring LaTeX template for writing the Final Degree Work report, which I have used as a starting point in writing this report.

ABSTRACT

This document aims to be an explication of the process, the successes, the failures, the result and the obstacles that I've faced during the last months to create a 3D interactive environment with AutoCAD 2020, ArcMap, ArcGIS Indoors, ArcGIS Pro and CityEngine.

I will start from the initial idea we had on paper, I'll explain all the problems I faced along the way, as well as how to fix them and the result that has been reached.

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INTRODUCTION

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This chapter reflects which steps were accomplished during the development of the final project. The fundamental point is to state the objectives of the presented work.

1.1 Work Motivation

I decided to get involved in this project because the idea of creating an interactive 3D environment seemed to be very interesting and a good opportunity to try out the knowledge acquired during these years at University Jaume I of Castellón. Besides, the final work would be implemented and used in real life so it added some interest to me.

My work area is 3D modeling and thanks to this project I could do something that I liked and that at the same time was a challenge for my skills. The idea of modeling the library and adding the geolocalization was challenging and I decided to accept it.

The project approach was clear, a 3D building had to be built to include it in the University app SMART UJI <http://smart.uji.es/> and it had to be functional. At the end of the project, the user should be able to interact with the building, locate books, study booths, and be able to move from one point to another in the library without a problem.

1.2 Objectives

The final project is part of a project already started by the GEOTEC research group at the University Jaume I: Virtual Smart Campus UJI.

Virtual Smart Campus UJI is a map-based view of the interior and/or exterior assets on the university campus that enables employees, students, and visitors to locate an area of interest and review information stored in the human resources and facilities management database. It will also allow employees and visitors to deliver a web-based service request or booking spaces applications and integrate other existing services like the monitoring of energy consumptions or solid wastes management.

GEOTEC research group developed the mobile application several years ago and they needed an update so that's where I came in. My task consisted of updating the 3D model of the library building with its corresponding travel path and incorporating it into the mobile application and the web www.smart.uji.es.

The initial approach was divided into four parts:

- The first part was getting the library plans in AutoCAD files, import them in ArcGIS Pro, and getting the transportation networks with ArcGIS Indoors.
- The second part was to create a database of the inside of the building with the connections, location of offered services, the stairs and elevators... and the map.
- The third part was modeling the building in CityEngine and exporting it for web and mobile application. In this phase, I not only had to model the building but I'd have to be able to view it floor by floor independently.
- The fourth and last part, was the correct implementation in the app.
- As an additional phase, and if the workflow allowed me, there was the implementation of displacement with augmented reality in Unity3D.

At the end of the project it was expected that I would get an environment where the user could interact with by searching for books in the library's database, check if they were available, on which floor and section they were and generate the navigation path from their initial position to the book. In addition, he could check the status of the study booths, availability, and location within the library. As a bonus point, there was the use of browsing in 2D or 3D with augmented reality, which would give it a greater sense of realism.

1.3 Environment and Initial State

The first steps in the project were the installation and configuration of the licenses and they were done by Juan Camilo Gómez.

The project started practically from zero because the only files I got were the AutoCAD plans of the previous project. The only problem was that these were outdated because they were previous to the works carried out in the extension building of the library. In this building are located services as the ORI, the OIPEP, or the CENT among others, so the first step was to update these files.

All the project was supposed to be done alone although I had support via email from the department for any question or problem.

PLANNING AND RESOURCES EVALUATION

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2.1 Planning

This section details the time planning of the work, including all its tasks and subtasks, the dependencies between them, and the possible dependencies with other jobs.

Below is shown a list of the software that has been used in the development of the project and its general use. Later on, the tasks developed with each one will be deepened.

- AutoCAD: 2D drawing of the plans of the different floors of the library.
- ArcMap: Creation of the points of interest and services offered by the university library.
- ArcGIS Indoors in ArcGIS Pro: Generate the geodatabase and travel path.
- Excel: Creation and modification of the file that allows me to generate the geodatabase.
- Revit: 3D model of the library.
- CityEngine: Union of the modeling and the displacement path.

In general, the approach to the development of the final project was quite linear. An initial time planning was proposed with the tasks that were planned and an approximation of the hours it would cost to carry them out. The planning is displayed in a Gantt Chart on Figure 2.1.

1. Install programs and validating licenses: 2 hours.
2. ESRI tutorials: 21 hours.
3. Install ArcGIS Indoors in ArcGIS Pro: 2 hours.
4. Create the project in ArcGIS Pro: 2 hours.
5. Create geodatabase in ArcGIS Pro: 2 hours.
6. Generate indoor geodatabase: 4 hours.
7. Charge data in the database: 2 hours.
8. Generate floorplans to indoors: 4 hours.
9. Create points of interest and services: 6 hours.
10. Model the library in CityEngine: 90 hours.
11. Export the library for app and web: 10 hours.
12. Import the library for app and web: 10 hours.
13. BONUS: Implement virtual reality: 120 hours.
14. Write the final memory: 15 hours.
15. Work on the presentation: 15 hours.



Figure 2.1: Initial time planning (made with ganttpro)

After the development of the initial plan, some deviations have been found in the initial planning, as shown in figure 2.2.

1. Install ArcGIS Pro and CityEngine and validating licenses.
2. Install ArcGIS Indoors in ArcGIS Pro.
3. Install AutoCAD 2020.
4. Install ArcMap.
5. Install programs and validating licenses: 10 hours.
6. ESRI tutorials: 21 hours.
7. Update AutoCAD files: 195 hours.
8. Create the shapefiles of points of interest, study books, bathrooms...: 24 hours.
9. Create the project in ArcGIS Pro: 2 hours.
10. Create geodatabase in ArcGIS Pro: 2 hours.
11. Generate indoor geodatabase: 3 hours.
12. Charge data in the database: 2 hours.
13. Generate floorplans to indoors: 3 hours.
14. Install CityEngine and validating the license: 4 hours.
15. Model the library in Revit: 145 hours.
16. Write the final memory: 24 hours.
17. Work on the presentation: 15 hours.

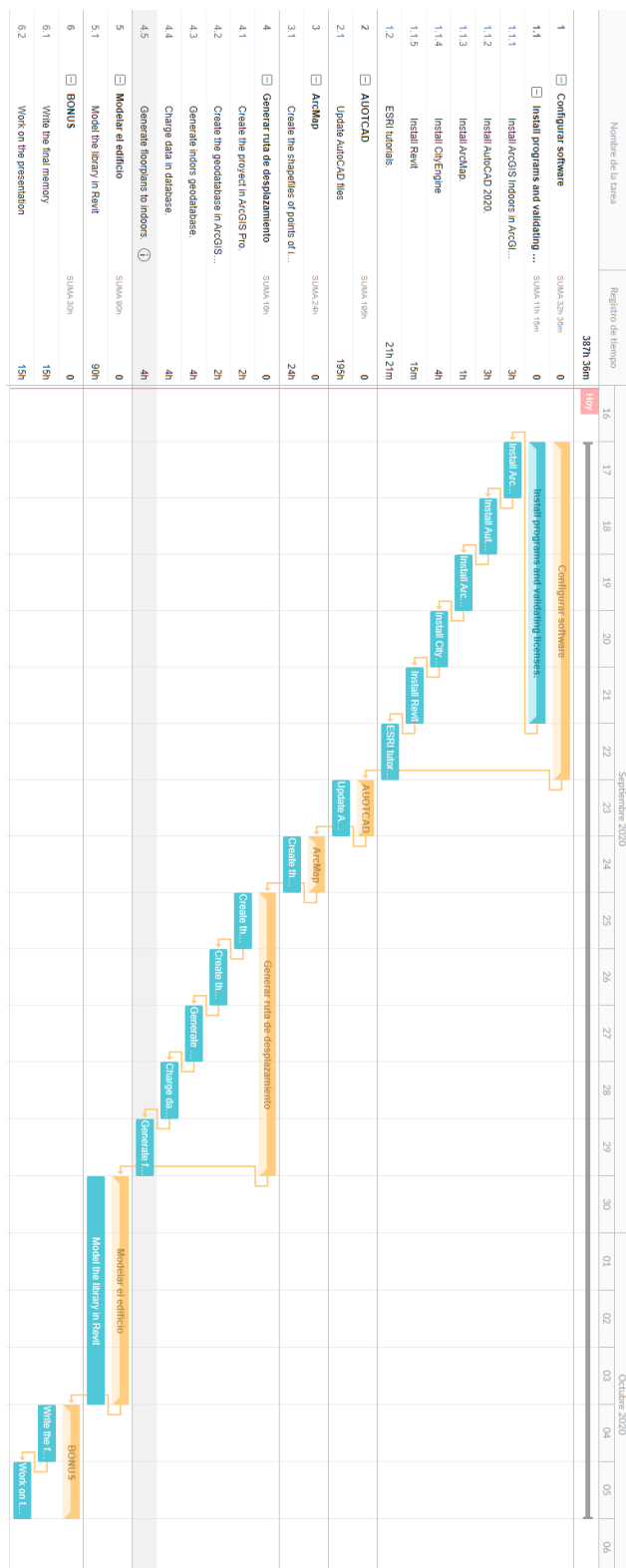


Figure 2.2: Definitive time planning (made with ganttpro)

The workflow development and the reasons for some decisions that have been made are explained in more detail in the next chapter.

2.2 Resource Evaluation

The development of the entire final project has been carried out by a single person, with a computer at home and internet access. The hardware specifications of the equipment used for the development of the final project are the following:

1. An AMD RYZEN 9 3900X 3.8GHZ processor, which gave greater speed when working.
2. An MSI B550M PRO-VDH WIFI motherboard.
3. An MSI GeForce GT 1080 Ti Gaming X graphics card with 11GB of memory to move programs like AutoCAD well.
4. Two Kingston HyperX Fury Black 16GB RAM memory.
5. A Corsair Hydro H100x Liquid Cooling Kit fan so that the equipment does not heat up when spending many hours working.

The ArcGIS Pro, ArcGIS Indoors, and CityEngine licenses were purchased by the university, and AutoCAD and Revit, thanks to the student license, were free.

WORK DEVELOPMENT AND RESULTS

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This chapter will explain the developed work and the obtained results, as well as the deviations and the series of inconveniences that have been faced up to here. In this way, readers of this memory must be able to understand the possible reasons for discrepancies between the objectives of the work, the planning that allowed to obtain it, and the final results achieved.

3.1 Work Development

On November 7, 2019, the ArcGIS Indoors, ArcGIS Pro and CityEngine licenses were requested. On December 3rd, I installed with Juan Camilo Gómez, ArcGIS Pro and CityEngine in his office. But the ArcGIS Indoors license, which was the first program to use, did not arrive until March 25 and so I installed it at home with some instructions given by him.

During this first period of time between licenses, I worked on the tutorials at [/www.esri.com/training/](http://www.esri.com/training/) to find out what I needed, what I had to look for and how I was going to develop the work.

To begin with, I needed the library plans and preferably in a .dwg format because it is a very common type of file and they allow a better design of the elements, but also because it allows me to extract all the information to a geographic information system.

The main goal was to get the library plans in an AutoCAD file format or compatible with it to study them and be able to import them into ArcGIS Indoors. Juan Camilo Gómez, a member of the GEOTEC research group, got me the plans but when analysing them I realized that they were old plans since they did not have the library extension building where the International Relations Office, the Center for Education and New Technologies or the Office of Professional Insertion and Internships are located among others.

As it was a hypothesis since I did not know exactly if these services were located there, I decided to search the internet for the updated plans of the university library and came across a section of the Jaume I University website that host these documents www.uji.es/serveis/otop/base/planols-superficies/planols/biblioteca/.

The next step I took was to look for the list of the services offered by the library by floors since just codes appeared in the plans and I found another section on the web that provided me with that information: www.uji.es/serveis/cd/bib/info/distribucio/.

With this information and comparing it with the plans that had been provided to me from the GEOTEC research group of the Jaume I University, I understood that the initial plans had to be updated if we wanted the 3D model of the library to be real and provide all the services expected for the app.

So with all the information I had, I started to update the plans. I decided to separate each plant into different layers to make it easier to process data later in ArcGIS. The floors had more or less the same composition so it was easy to divide it into different sections such as bathrooms, study booths, stairs, elevators ...

Below is shown a list with the name of the layer, the color in which it has been drawn and what they represent:

- A-AREA-BDRY: Perimeter rooms, red.
- A-AREA-IDEN: Numeric identifier, yellow.
- A-AREA-TYPE: Type of room, yellow.
- A-DOOR-FULL: Door, orange.
- A-FLOOR-EVTR: Elevators, cyan.
- A-FLOR-HRAL: Stair and balcony handrails and guard rails, magenta.
- A-FLOR-LEVL: Level changes, ramps, pits, and depressions, magenta.
- A-FLOR-OTLN: Building perimeter, magenta.
- A-FLOR-STRS: Stairs, yellow.
- A-FLOR-TPTN: Toilet partitions, red.
- A-FURN: Furniture such as tables, desks... Black.
- A-GLAZ-FULL: Windows, blue.
- A-GLAZ-SILL: Window sills, blue.
- A-WALL-FULL: Full height walls, stair and shaft walls, walls to structure, white.
- A-WALL-PHRT: Partial height walls, white.
- S-COLS: Columns, white.
- S-SHEAR-WALL: Shear walls, separations between elements; green.

All this division was done anticipating that when putting the plans in ArcMap it would be necessary to identify the points of interest and the different services offered in order to be able to make the navigation routes.

When I finished redrawing the plans in autocad I prepared them to export so that the import in ArcGIS be correct because if the elements weren't closed polylines the importation gets lots of warnings and an incorrect output.

This work wasn't taken into account in the initial planning, which meant a workload of almost 200 hours.

Below are a series of images of the final result:

Figure 3.1: Level S of the university library (made with AutoCAD)



Figure 3.2: Level 0 of the university library (made with AutoCAD)



Figure 3.3: Level 1 of the university library (made with AutoCAD)

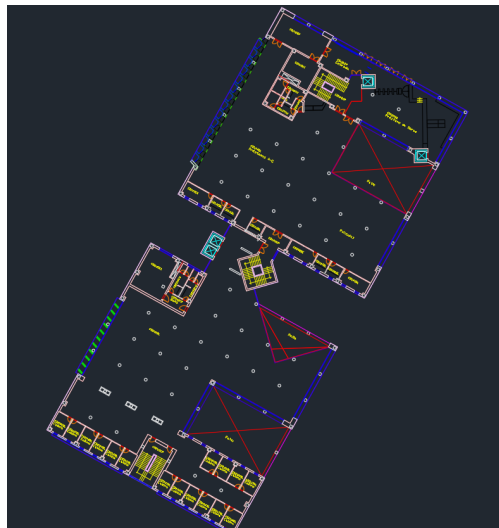


Figure 3.4: Level 2 of the university library (made with AutoCAD)

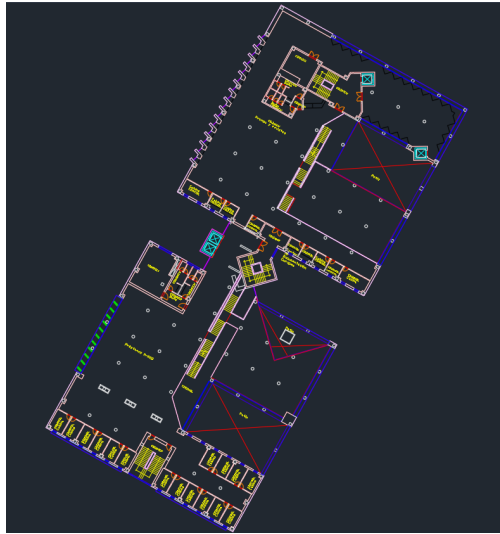


Figure 3.5: Level 3 of the university library (made with AutoCAD)

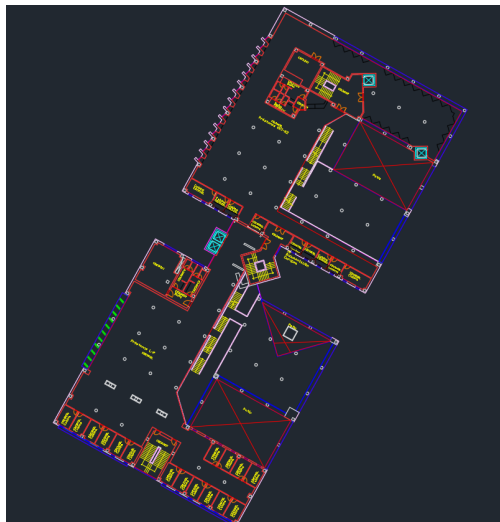


Figure 3.6: Level 4 of the university library (made with AutoCAD)

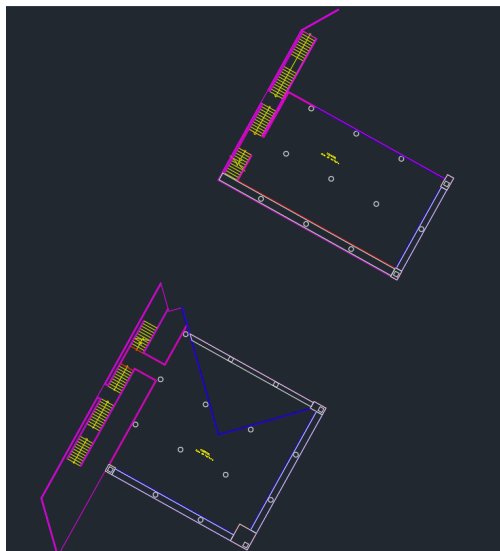


Figure 3.7: Level 5 of the university library (made with AutoCAD)



Figure 3.8: Level 6 of the university library (made with AutoCAD)



Once I had the first floorplan updated according to those found on the web, I proceeded to find out how to import them into ArcGIS Indoors with all the information. But I ran into a problem again: In order to exchange services and points of interest's information between AutoCAD and ArcGIS Indoors, I needed to download ArcMap with its corresponding license that I had to ask my tutor Joaquín Huerta since it is not a free program.

But before being able to request a license, ArcGIS reported from the web that due to the global COVID-19 crisis (April, 2020), it had suspended all ArcMap service to users to dedicate all the resources to the companies that needed it to be able to help in this crisis.

The alternative to this problem was to start over from scratch with the initial plans. It was not ideal because they were not updated but it gave me a base from which to work in case we could not solve the download of ArcGIS Desktop.

So I went back to the plans that had been initially shared with me and proceeded to import them into ArcGIS Pro.

The first step in an ArcGIS implementation is to deploy an ArcGIS Enterprise environment. This task was done by Juan Camilo Gómez because he was in charge of giving me user permits.

The second step was to download and install the indoors toolbox. ArcGIS indoors comes with a set of geoprocessing tools in ArcGIS Pro that automate, among other things, the CAD to Indoors workflow, the creation of ArcGIS Indoors routable networks...

At this time, the programs were configured so I could start loading data to the ArcGIS Indoors information model. Before I can add data to the project, I need to create an Indoors Geodatabase with the 'create indoors geodatabase' geoprocessing tool to populate a blank file geodatabase with all required ArcGIS Indoors feature classes, configuration tables, and relationships.

This geodatabase is where all the information related to the building would be located. It uses an Excel configuration spreadsheet to map CAD layers to the Indoors facilities, units, levels and details feature classes.

The next step was to create the transport network between points, but for this I needed the Excel Configuration Spreadsheet .xls file that had to be included in the files that GEOTEC research group gave me. I asked Juan Camilo Gómez but he did not have it and he did not know who could have it since the documents he had had been made by someone else.

At this point, there was still a third alternative, which was to try to introduce the library plans in CityEngine and model it without the transport networks, but when the program started, it gave a license failure. On April 8, I asked Juan Camilo Gómez for help by mail, since he was the one who provided me with the programs and fixed the whole issue of my licenses.

On April 13 Juan Camilo solved the CityEngine license issue for me via Hangouts and I was able to get to work. On the subject of Excel Configuration Spreadsheet .xls he told me that he was in contact with the Esri enterprise and that he was seeing if he could solve it but it was not safe at all and he had to have other possibilities in mind to be able to work.

On May 13, Juan Camilo gives me the link <https://learn.arcgis.com/en/paths/level-2-facility-mapping-for-covid-19-response/> of a course that ESRI had launched and in which was the Excel Configuration Spreadsheet .xls file that I had requested before April 6 to be able to do the 'floorplans' to indoors.

I tried to create the route with the initial plans and since they did not give me a problem, I decided to get it right from the beginning.

I took the updated plans and entered them into ArcMap. I had to do two things, create the points of the services and POIs that are in the library and export all the layers in a format suitable for ArcGIS Pro.

First, I had to create a layer in .shp format for each service or point of interest found on each floor of the building such as bathrooms, elevators, study booths ... Finally, when I already had all the layers with the data correctly marked, what I did was export to shapefile format so that when importing them into ArcGIS Pro it would not give me problems.

All these data would be necessary later to be able to create the travel route and to be able to locate the different services offered by the building.

Figure 3.9: Level S of the university library (made with ArcMap)

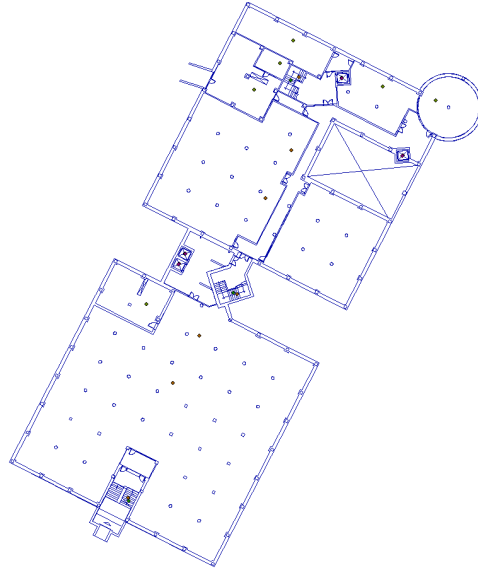


Figure 3.10: Level 0 of the university library (made with ArcMap)

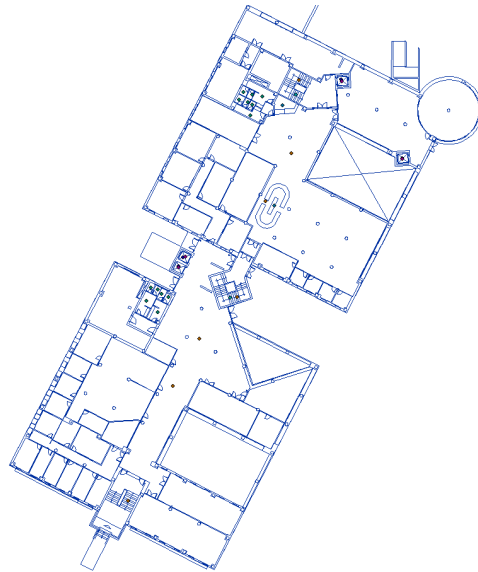


Figure 3.11: Level 1 of the university library (made with ArcMap)

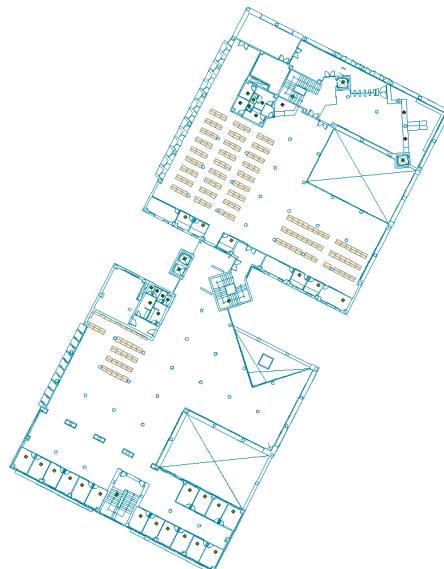


Figure 3.12: Level 2 of the university library (made with ArcMap)

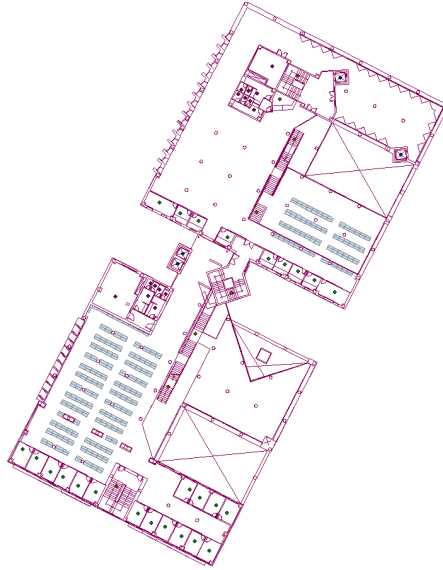


Figure 3.13: Level 3 of the university library (made with ArcMap)

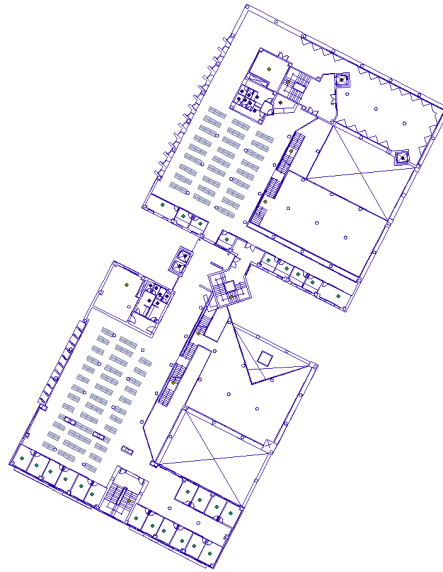


Figure 3.14: Level 4 of the university library (made with ArcMap)

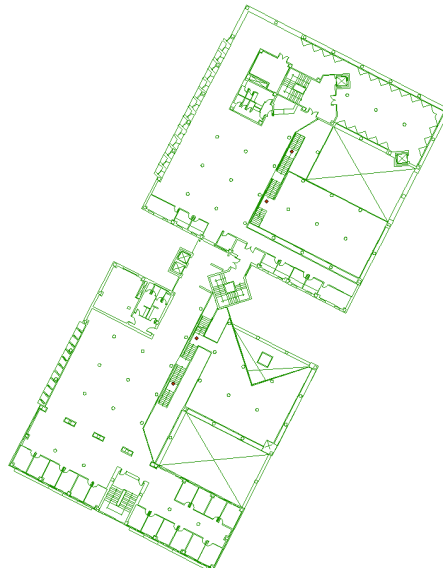


Figure 3.15: Level 5 of the university library (made with ArcMap)

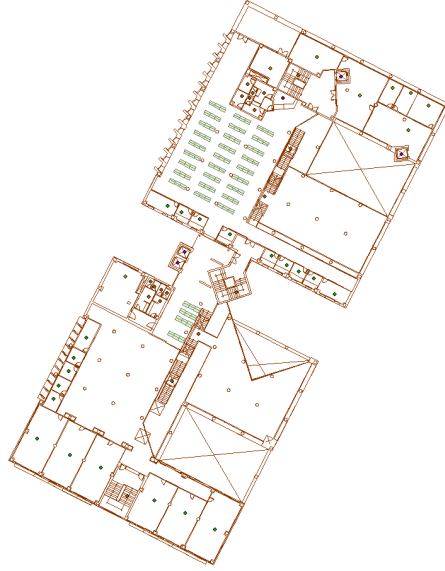
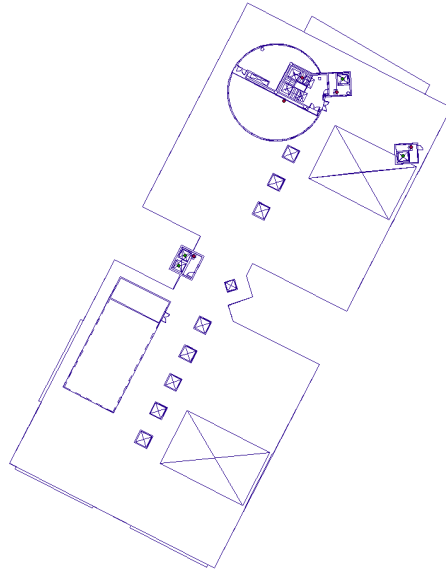


Figure 3.16: Level 6 of the university library (made with ArcMap)



When I finished working in ArcMap, I already had the plans, the services such as bathrooms, book loans, study booths, offices ... and all the points of interest in shapefile format, so I proceeded to enter them in ArcGIS Pro.

This trip the 'Indoors to floorplans' tool let me create the travel path correctly, so I proceed to create Units, Level, Details and Facilities. In the following images is shown the travel path.

Figure 3.17: Travel path in level S of the university library (made with ArcGIS Pro)

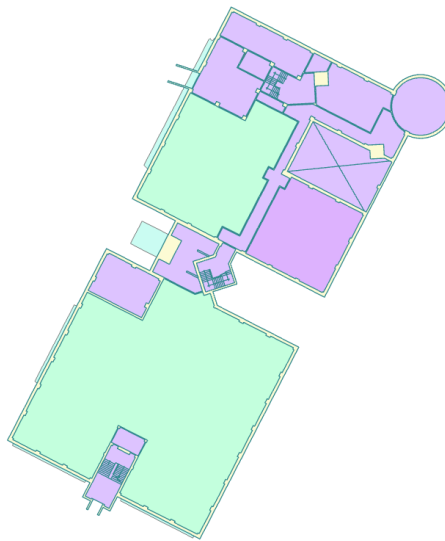


Figure 3.18: Travel path in level 0 of the university library (made with ArcGIS Pro)

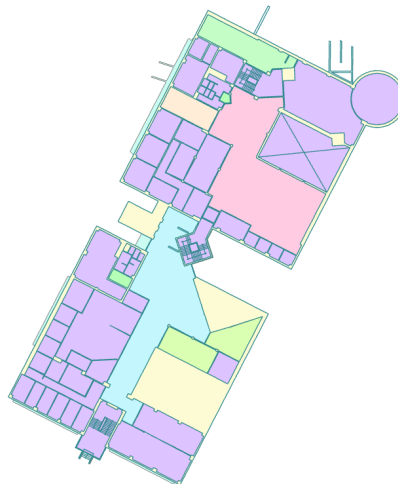


Figure 3.19: Travel path in level 1 of the university library (made with ArcGIS Pro)

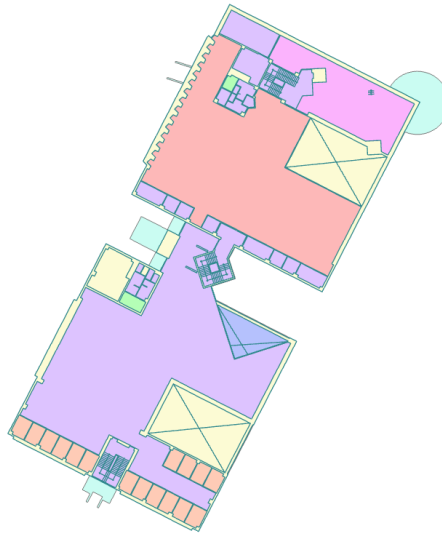


Figure 3.20: Travel path in level 2 of the university library (made with ArcGIS Pro)

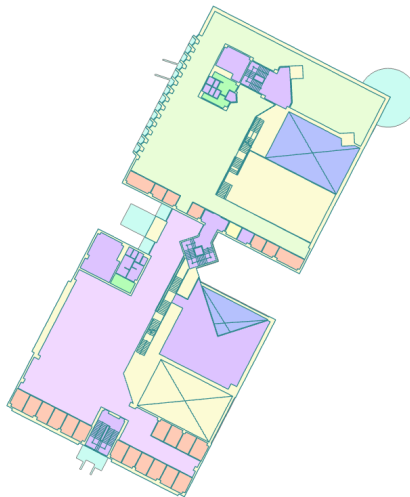


Figure 3.21: Travel path in level 3 of the university library (made with ArcGIS Pro)

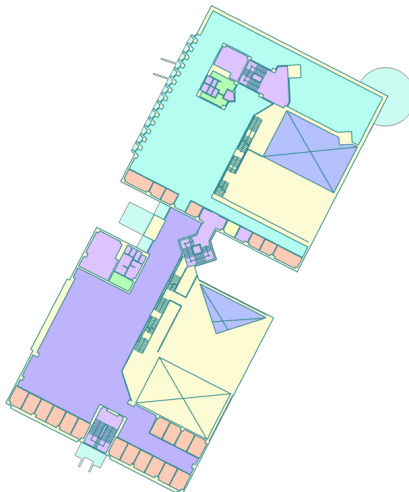


Figure 3.22: Travel path in level 4 of the university library (made with ArcGIS Pro)

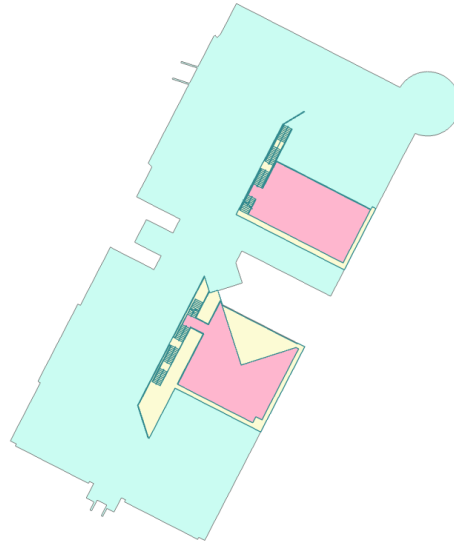


Figure 3.23: Travel path in level 5 of the university library (made with ArcGIS Pro)

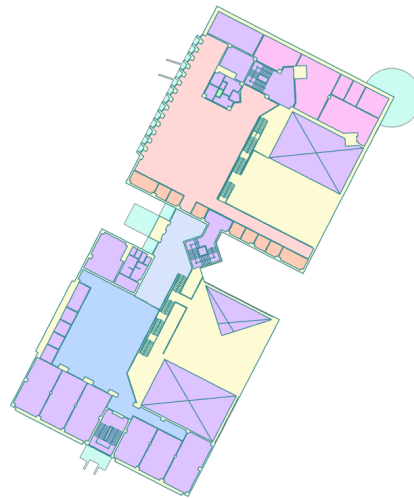
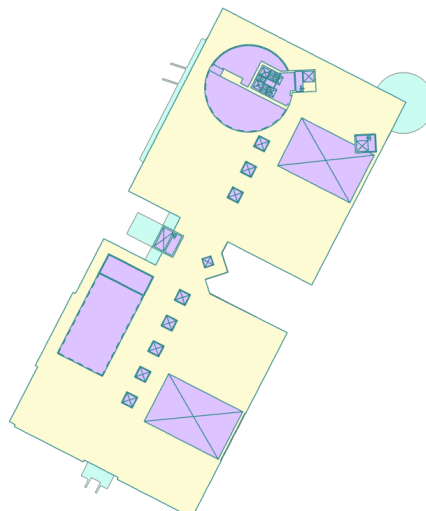


Figure 3.24: Travel path in level 6 of the university library (made with ArcGIS Pro)



On May 27th CityEngine shows me a text box that says 'Workspace locked' as soon as I run the program and without actually opening it. I got in touch with Juan Camilo and on June 25 the problem was reported to ESRI and in September 7th he gave me the license.

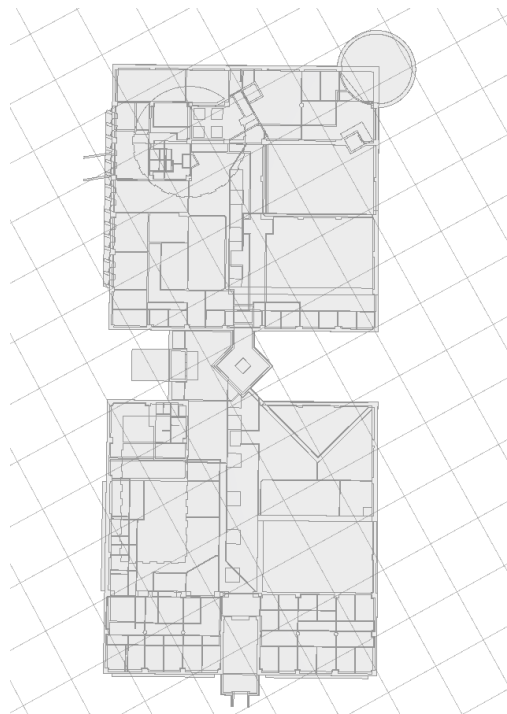
The program still did not work and on the morning of September 9, we began to fix the bug through Google Hangouts. After two hours in a call, we continued with the same problem so we agreed that Juan Camilo would speak with the University.

That same afternoon we managed to connect to the GEOTEC server and I got ready to work.

The first failure it gave me was the incorrect representation of the floorplans. The files were imported but when viewed they were unrecognizable lines as we can see in the images above.

How should they look:

Figure 3.25: How should they look



How they actually look in CityEngine:

Figure 3.26: How they actually look



Since I couldn't import the plans in various formats (shp, dwg, dxf ...) or the ArcGIS Pro geodatabase and I didn't have time to try to fix the error, on September the 10th I proceeded to model the building in Revit.

Working with Revit has been quite simple, it is a tool used in architecture that facilitates the work when constructing buildings. I just had to import the plans in .dwg format and start lifting heights. On September 18, the building was finished.

Figure 3.27: Level S of the university library (made in Revit)

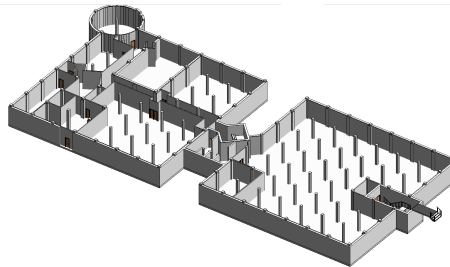


Figure 3.28: Level 0 of the university library (made in Revit)

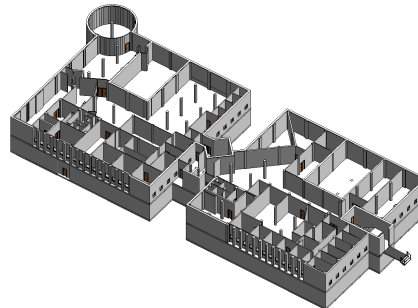


Figure 3.29: Level 1 of the university library (made in Revit)

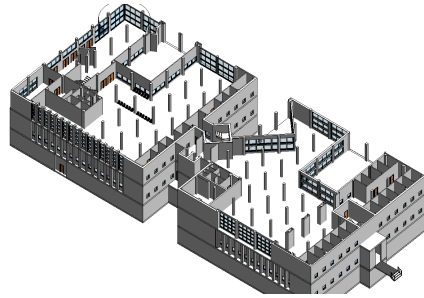


Figure 3.30: Level 2 of the university library (made in Revit)

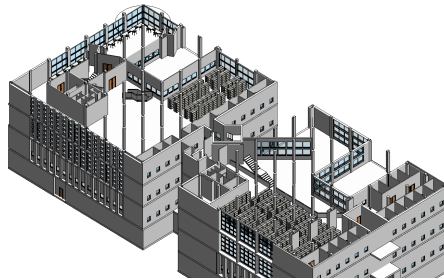


Figure 3.31: Level 3 of the university library (made in Revit)

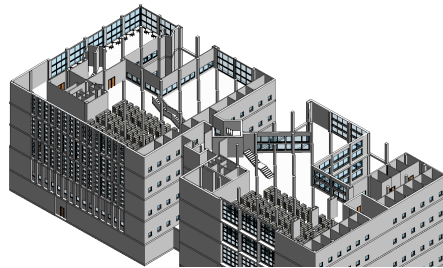


Figure 3.32: Level 5 of the university library (made in Revit)

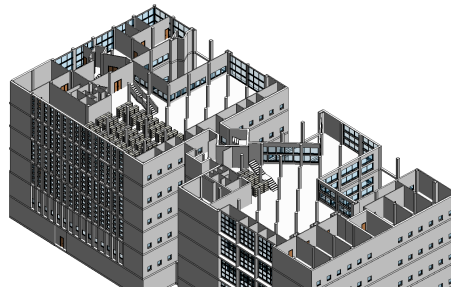
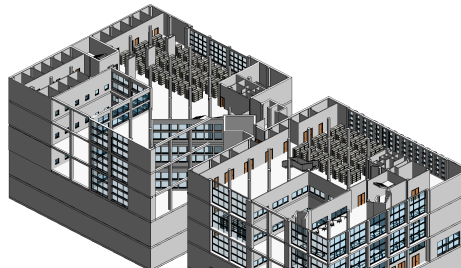


Figure 3.33: Detail of the university library (made in Revit)



3.2 Results

The initial plan was to create the geodatabase, the displacement path, the 3D modeling, and its export to the web and app.

The result of the final work has been to make the plans in AutoCAD from scratch, create the points of interest and the services available in the building, create the geodatabase, the travel path and model the building.

It was not counting on making the plans or having to create the points of interest and the services available in the building, but it has been compensated with the impossibility of exporting it to the web and app.

The technical proposal included, as a bonus, the development of virtual reality travel if time was available but it was not possible either.

Of the four points that were raised in the initial objectives, all have been met except for the last: the correct implementation in the app and the implementation of displacement with augmented reality in Unity3D.

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CONCLUSIONS AND FUTURE WORK

In this chapter, the conclusions of the work, as well as its future extensions are shown.

4.1 Conclusions

In relation to the degree, it's related to the following subjects:

- Databases: Creating a geodatabase that contains all the floorplans information.
- Graphic expression: Modeling the library building.
- 3D Design: Modeling the library building.
- Design and Development of Web Games: Importing the 3D model in the website.

Regarding the work I carried out, it has left me a bittersweet taste.

On the one hand, I have faced quite a few problems that we did not even think about initially, but most of them, and those that were in my hands, have been solved quite satisfactorily and I'm quite proud of me.

But on the other hand, what initially attracted me to the project was its visual result and since I did not see that final result implemented in the web and app, I am left with the feeling of not having finished the project.

Likewise, the delay I have had to cope with when solving the problems that were out of my hand and the stress that I have been subdued to in recent weeks to be able to reach the delivery deadline, make me be unhappy with the project.

4.2 Future work

The work can be finished, and if Joaquín Huerta and the GEOTEC research group want, I would like to be able to develop it in its entirety.

All I have to do is export the data from CityEngine to the web and app. The programming part would not be a problem since it is implemented from previous versions and it would only be to fix errors that the port can give me.

On paper it seems that there is not much work to be done and that it should be easy, but I can't tell for sure by looking at what happened months ago.



OTHER CONSIDERATIONS

This appendix is included to comment some aspects not considered in the rest of the template and as an example of the format of an appendix.

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