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Generative design for Hospital Pharmacy: optimizing spaces/flows with Dynamo/Refinery

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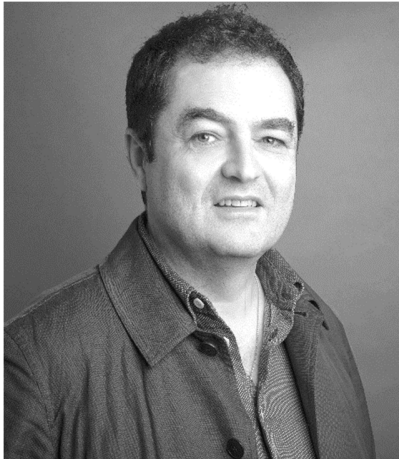
Learning Objectives

- Learn about Pharmacy logistics challenges and pharmacy architectonic rules
- Design algorithms to solve complex logistic problems in a Pharmacy department with Dynamo/Refinery
- Integrate algorithms and coding into architecture and engineer workflows
- Learn a new way to leverage data for better informed decisions

Description

The evolution of BIM tools and processes combining Generative Design and Automation offers new possibilities to the architects and engineers working on complex buildings and its vital interiors, in this case a hospital and its pharmacy. AP-HP Group, representing 39 hospitals in Paris, collaborates with ENGIE AXIMA BIM Factory to re-design the pharmacy and the flows inside it. In this class you will see how we have utilized Dynamo, Refinery and coding. We will demonstrate how algorithms allow us to carry out parametric studies on the «generative space plan» and optimize «automatic generation of a 3D BIM model». We will show how we have used macro and micro generation to evaluate the different options for flow optimization of people and goods present in the pharmacy and how to make qualitative and logistic analysis. The result is a better architectural configuration of the Hospital pharmacy and an improved working environment.

About the Speaker



French architect and engineer, Dominique is currently a project manager for Engie Axima, working on specific BIM services for hospitals and other innovative projects such as indoor air quality simulation. After his engineer graduation from Ecole Centrale de Lyon in 1987, he started his career in Budapest (Hungary) in the manufacturing industry for Schlumberger Industries and became Country manager. Until 1997, he developed businesses in eastern Europe and achieved several technology transfers between western and eastern Europe. Back to France, he worked as a sales representative for Compuware, then followed design courses at Ecole Boule and Ecole d'Architecture Paris Val de Seine where he graduated as an architect in 2007. After working for different Parisian Architecture agencies (Architecture Studio, ADPI, Paul Andreu) he specialized in BIM. He joined the ENGIE group to develop BIM technology. Dominique has a pilot license, speaks Hungarian and is an accomplished skier.

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How it started ...

In spring 2018, ENGIE Axima won a public call for expression of interest for the future digital hospital. The winner concept of “FLEXIBIM” was introduced as a BIM based solution in the hospital environment:

- To create and visualize modular space and organization configurations for new construction or rehabilitation works, taking into account staff functional needs as well as patient wellness
- To evaluate those proposed solutions on every point including technical impacts on air quality, consumption, lighting, ...
- To involve staff and patients into the decision-making process through VR solutions
- To conduct pre-feasibility studies

Making it happen

As the FLEXIBIM concept reached a general ovation, ENGIE Axima initiated a partnership procedure with the biggest hospital organization in France, the Public Assistance of Paris Hospitals (referred as APHP in the following) that is also an important international influencer in the hospital environment. APHP represents 39 hospitals receiving 10 million patients per year.

A collaborative contract

It was essential to involve our partner in the process both financially (30% share) and technically in order to guarantee the success of the operation. So, we conducted a negotiation for 6 months to produce a contract around a common Proof Of Concept. It was established that each party will provide a team of people to work on the project in a strict 5-month planning that was paced by steering committees, technical committees and user group meetings.

Also, as an incentive, it was agreed to include a percentage commission for APHP for further leads that would materialize concrete FLEXIBIM operations.

Chosen site

APHP wanted to take a real case that would be subject to works on a short term, so the inner Pharmacy of the St Louis Hospital was retained: 1300 m² to reorganize and optimize with a material/people flow constraint.

In the following pictures, one can notice the gap between the existing stock management and the automated delivery service which made it obvious there were possibilities for optimization. The fact was that Pharmacy staff was totally qualified as regards medical procedures and not educated about logistics, but still delivering medicines and materials to the different services within an uncomfortable working place.



ARCHAIC STOCK MANAGEMENT IN THE PHARMACY

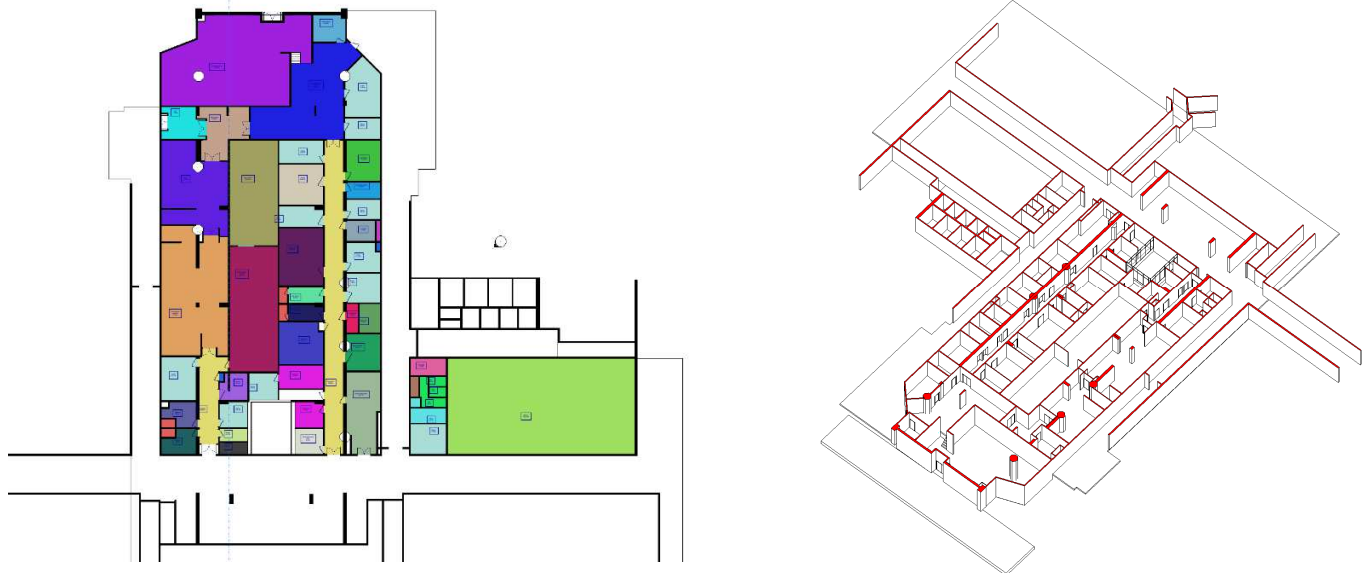


AUTOMATED DELIVERY OF PREPARED CONTAINER TO HOSPITAL SERVICES

Data acquisition

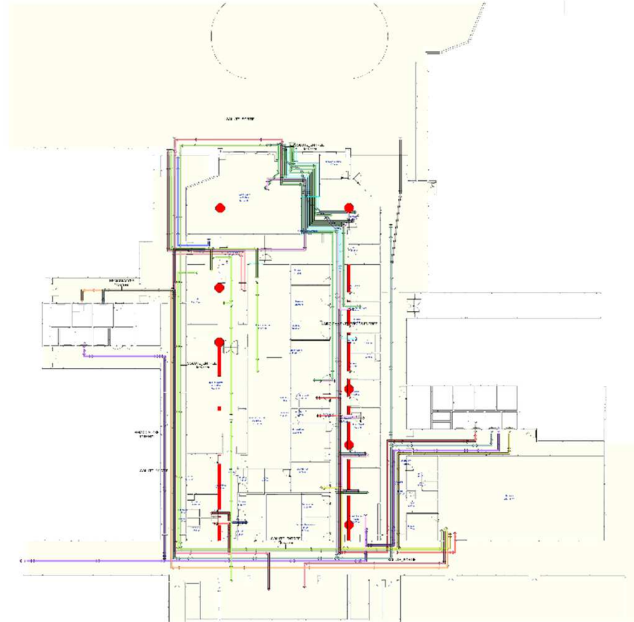
To start with, we gathered information to build a BIM model of the existing situation and we conducted user group workshops to acquire the following data:

- Existing plans
- List of rooms
- List of furniture
- A proposal made by an architect in order to have the architectural program (no other sources available) and room adjacency matrix
- Pictures and explanations about the Pharmacy
- List of flows (horizontal and vertical) for people and materials/medicines



EXISTING BUILDING BIM MODEL

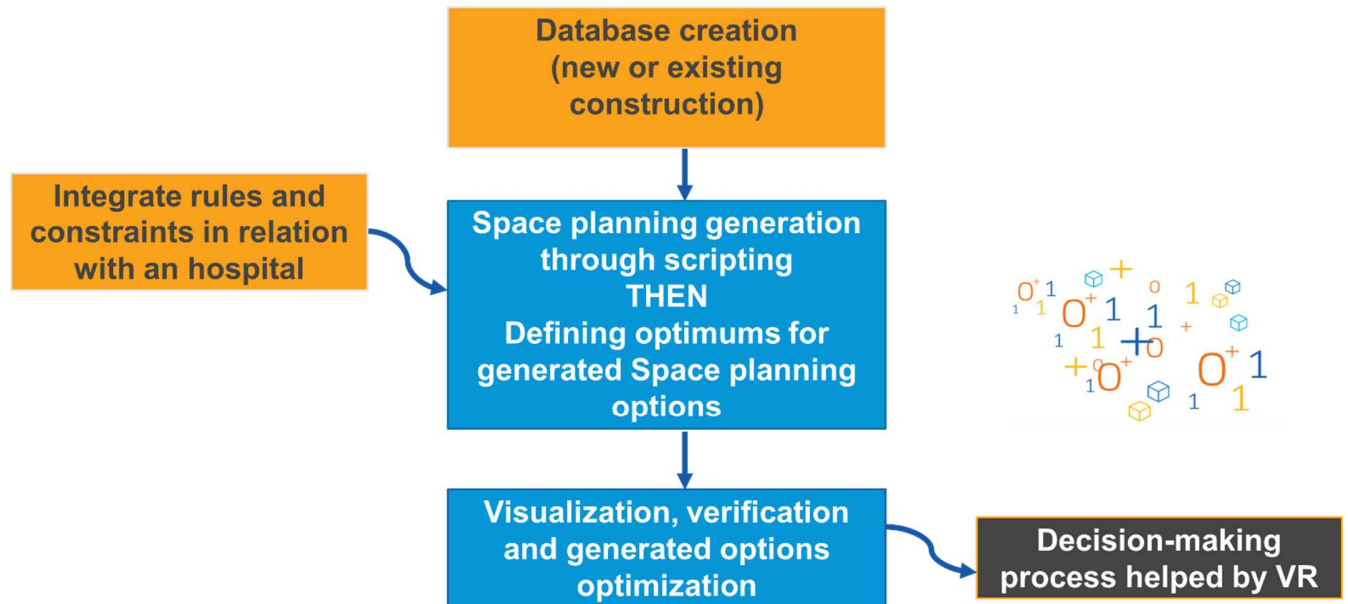
Many data were unnecessary for our studies (such as for example procedures for sterilization) and technical plans were in general outdated, so we had to focus on limiting the constraints to flows, volume of stocks or logistical aspects in order to obtain a great number of options. On the pre-conception point of view, there was a strong advantage of working together to analyze a process with people knowing their jobs. Indeed, the simple fact to be able to visualize the existing situation lead the pharmacy staff to conduct a natural optimization and to instantly correct wrong unconscious practices.



COMPLEX EXISTING PHARMACY FLOW ANALYSIS

Imagining a space planning process

The generative process was initiated according to this figure below.



GENERATIVE PROCESS

Rules and constraints

The rules we decided to retain were oriented by the hospital needs:

- Minimize stock space (volume could convert to area with fixed height) and maximize workplace
- Reduce flow paths
- Optimize natural light in workplace

Since we could not address together the space planning exercise with the flow requirement, we decided to check flows on generated optimized space solutions in a second time.

Data creation

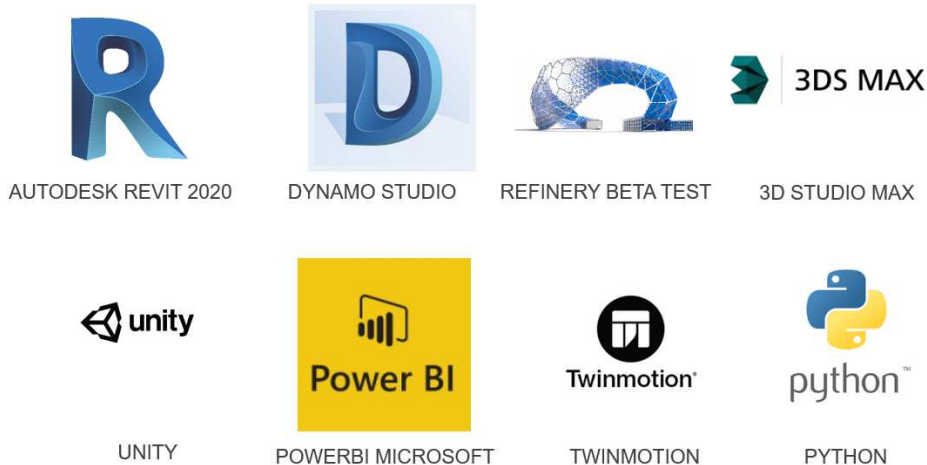
The team created:

- A room Excel matrix by department
- A .sat file of the overall area to charge into Dynamo

To simplify the script, we chose to deal with the adjacency factor using departments that would include their services.

Tools

Hereafter is the tool palette we have been using during the project.



Space planning script

In order to achieve a complete space planning technique, we split our problem in two different scales:

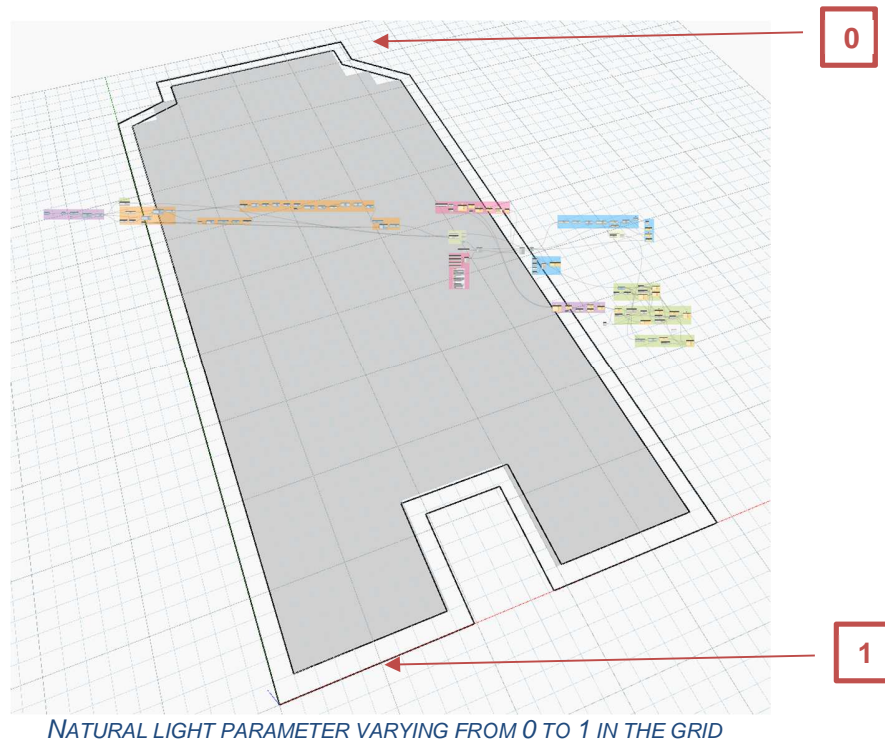
Macro zoning (Dynamo+Refinery)

It consisted of preparing a department Excel matrix from which the script would create a subdivision of the total area in macro zones that corresponded each to one department. Tolerance area parameters were included into the script.

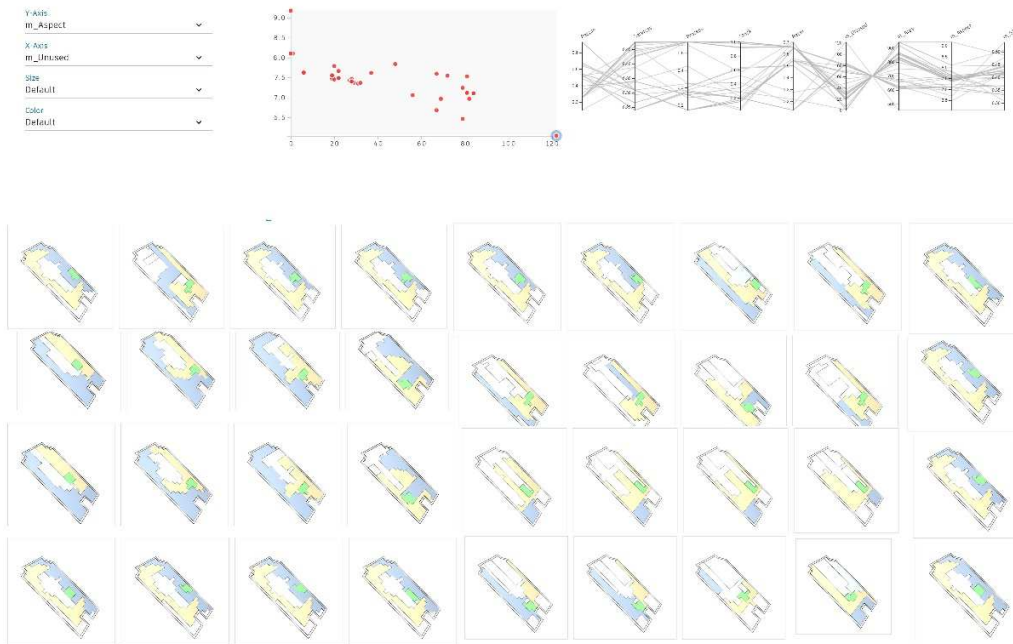
The pharmacy was divided in 5 departments:

- Offices
- Services (toilets,)
- Clinical research
- Stock
- Delivery/transformation zone

To represent the natural light constraint, the script contained a parameter which value varied from 0 to 1; due to the natural light source configuration (natural light was located at the ends of the “bottle” shape of the area), good natural light could be obtained if the parameter was close to 0 or 1.



Also, the script developed with the aid of Autodesk Consulting, introduced the notion of “seed” that represents the physical beginning of the generative design calculation. Once the script was ready, we connected it to Refinery to generate optimized solutions in correspondence with the set priorities.



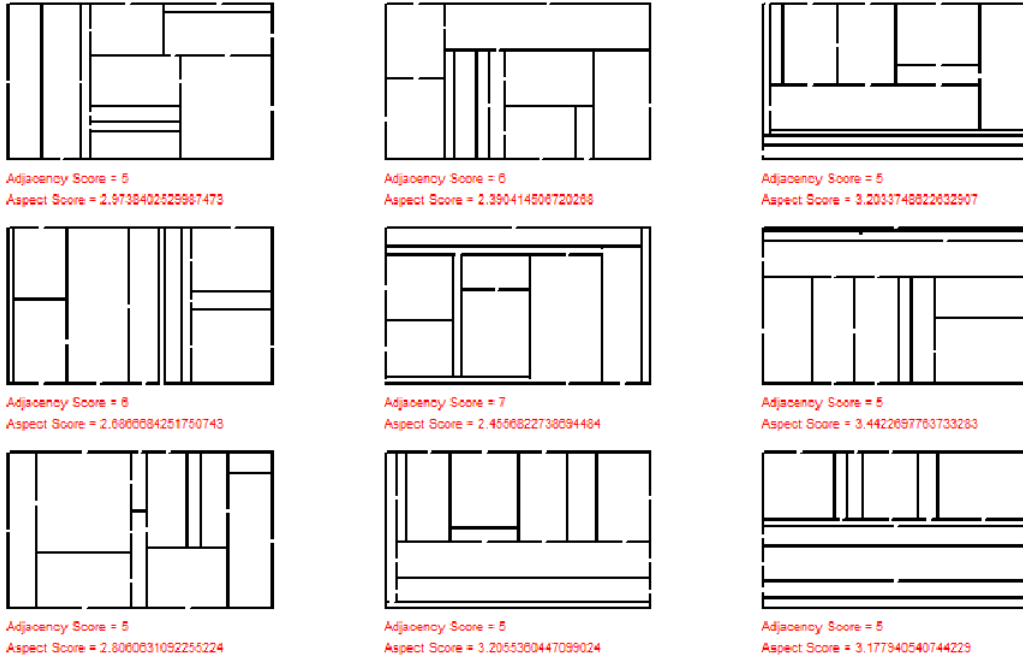
Subdivided area.

Micro zoning (Dynamo+Refinery+Python)

Once that the macrozones were configured, we built two experimental approaches to subdivide them.

Script 1

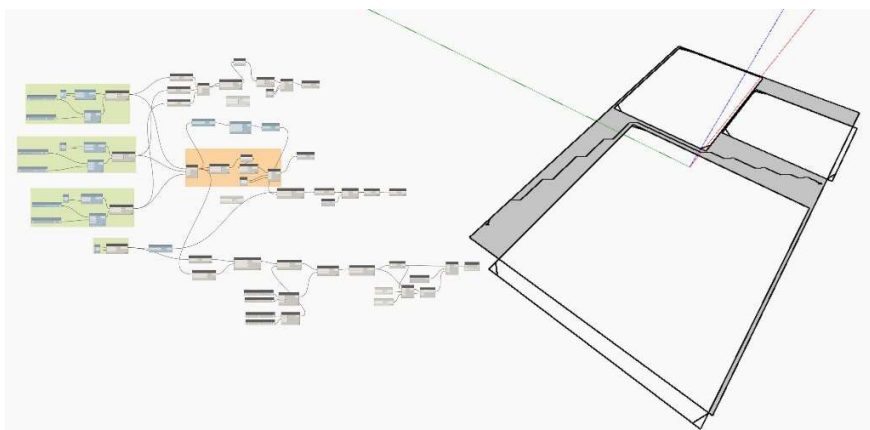
From the Excel/JSON room matrix of a department that includes adjacency parameter the script would further subdivide one macrozone into microzones or rooms.



EXPERIMENTAL SUBDIVISION OF MICROZONES

Script 2

From the Excel/JSON room matrix of a department that includes adjacency parameter the script would further place microzones or rooms with Dynamo and optimize the path between two points in a department figuring an inner circulation path.



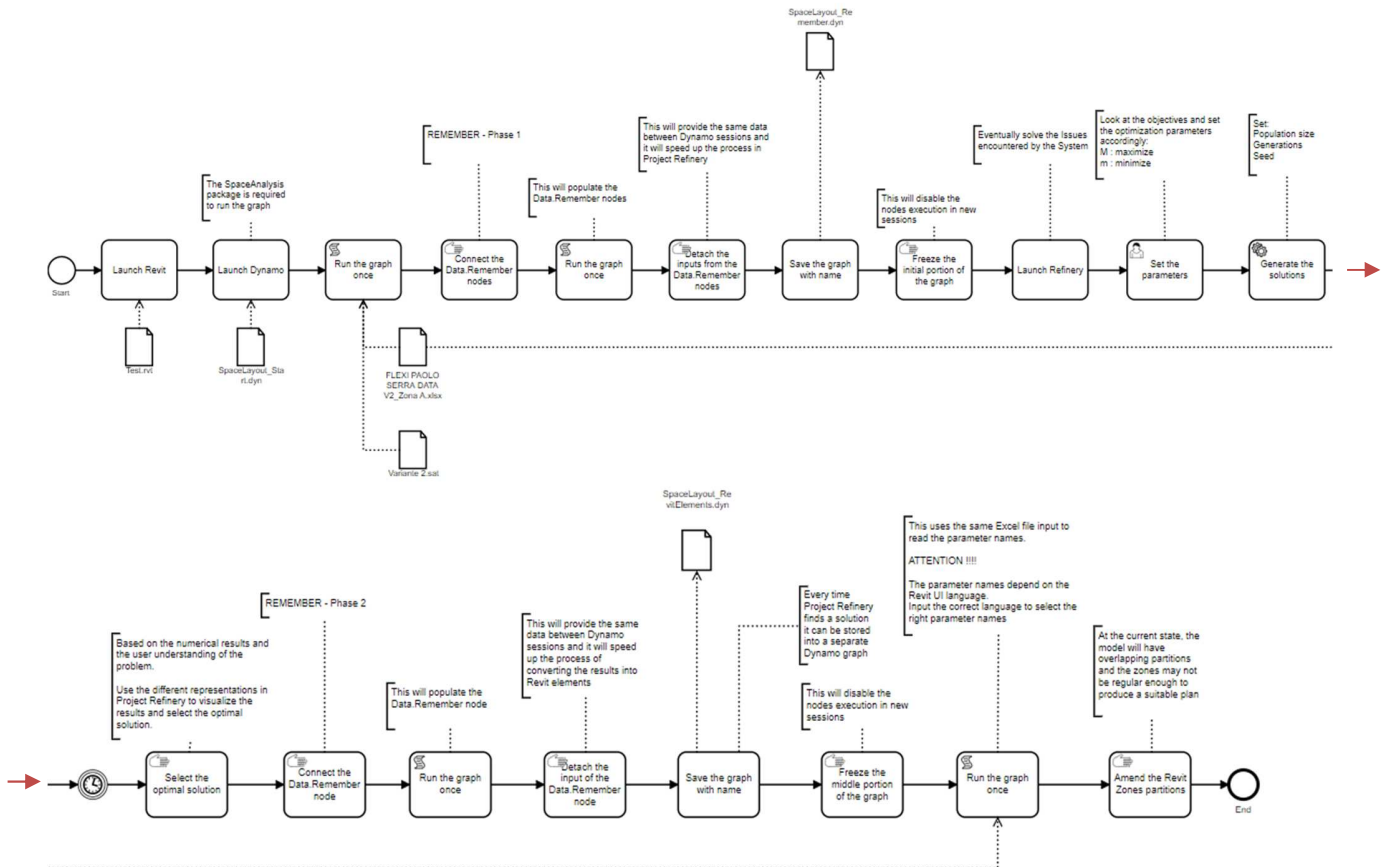
EXPERIMENTAL SPACE PLANNING OF MICROZONES

During the short time of the P.O.C., we were unable to finalize either experimental scripts, but it did not stop the process, macrozones were sufficient for our case.

Architecture automation through coding

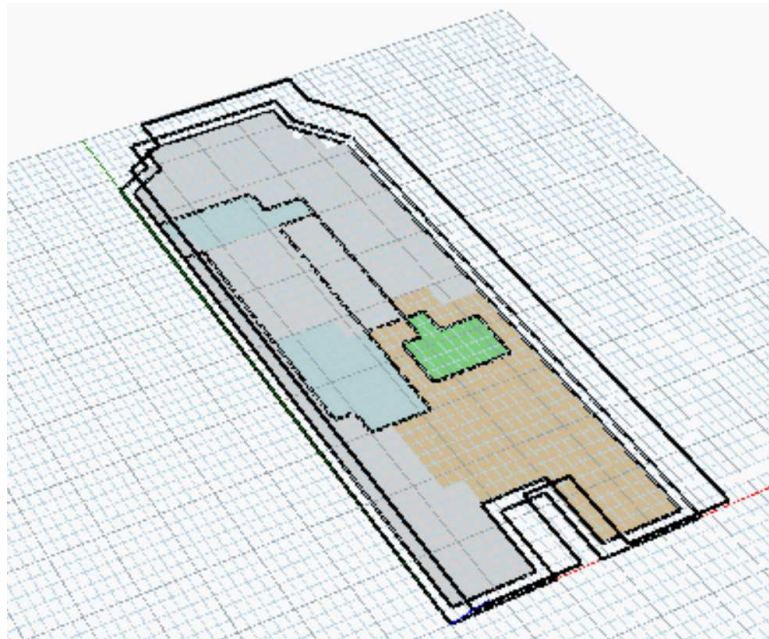
Scripting

Our script followed several steps shown hereafter.



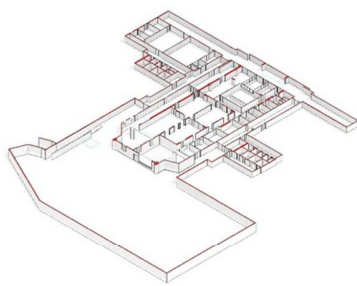
Wall creation automation

Once Refinery has done its operations, we could go through the results manually and generate automatically with Dynamo the walls of a selected solution in Revit as a base to an architectural project.

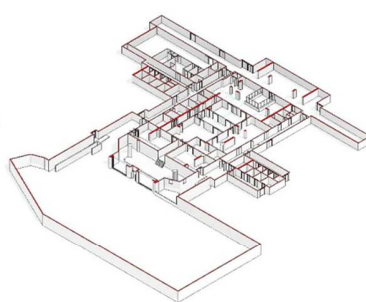


ONE RESULT BROUGHT BACK TO DYNAMO PRIOR TO WALL GENERATION

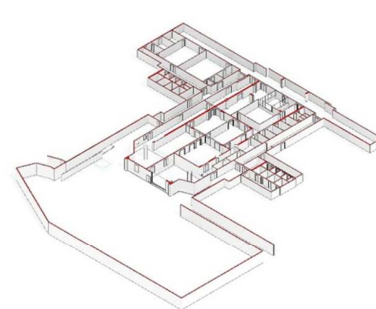
Amongst the 150 generated options, we selected three to be developed. For each, wall generation was accomplished in 10 seconds with Dynamo.



Model generation:10s



Model generation:10s



Model generation:10s



3 OPTIONS TO DEVELOP

Developing the generated versions

From the created bases, we finalized the microzoning manually and according to the known constraints. At that point, one must admit it was not the best case to start practicing generative design as the site was overconstrained.

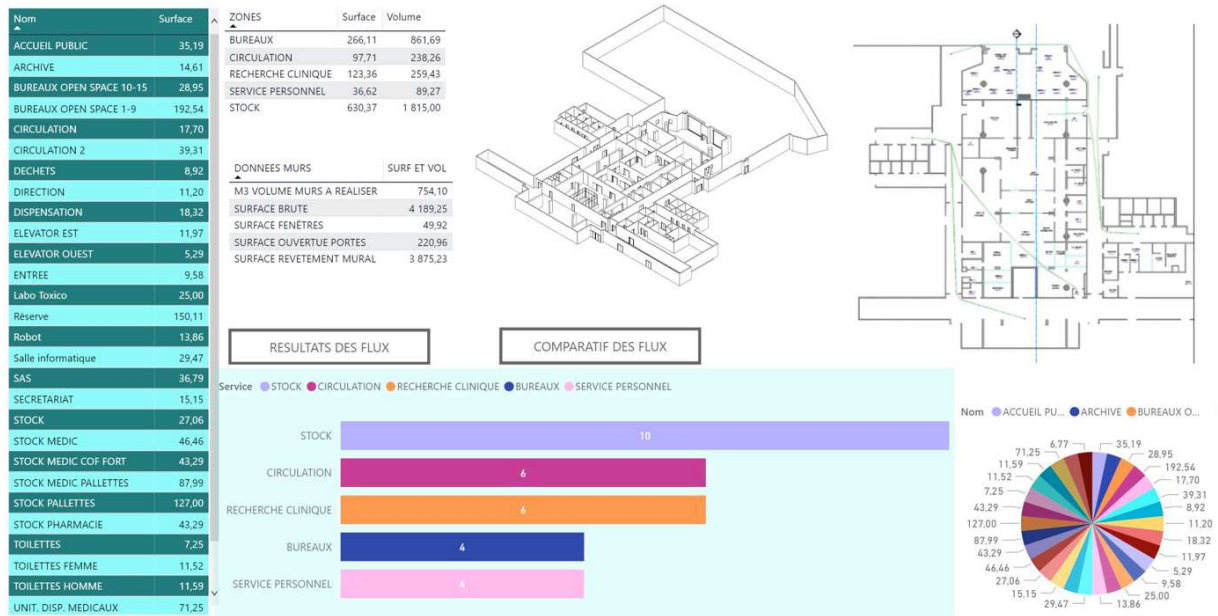


PRESENTATION OF 3 DEVELOPED VERSIONS

Analyzing the solutions

Once the generative process had produced three acceptable solutions, we had to present the results to the user group for validation and we prepared comparisons using Power BI and extractions from Revit showing:

- Working place area gains
- Stock spaces
- Walking length and new goods paths
- Natural light results
- Room areas compared to program



POWER BI ANALYSIS PER VERSION

The user group and the Technical Committee chose unanimously to further develop version 2.

Refining the solution with VR and layout tool

To refine the decision-making process of APHP, we imported the model into different platforms.

Twinmotion

With Twinmotion, we could texture the model and populate it with people and furniture. The user group had the opportunity to feel and test its new working place in VR.



TEXTURING AND VR IN TWINMOTION

Realiz3D

Through another partner, Realiz3D, we developed a web-based platform to make the model available to the user group so that they would be able to play with different space solutions themselves, modifying the layout or adding equipments/furniture.



PLAYING WITH THE MODEL AND VALIDATING SOLUTIONS

Conclusions

Despite the difficulties of the chosen site and of the implementation of generative design, APHP was satisfied with the result of the P.O.C. and expressed new directions:

- The possibility to include to the generative design process a cost estimation of the works/energy consumption per solution in order to further refine the decision-making process
- The feasibility to make a tool that could assess different architectural proposals for instance in a public competition as APHP is today limited to pleasant graphical materials that do not use all the possibilities of a model.

As this first step was promising but not replicable for commercial purposes, we intend to pursue this research involving Operational Research, Artificial Intelligence and Machine Learning. However, this process showcases that new ways of collaborating in the building industry exist in achieving common pre-conception between architects and professionals.

APHP confirmed its willingness to implement the solution on other buildings in a short term.

Resources

Videos

1. <https://www.youtube.com/watch?v=CtYRfMzmWFU>
2. <https://www.youtube.com/watch?v=E2SxqUvtplk>
3. <https://www.youtube.com/watch?v=a6bDLMWIS98>
4. <https://www.youtube.com/watch?v=ZANPF81tPHw>
5. <https://www.youtube.com/watch?v=x6n7YZyk7Mc>
6. https://www.youtube.com/watch?v=a_o-rYb8wyo

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