

MASTER

Transport hub 2030

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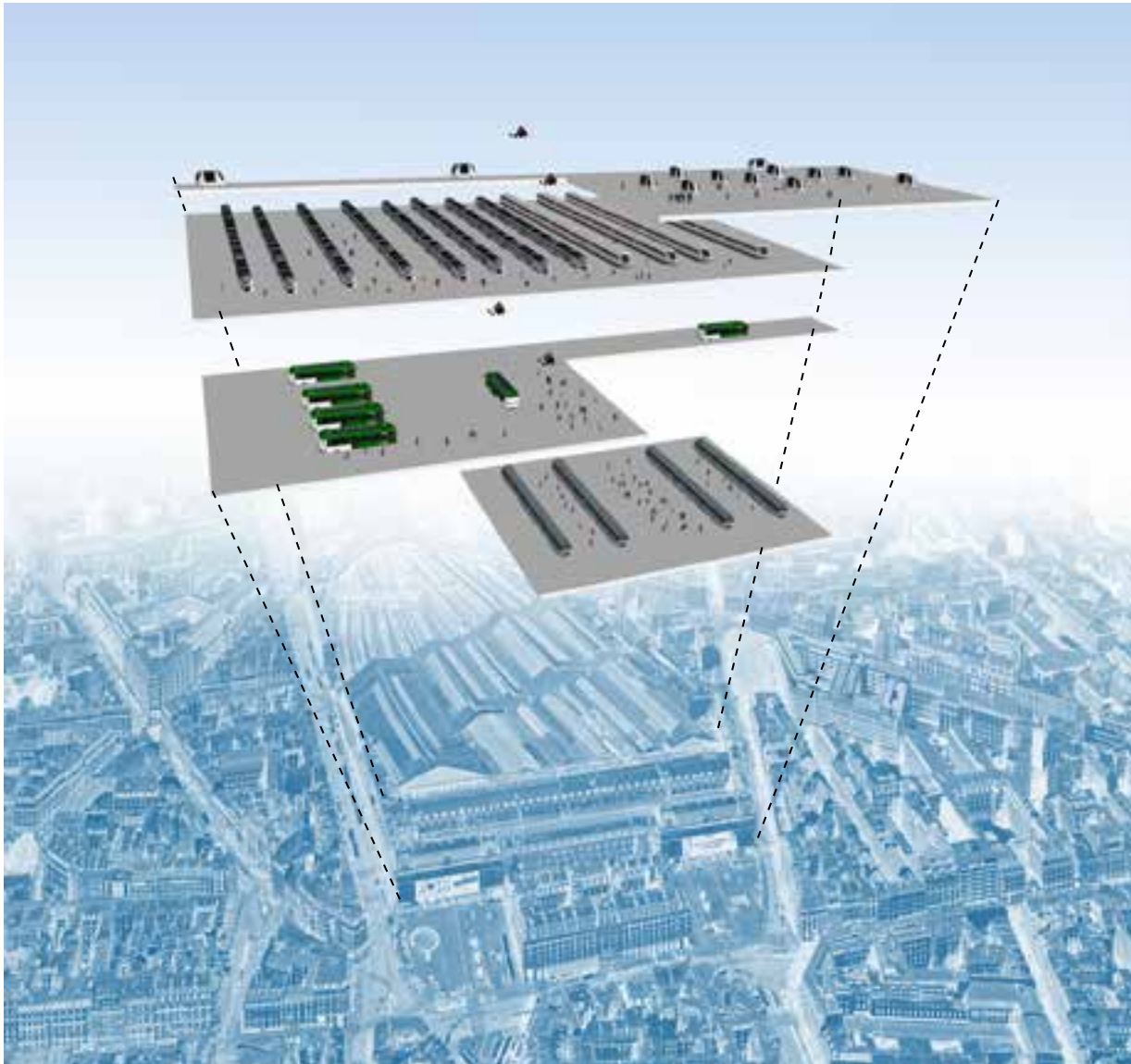
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TRANSPORT HUB 2030

GRADUATION STUDIO - BUILDING FOR THE MASSES

LIEN DE KLEIN

TRANSPORT HUB 2030

GRADUATION STUDIO - BUILDING FOR THE MASSES

LIEN DE KLEIN

ABSTRACT

Coming decades public transport all over the world will face great challenges. Not only passenger number and travel intensity will grow, also new types of transport that are developed have to be integrated in the existing infrastructure. This will affect railway stations, as a built environment, but also traffic flows inside it. In this research current properties and processes of railway stations are analysed and as a case study Saint Lazare station in Paris is redesigned to meet the requirements that are projected for the year 2030. The main goal is to develop a future-proof transport hub with all kinds of innovations in public transport techniques, passengers information systems and use of public space. At the same time aesthetics and building innovations are crucial in the design.

From the research, on site and from literature, it was clear that the location needs to host all kinds of public transport under one common roof. The current platforms are scattered around the area of the station and must to be relocated to increase overall logistics and efficiency. The shopping mall is now literally in the way. Off course shops, restaurants, etc. are vital but can be more integrated. As Saint Lazare is situated in a business region flexible offices and conference facilities will have a added value to building, which is also true for open green space that is now lacking.

The choice for the redesign was directed by the complexity of the functions (interior), so the exterior of the building followed. The current building has two characteristic fronts that are preserved. The new monumental roof connects the restructured inner space with the authentic elements, and being steel and glass this will create a nice contrast. All kinds of innovative techniques (e.g. passengers information app) will facilitate efficient connections and moving of people. The result is a beautiful future-proof and flexible building, for transport but also for business and a pleasant stay.

TITLE | Transport hub 2030

GRADUATION STUDIO | Building for the masses

DATE | November 6th, 2019

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INTRODUCTION

As far back as I can remember, I've wanted to see and discover new places. So when I turned 18, I decided to take my new sense of freedom and explore Europe. With a friend, I travelled from country to country by train. While my friend was mostly interested in the trains, I found myself intrigued by the stations and impressed by the enormous station halls. In his book *Wereldstations*, Jo Coenen describes stations as 'cathedrals of the 21st century'.¹ This quote perfectly describes my impressions.

I also was intrigued by the number of people moving through the space and their different paces. Some were running to catch a train, and others were standing around, seemingly with all the time in the world.

So when going into the graduation studio 'building for the masses', I had to think about the masses of people in train stations. This is how I came to the idea of designing a station. I think buildings need to be sustainable. I don't mean that it has to be energy neutral, but that it is functional for the long-term. I am also fascinated by new types of transport, like the

hyperloop, whose impact on buildings and traveling methods can be enormous.

New types of transport are now especially relevant because of the climate goals countries need to meet. The transport sector consumes enormous amounts of energy and has a lot of new developments that have not been implemented. In my design, I want to incorporate the current forms of transport with the new forms of transport currently in development. I want to design a station for the future. I chose the year 2030, because by that time new transport types can be introduced and most of the current types of transport will still function. To that end, this research determines what types of transport will be incorporated in the project and where the project will be located.

“
In 2030 because there's going to be a need for more direct and more dynamic types of travel because of the sustainability goals. There's going to be a development in transport, but still the types of transport that currently work like trains and metro which already have a good infrastructure, are not going to be obsolete by 2030.
”

VISION

“Cities want to have less cars but more transport. Transport needs to be smarter and quicker and the current stations can't cope with this problem.”

Current stations are not sufficient to deal with the needs of the future. There is a need for a diffuse system that fits every type of passenger. Personal transport will decrease, which will increase the need for public transport. The stations of the future need to adapt to this. A station of the future will be a hub, because it will house multiple types of transport.

'A man is having breakfast at his home in a suburb just outside of Paris. He checks his agenda and sees that he has a meeting at 10 in one of the meeting places at the Saint Lazare station. He uploads his agenda to his travel app which gives him his travel plan. He lives a short walk from the regional train station so he walks to the station. His app tells him to enter in the back of the train because there is the most space. When he enters the train he scans his phone. During his short train ride he checks the minutes from the last meeting as a final preparation for the meeting he is about to have. When he exits the train the travel app tells him that the meeting is in room 6 and shows him the route through the building. After the meeting he has lunch at the food court. When it is time to go to the office his travel app tells him to get to the personal rapid transit and that his pod will depart from platform 11. He scans his phone again to enter the vehicle. In the pod he sees a colleague of his and they chat for the duration of the trip. The pod stops at the platform in front of the office. The man gets out and walks to his office where he continues his day.'

READERS GUIDE

This book describes the project through 3 phases.

The first phase is obtaining knowledge, which includes answering the research question and defining, visiting, and analysing a location for a station.

The second phase is processing the knowledge. The knowledge obtained in the first phase was used to reach conclusions of what is relevant for the project. These conclusions will form the basis of the second part of the phase: the program. The program will state what functions the station will have and how they are related to each other. This part will also state the goals of the project.

The last phase is the interpretation of the knowledge. This phase will show how the knowledge is used to create a design. The design is explained through images and drawings. This phase will end with a discussion of the design and the design process.

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RESEARCH

RESEARCH

This research determines how to design a transport hub that could be in use in 2030. The primary users of a transport hub are travellers. The goal is to make the trips of all types of future travellers as pleasant as possible. The main research question is:

‘What design of a transport hub for 2030 deals with the complexity of diverse types of transport and different kinds of users?’

There are several areas that go into creating a pleasant travel experience.

The first is the **future prediction**. What public transport types are in development that could be added to the current public transport system or even replace it? These future transport types need to be functional for the masses by 2030. This requires a timeline of the development of the future transport types.

The second is the **organisation** in the transport hub. the components of a transport hub and how they are related to each other must be determined. Examples of existing transport hubs will give an indication of how the organisation could work.

The third is **‘the back of the house’**. This is defined as all the spaces in the station that make it function that the traveller doesn’t see. What spaces form the back of the house and how they relate to the ‘front of the house’ was determined by visiting existing train stations.

The fourth is the **users** of the station. The types of users and how they behave in a station was defined based on the locations. The number of people was determined to find out where the crowds form in the building.

Examining these areas will help answer to the research question and determine what is needed to design a transport hub with current and future transport types that can handle a large number of people.

ORGANISATION

To create a functioning transport hub, the organisation of all components of the hub needs to be clear. The identification of the components and their relation to each other is described in the document 'Het Stationsconcept', written by the Spoor-Bouwmeester Bureau.² The Spoor-bouwmeester Bureau is a Dutch committee commissioned by the Dutch rail companies Prorail and NS. This document is a starting point for the design or re-design of a station. This document contains three relevant topics: users, experience and station domains.

USERS OF A STATION

'Het Stationsconcept' defines different user groups in a station. The most important user group is the passengers, who are split into two categories: departure and arrival. The second group is people who drop off and pick up passengers. The third group is passers-by, who visit the station or use it as a transit. The last group is the station and facilities staff.

EXPERIENCE OF THE STATION

The station concept defines different stages in passengers' experiences. The first is 'discover upon departure', which describes the need to discover the possibilities that the station offers. A clear presentation of information is important in this experience. The second experience is 'inspire on the journey'. Here the passengers leave the known environment and get on the train to their destination. The experience describes the anticipation of the journey of the passengers. The third experience is 'welcome on arrival', which describes the transition from the journey to the surroundings. The passengers are welcomed by the station. The last experience is 'invite to the surrounding', which involves describing the station as a porch to a city.

DOMAINS OF A STATION

Several domains are given in the station concept, but not all are present in every station. These domains describe different parts of the station that have different functions and house different facilities.

There are four domains and one zone: **the surroundings, reception, travel, and stay domains and the walk connection zone.**

The surroundings domain is the area around the station that connects the station to different types of travel, like buses and trams, parking for cars and bicycles, a taxi area and drop off and pick up areas. It focusses on pedestrians and has a local identity.

The reception domain is the entry of the station. This domain has a public character. It is the place where people can meet, for example, a station hall. This domain provides the passenger with information and houses the ticket sales, service desk and assistance.

The travel domain is incorporated with the train network. The goal of this domain is to efficiently move people on and off a train. It also houses short waiting areas and retail stores. The public nature of this domain is limited compared to the others.

The stay domain is the area where passengers can wait and be entertained. This domain is usually only present in bigger stations and terminals. It is preferably a separate area that is not crossed by the walk connection zone. It houses stores and food and beverage services and can house events.

The walk connection zone is the area that connects the domains. The zone ensures a rapid flow between the station entry and the platforms. This zone is the most generic part of the station because it needs to be recognisable and clear. It can also function as a connection between city districts.

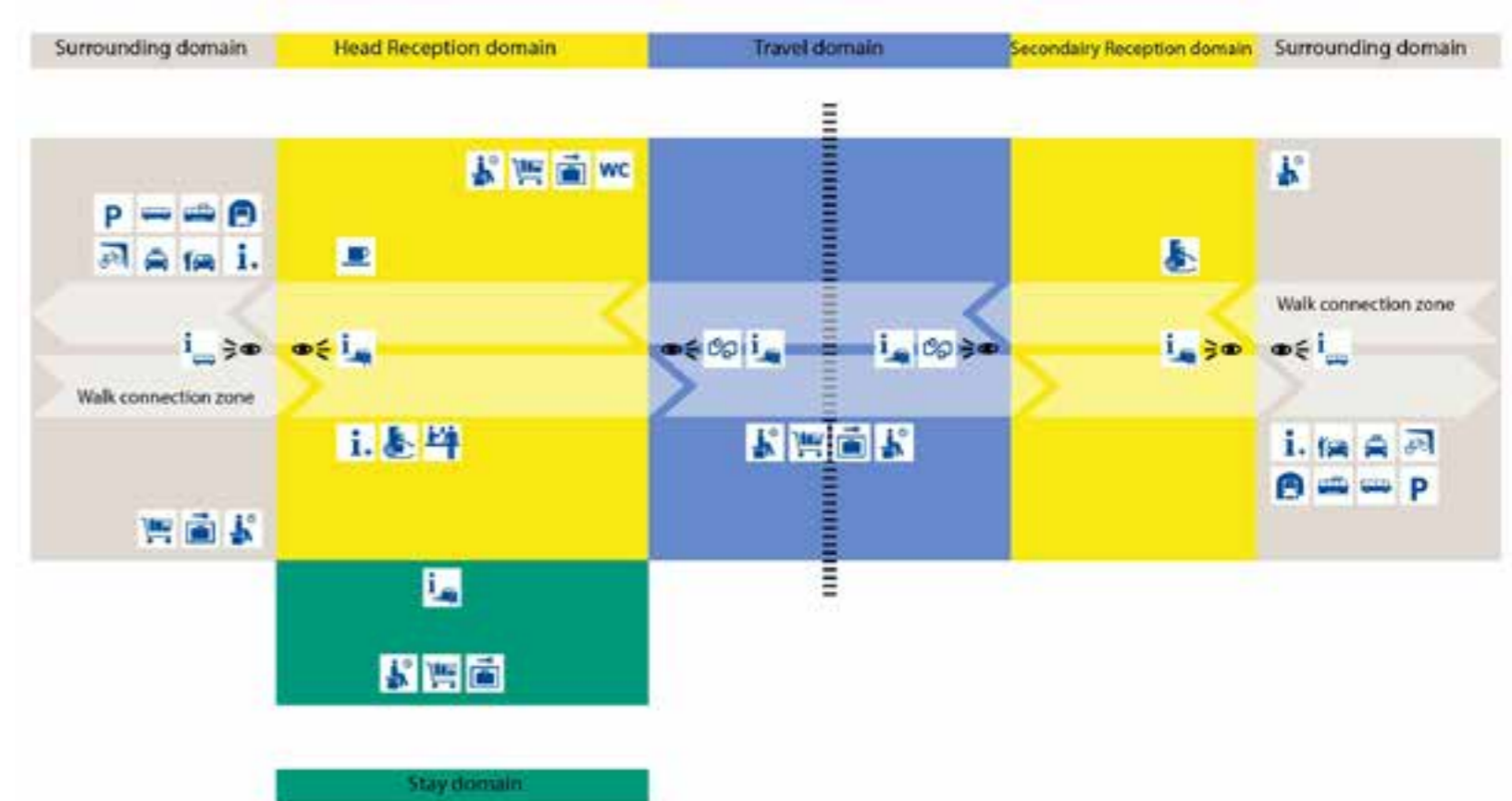


Image 1: Scheme of the domains for the stationconcept²

DOMAINS WITHIN STATIONS

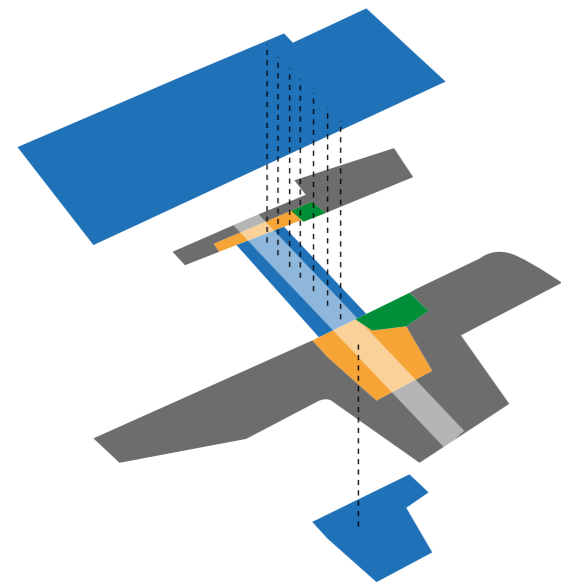
The domains named in the station concept seem clearly separated and recognizable. But is this the case for most stations? To understand how the domains are organised within a building and whether they are separated, five stations were analysed.

Travel is the largest domain in every station, followed by reception. This was to be expected. The domains are clearly defined in almost all the stations. The exception is Gare du Nord, where the reception domain is hard to distinguish from the stay domain.

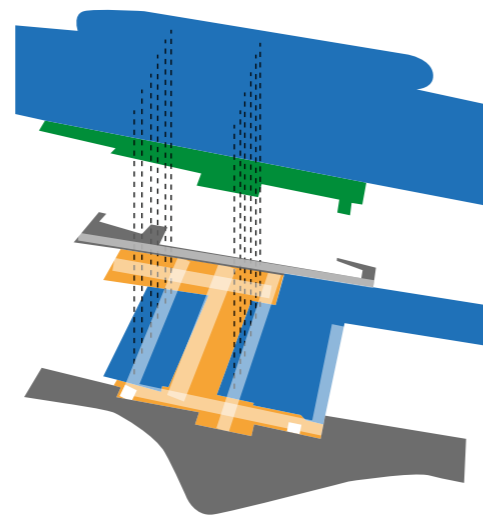
Not all domains exist in every station. In particular, the stay domain is not always present and is not always clearly defined. This could be because the stay domain is not part of every passenger's experience.

The domains function differently in different types of stations. Stations built along a train track, like Rotterdam and Amsterdam Central, begin and end with a reception domain. These stations also function as a connection in the city. This means that there is a different kind of movement. They quickly move through the station without using it. Antwerp Central station is interesting because some trains end at the station, but there are also train tracks that run underneath the station.

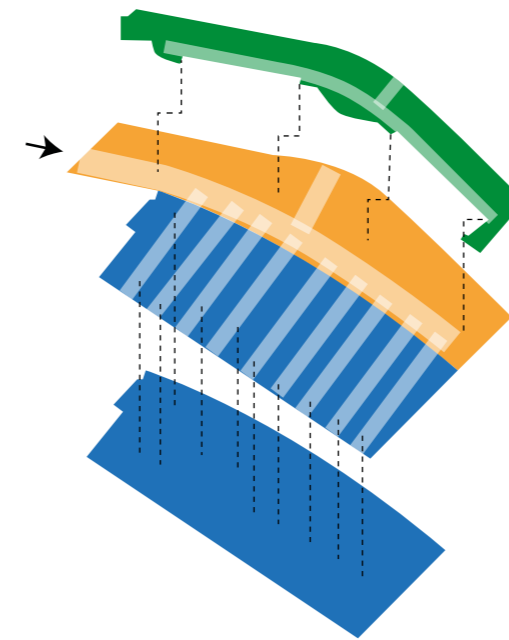
Rotterdam Central Station



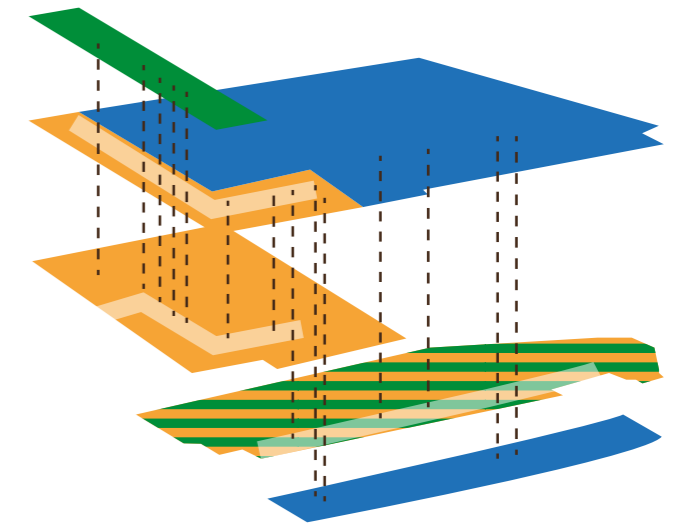
Amsterdam Central Station



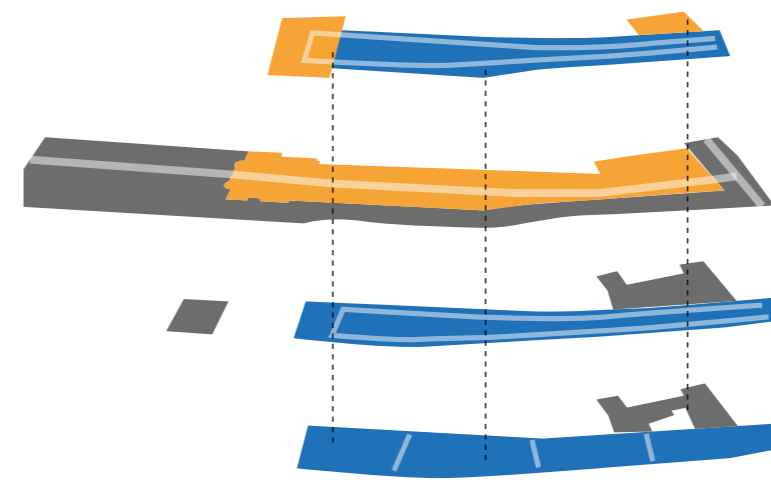
Waterloo station



Gare du Nord



Antwerp Central Station



- Surrounding Domain
- Reception Domain
- Travel Domain
- Stay Domain

Image 2: Domain analysis

TRANSPORT HUBS

Making a station with one type of transport is complicated, and combining multiple types of transport in one building is even more so. To understand how to combine multiple types of transport and how travellers move through the transport types, a range of transport hubs and stations that house multiple types of transport are reviewed. These hubs come in various types: the umbrella, multiple buildings, one building and combinations of these types.

UMBRELLA

In the umbrella type all the transport types are combined under one roof. Under this umbrella there can be several small buildings.

BELFAST TRANSPORT HUB



ANAHEIM TRANSPORT HUB



MULTIPLE BUILDINGS

The multiple building type works as it's called. Each building houses a transport type and is connected to the others.

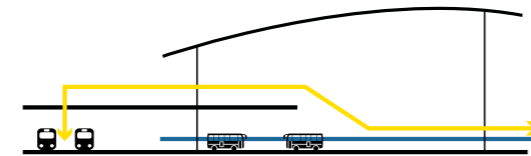
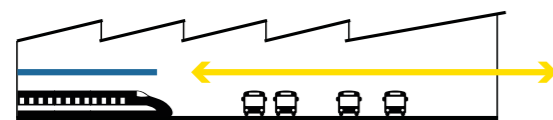
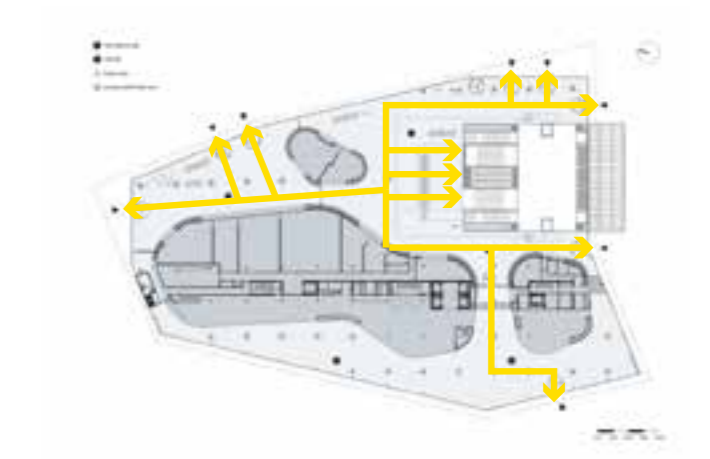
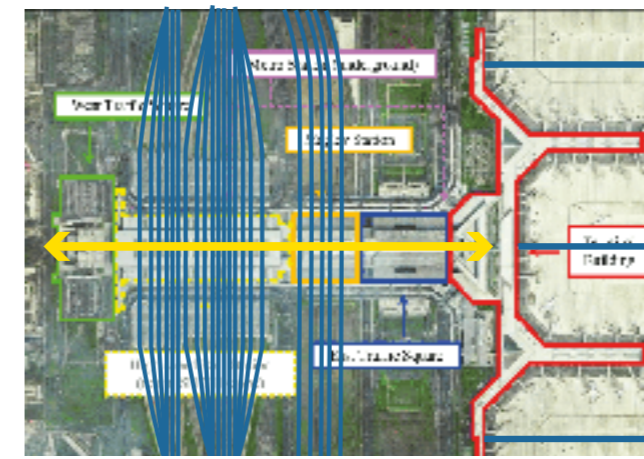
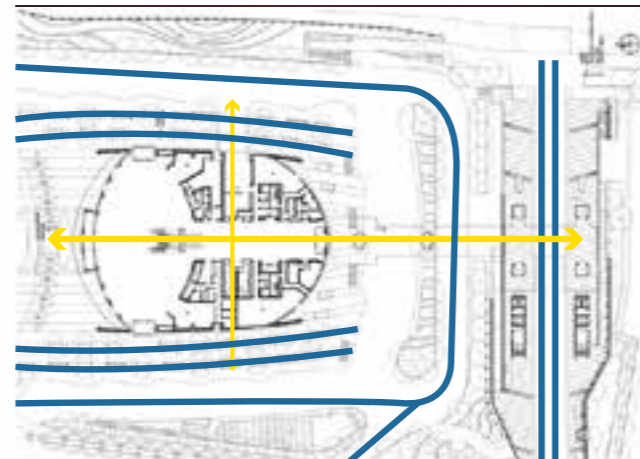
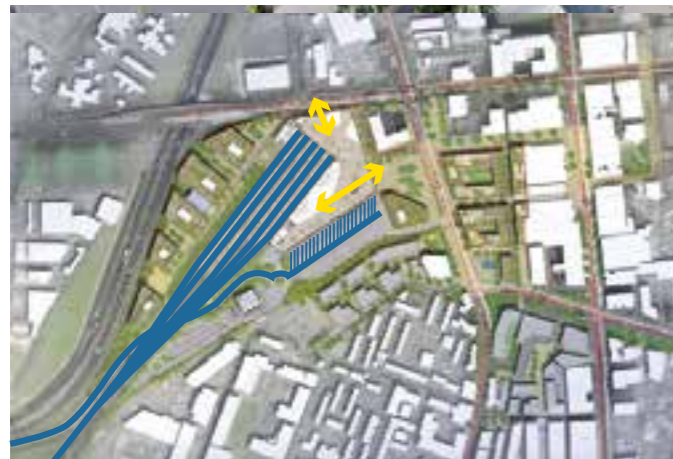
HONGQIAO TRANSPORTATION HUB



ONE BUILDING

In the one building type all the types of transport are combined in one building.

DELFT STATION



— Circulation of travelers in the station
— Direction of the transport types



Image 3: Analysis Belfast transport hub

Image 4: Analysis Anaheim transport hub

Image 5: Analysis Hongqiao transportation hub

Image 6: Analysis Delft station

MULTIPLE BUILDINGS AND UMBRELLA

In this combination there are multiple on it's own standing roofs that form the station.

HANGZHOU EAST RAILWAY STATION

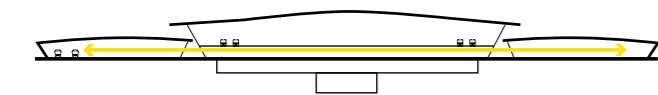


Image 7: Analysis Hangzhou east railway station

ONE BUILDING AND UMBRELLA

In this combination the station consists of one building that has a overhanging canopy.

HONG KONG WEST KOWLOON STATION

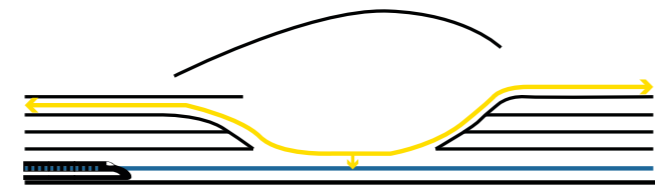


Image 8: Analysis Hong Kong west Kowloon station

FUTURE TRANSPORT

Types of transport change over time. Faster, cheaper and more sustainable alternatives replace obsolete types of transport. By 2030, new transport types could replace current transport types. To estimate what kind of transport types could be used by 2030, transport types that are being developed were researched using a Gartner hype cycle.

The types of transport that have been researched are the: **hyperloop, maglev train, autonomous busses, personal rapid transit and drone taxi.**

HYPERLOOP



Image 9: Hyperloop

In the hyperloop, cargo capsules travel through a low pressure tube. Because the low pressure reduces friction, the capsules can reach high speeds.³ This system combines the speed of airplanes with the ease of train traveling. The hyperloop was originally introduced by Elon Musk, but there are now multiple companies developing this concept. One of these is Hyperloop Transportation Technologies. They plan to present the first commercial hyperloop at the world expo in Dubai in 2020.⁴ It will be a route from Abu Dhabi to Dubai.

To incorporate a hyperloop in a transport hub, a multi destination network needs to be developed. Hardt is a company developing a hyperloop system similar to a highway with exits. In a presentation at the Railtech conference in 2019, they announced their plans to have a working tube with exits by 2030. This means that a fully working system won't be developed in time to be a possibility for this transport hub.

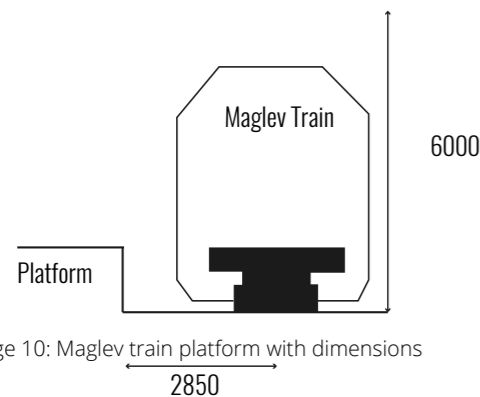


Image 10: Maglev train platform with dimensions

MAGLEV TRAIN

A maglev train is a high speed train that uses two magnets, one in the rails and one in the train, to decrease friction.⁵ The maglev train is similar to the current high-speed trains, but it runs smoother, quieter and faster.⁶ Maglev technology has been researched and developed for over 60 years. The first commercial low speed maglev train ran between the Birmingham airport and railway station between 1984 and 1995.⁷ Only 3 countries currently have a high speed maglev train system: Japan, South Korea and China.⁸

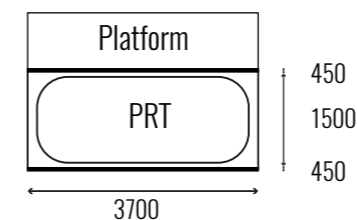


Image 12: PRT platform with dimensions

PERSONAL RAPID TRANSIT

Personal rapid transit (PRT) is a network of small automated vehicles that move through a simple concrete guide system.¹⁰ This has the advantage that the infrastructure costs are relatively low compared to other transport, like trams or metro. The vehicles can house up to six people.

Five PRT systems are currently operating in the world. One of them is between Heathrow airport and its business car park.¹¹

A PRT network uses more vehicles than current public transport systems. Its advantage is that passengers can be sorted based on their destination. Instead of getting into a large vehicle that stops at every destination, passengers are sorted into groups who have the same destination and are put in a small vehicle that goes directly to it. PRT requires a smart system that can sort people based on their destination.

AUTONOMOUS BUS

Self-driving busses and cars have been in the news a lot lately. Uber has announced plans to replace human drivers with robotic ones, and Mercedes-Benz, Volvo, Tesla and Google have announced that they are working on self-driving vehicles.⁹ Autonomous driving technology has reached the point where it can react to car traffic and traffic lights, but it can't react to hand signals and people on the road.

The autonomous bus would not replace any current form of transport, because for travellers it is similar to a normal bus. It is mainly beneficial for transport companies, because it saves driver costs and autonomous cars drive more economically than humans.

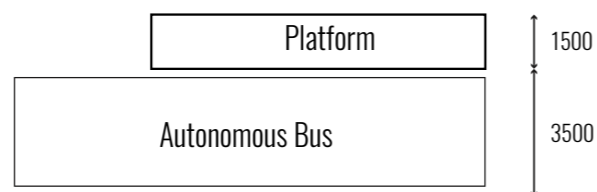
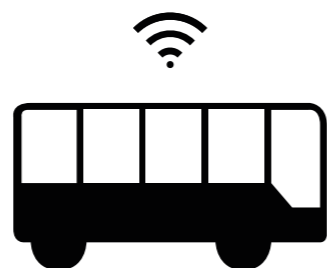


Image 11: Autonomous bus platform with dimensions

DRONE TAXI

Self-driving drone taxis are comparable to helicopters, but with propellers spinning parallel to the ground, similar to drones. The autonomous flying vehicles can transport one person at a time. In 2016, the first self-driving drone taxi was introduced at the CES technology convention.¹²

Taxis in most cities are considered a high class and expensive form of transport. Taxis' advantage over other public transport vehicles is that they are private and take passengers directly to their destination. The drone taxi has the same advantage, but it has the extra advantage of avoiding traffic.

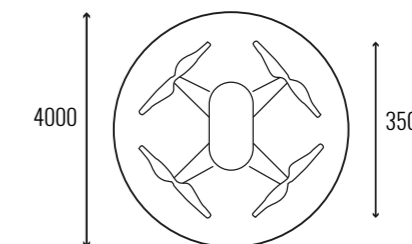


Image 13: Drone taxi platform with dimensions

GARTNERS HYPE CYCLE

Technology is not the only factor that determines when a new transport system is ready to be incorporated. Because a transport hub is for the masses, the transport type needs to be applicable to the masses. This means the it needs to be commercially viable.

The Gartner hype cycle is a methodology that provides a graphic representation of the maturity and adoption of technologies.¹³ The hype cycle identifies a common trajectory that every technology goes through. The trajectory consists of 5 phases: innovation trigger, peak of inflated expectations, trough of disillusionment, slope of enlightenment, and plateau of productivity. A product starts with a trigger, then there is a peak with high expectations, then it goes through a dip when the hype isn't fulfilled, then there is an enlightenment when the technology becomes widely understood, and it ends when the plateau of productivity is reached and where the technology hits mainstream adoption.

The goal of using the cycle is to see if the transport types researched above will hit the plateau of productivity by 2030. The Hyperloop will not be included because the technology will not be ready in 2030.

The most developed transport type is the **maglev train**. The maglev train is in between the phases trough of disillusionment and slope of enlightenment. The maglev train is used in Japan, but is expensive and it doesn't turn a profit. But even though the maglev train seems to be written off, some argue maglev trains should be reconsidered. The article 'Maglev trains: why aren't we gliding home on hovering carriages?' states that the maglev train has great advantages for application in Europe.¹⁴ It explains that maglev trains are reliable and quiet and have low energy and maintenance costs. The article says that these advantages are relevant for the changes countries need the make to meet their climate goals.

Autonomous driving has been studied for a while, including by Gartner. In the analysis for the transport industry of 2019, autonomous driving was placed in the trough of disillusionment phase.¹⁵ However, public autonomous driving could be going up the slope. The article 'Autonomous cars are the future of transport? Don't believe the hype' states that autonomous cars don't live up to the hype, and that mass transit is the future instead of single-occupancy cars.

Drone taxis were introduced in 2016 at the CES convention, but have not reached the plateau of productivity. Since their introduction, drone taxis have faced many issues, mostly concerning regulations, which haven't been developed yet.¹⁶ Noise and safety are examples of regulations that have caused issues. Another issue is that the public does not trust in the autonomy of the drones. Because of these issues, drone taxis are in the beginning of the trough of disillusionment phase.

The **personal rapid transit** is the least advanced in the cycle. PRT is still being hyped. The advantages of PRT are a subject of discussion and new systems are in development. But according to the article 'Can Personal Rapid Transit Replace 90% of Cars on the Road?',¹⁷ the top of the peak is approaching. This article concludes that PRT could be successful, but there are significant challenges to overcome.

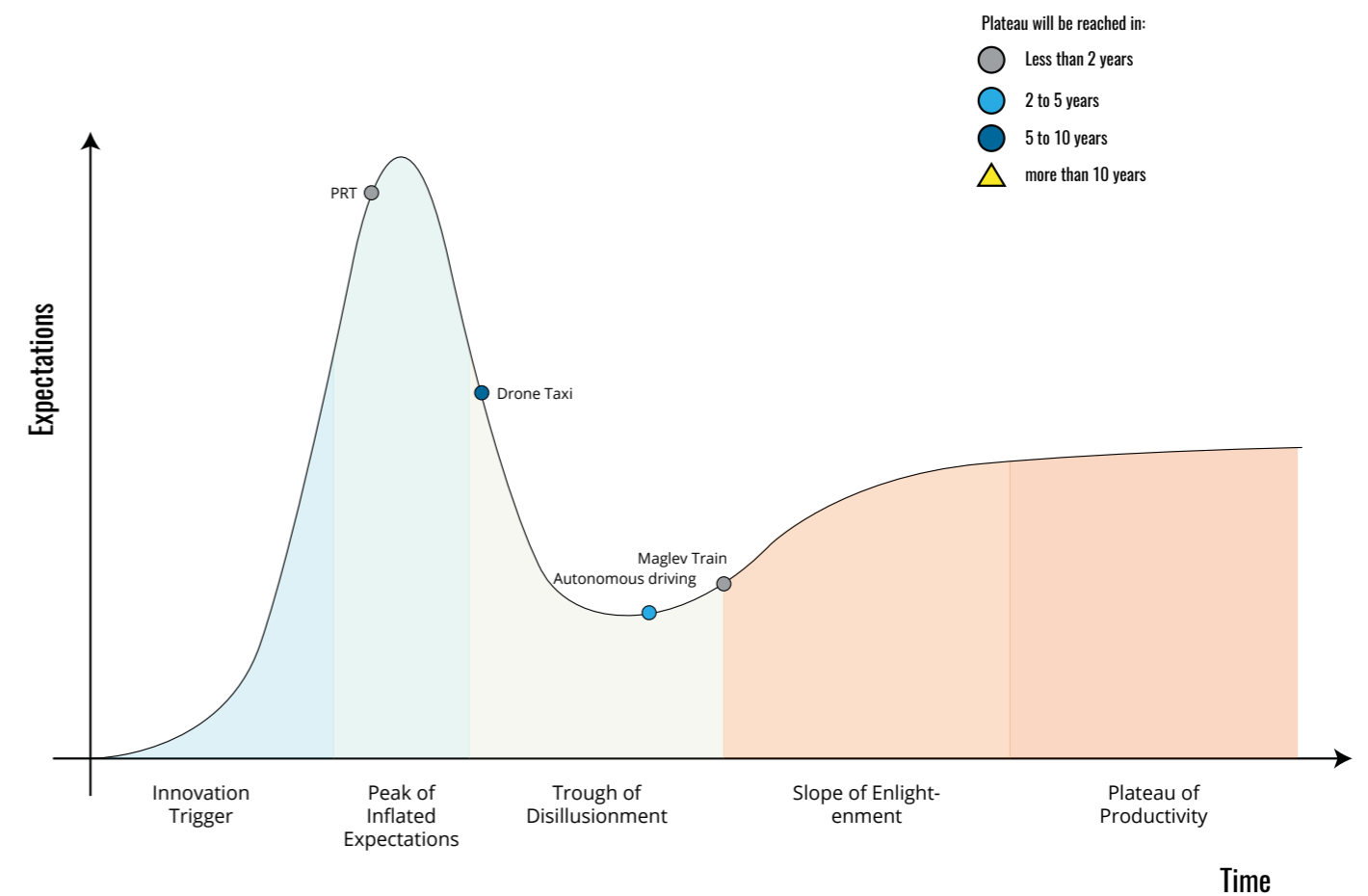


Image 14: Gartners Hype Cycle for future transport

In the image, the transport types are placed on the cycle. This shows the stage each transport type is in now, but for this research, we need to know where they will be in 2030. Therefore, a scale was added that shows in what timeframe the transport type will reach the plateau of productivity. This is an educated guess according to how far along the transport type currently is in the cycle.

“There is already a shift happening in the communication of information. Users are going from looking for general static information to getting personal dynamic information.”

Much will have changed by 2030 besides the types of transport. The way to get on and off the transport can also change because of new technologies. Important factors in how to get on and of a type of transport are the access control and the inquiry of information. I visited the conference Railtech 2019 to talk to people in the rail sector and learn what they think about the future of transport. There I spoke with several companies and learned that the access control and information will change quickly.

When I asked the company Siemens how they saw a station in 2030, they told me that there wouldn't be tickets but that everything would work by an app on the phone or even facial recognition. This means that travellers would have their entire journey mapped on their phone, which would tell them where to get on and off the train and what transport to take to where. Siemens has developed a smart system called digital station.¹⁸

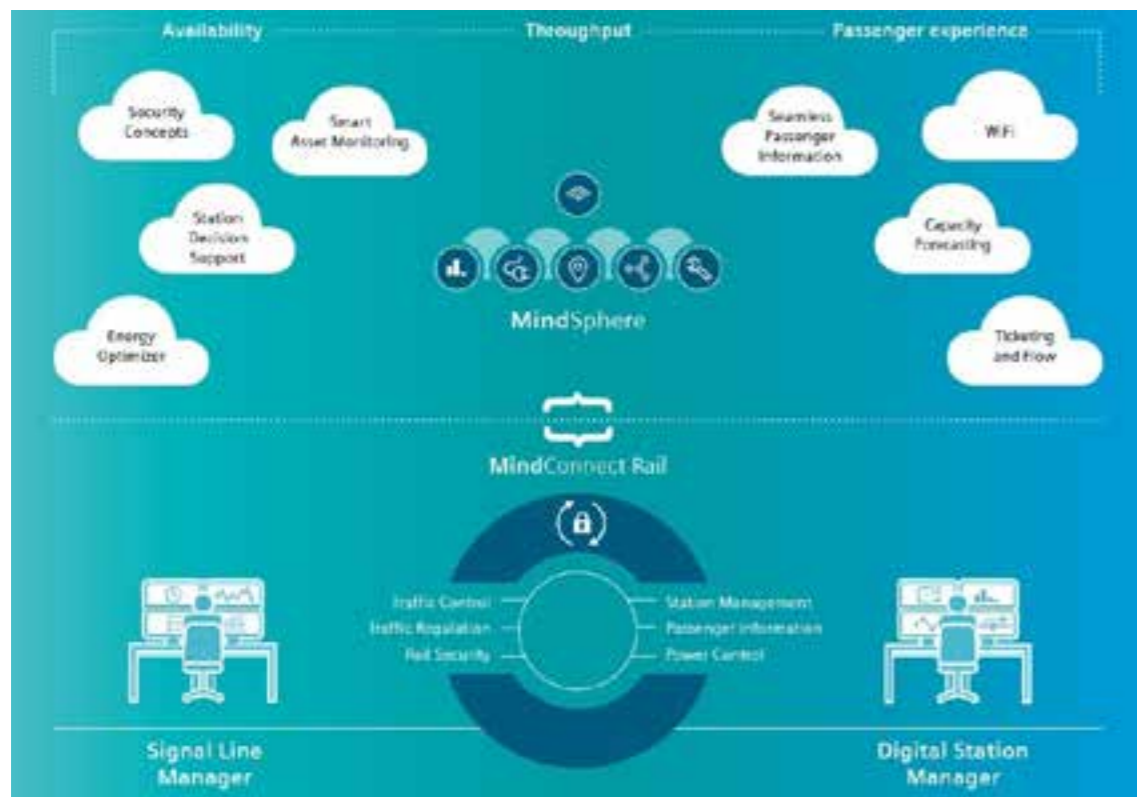


Image 15: Illustration of Digital station by Siemens¹⁸

USERS

A transport hub is used by many types of people, not just for travellers. Additionally, the travellers can be divided into groups. It's important to know who the hub is designed for and what their specific needs are. All these different users show different behaviours, which should be incorporated into the design. The table below shows the behaviours, required facilities, desired experiences and used transport type of the users in the hub. These profiles are based on personal travel experience and the profiles in the document 'Het stationsconcept'

| Types of users | Behaviours | Required facilities | Desired experiences | Used transport type |
|----------------------------|--|---|---|-------------------------|
| Commuter | Knows the way Shortest route In a rush Travels alone | Visits the small shops | Moves as quickly as possible in/out the train Wants something for on the way | Train, Bus, Tram, Metro |
| Business trip | Arrive early Carry luggage Travels mostly alone | (Private) waiting room Work space Shops | Comfortable wait Spend time functionally Wants something for on the way Privacy | Train, Bus, Tram, Metro |
| Tourism | Arrive early Don't know the way Travel together Carry luggage | Information Shops Cafés Waiting area (security check) | Want entertainment during their wait Anticipation for trip | Train, Bus, Tram, Metro |
| Day trip | Arrive on time Travel together | Shops Cafés | Wants something for on the way Anticipation for trip | Train, Bus, Tram, Metro |
| Layover | Have Time Have Luggage Searches for a place to stay to wait | Information Shops Cafés Waiting area (security check) | Comfortable and entertaining wait Explore the city | Train |
| Meeting people | Stay in one place | Covered recognisable space | Easy accessible covered wait that is recognisable | |
| Users of facilities | Moving and staying in the station | Covered recognisable space Shops Restaurants Cafe Other added functions | Easy access to facilities without leaving to enter transport area Connection to the hub without begin interfered by it | |
| Employees | Move fast Know the way | Break area Toilets | Want to get home quickly | |

Table 1: Types of users

BACK OF THE STATION

A station contains many spaces that are not visible to the public. These spaces are needed to keep the station running and have to be incorporated into the design. To find out what is part of the back of the station, I visited Utrecht Centraal. The station manager of Utrecht Centraal led a tour and explained what was going on behind the scenes. This resulted in a scheme that divides all the functions into parts (technique, cleaning, logistics and staff training) and shows the relations the functions have to the public parts of the station.

The subparts are: **Technique, cleaning, logistics and train staff.**

The **technique** part of the station can be divided into two parts: installation and cables. There are two kind of installations: one for the climate within the building and one for the food-related functions. The first kind of installation doesn't have a connection to the public functions and can be located at multiple places in the building. The second kind needs to be connected to the functions that need these installations. An example is collecting the fat from frying equipment in a restaurant.

Second, a station contains a network of cables to control and power the trains. These cables need to be accessible for repair and maintenance. This is why there are tunnels underneath the tracks that house all these cables. There are two tunnels that run perpendicular to the tracks, one at the beginning and one at the end. These tunnels are connected to each other.

Cleaning a station is an enormous task involving a lot of people. Three area are involved in ensuring the station stays clean. First is storage of cleaning supplies and equipment. The second is the canteen. There are a lot of people involved in cleaning the station, and they need a space to have their break. The third is the offices. It takes a lot of organisation to keep the station clean and the people coordinating need a functional workplace.

The **logistics** deal with all the projects for the facilities involving going in and out of the building. This means the loading and unloading of products and dealing with waste. There needs to be a place where (garbage) trucks can load and unload without getting in the way of the travellers. This point is connected to a space where the products can be sorted for distribution and the waste can be collected. From this space, there needs to be a private route that leads to all the functions.

Interestingly, Utrecht station has no separate route for logistics. This is a real problem according to the station manager, because it means the logistics clash with the travellers. Additionally, the functions hardly have any storage, which means there is a lot of traffic between the logistics department and the functions.

The last part of the back of the station concerns the **train staff**. This concerns the spaces that employees involved with the transport need, such as offices for the control and logistics of the transport and a canteen for all the employees. Think of conductors and drivers. There are also a lot of projects going on in a station. This includes testing new technology, research, maintenance and renovation. Temporary spaces give these project a place to work from.

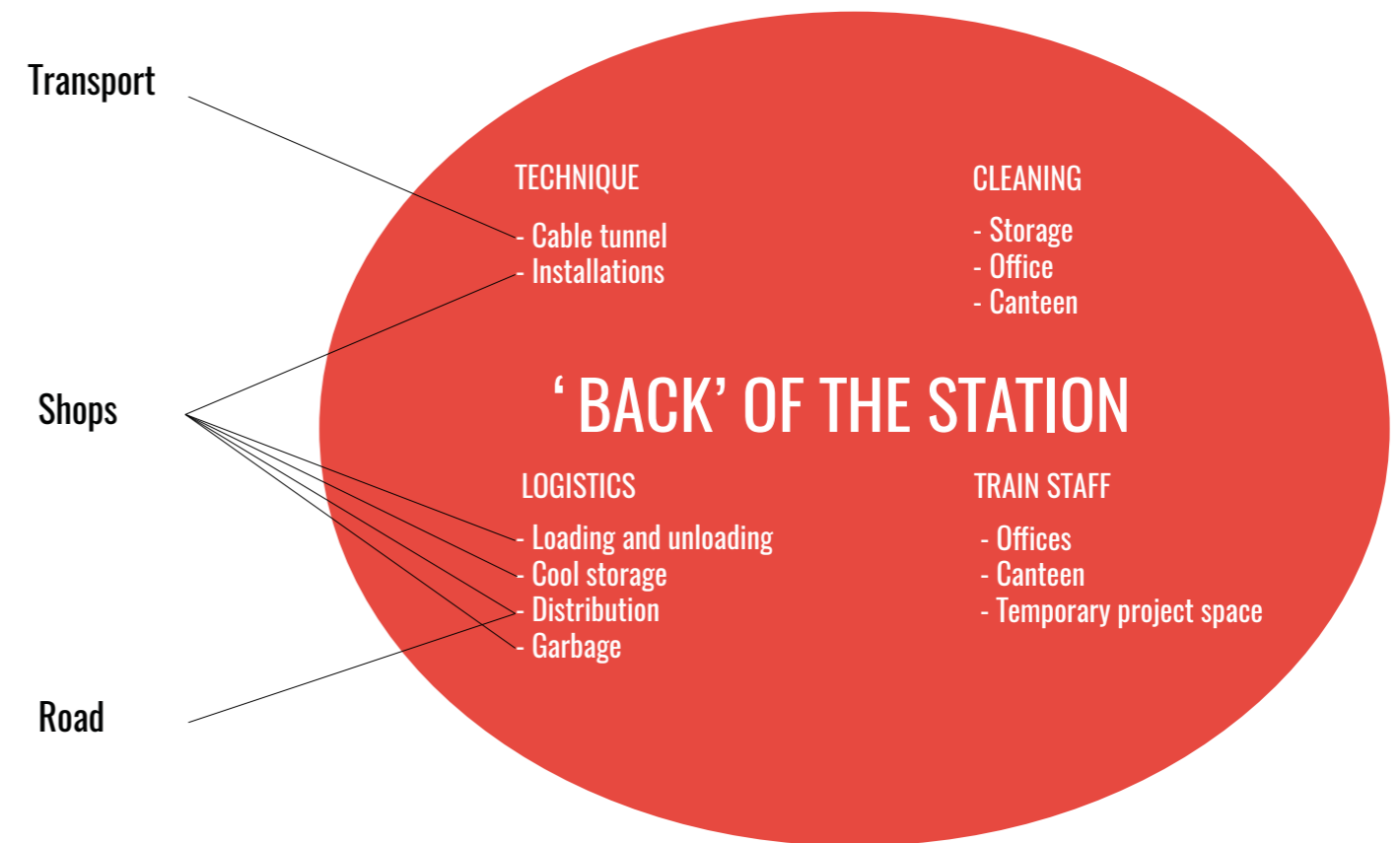


Image 16: Scheme of the back of the station functions



LOCATION

LOCATION DETERMINATION

The chapter location is divided two main parts: selecting a site and the research of the selected site. There are some guidelines created to direct the search for the location. The guidelines concern the amount of public transport in the city and the innovativeness of the city.

The research of the site will be approached from different angles. The area in which the site is situated and the site itself will be researched. The site will be visited to get a clear image of the location.

Paris was chosen for the future transport hub based on several parameters. The location of the future transport hub needs to be a city that is innovative regarding public transport and where the public transport system is frequently used. The city needs to be innovative because they need to be willing to implement new technologies. Initially, several innovative cities were picked. To determine the innovativeness of the public transport in a city, the development plan of each city was researched and scaled from 1 to 4.

- 1: Expanding the current transport types
- 2: Innovation in current transport types
- 3: Ambition for innovation and new transport types
- 4: Realising new transport types

For each city, the number of passengers per year was determined. To determine how much the public transport is used, the number of passengers was divided by the inhabitants of the city.

“
Finding a city that wants to change and is willing to develop and where there is a need for a lot of public transport.
 ”

| City | Metro passengers annually in millions | Bus passengers annually in millions | Train passengers annually in millions | Tram passengers annually in millions | Total passengers annually in millions | Inhabitants according to google | Passengers per inhabitant | Innovation scale |
|-----------|---------------------------------------|-------------------------------------|---------------------------------------|--------------------------------------|---------------------------------------|---------------------------------|---------------------------|------------------|
| Barcelona | 390.4 | 410 | 175 | 8 | 983.4 | 1.609 | 612 | 2 |
| Berlin | 937 | | 55.3 | 395 | 1387.3 | 3.575 | 389 | 3 |
| Budapest | | | | | 1456.35 | 1.756 | 830 | 2 |
| Hamburg | | | | | 751 | 1.81 | 415 | 3 |
| London | 1357 | 2247 | 355 | 29.1 | 3988.1 | 8.136 | 491 | 4 |
| Paris | 1538.7 | 332.9 | 492.5 | 103.7 | 2467.8 | 2.2 | 1122 | 4 |
| Stockholm | | | | | 292 | 0.96 | 305 | 3 |
| Vienna | 440.1 | 208.3 | | 305.8 | 954.2 | 1.868 | 511 | 3 |

Table 2: Numbers for cities in Europe - for sources see reference page

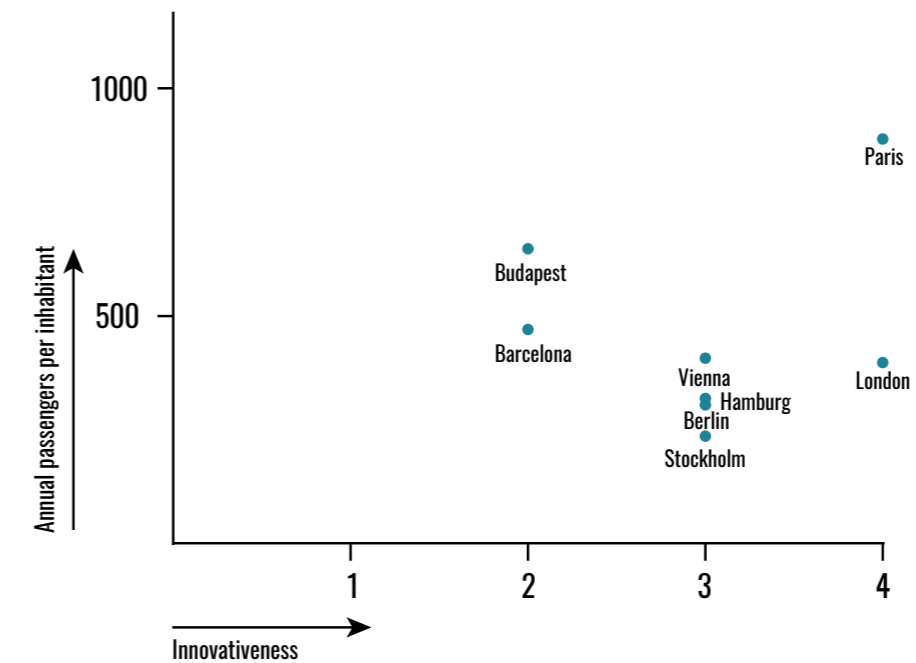


Figure 1: Innovativeness compared to passengers

The metro has by far the most passengers (see Figure 1).¹⁹ The train, bus and tram have significantly fewer passengers, according to a survey done at the 10 biggest stations in Paris. This survey gives insight into the public transport users in Paris. It states that the reason people use public transport is mostly work related (see Figure 3). 31% of people use public transport to get from home to work and 30% use it for professional trips. Another 29% use public transport for pleasure and visits. The means people use to reach the stations differ for every station

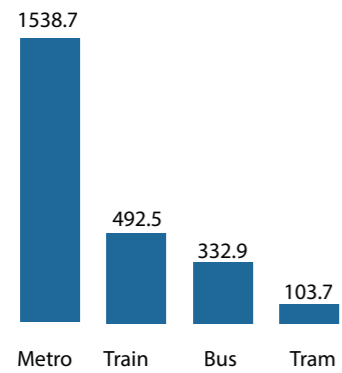


Figure 2: Paris' public transport passengers in 2017¹⁹

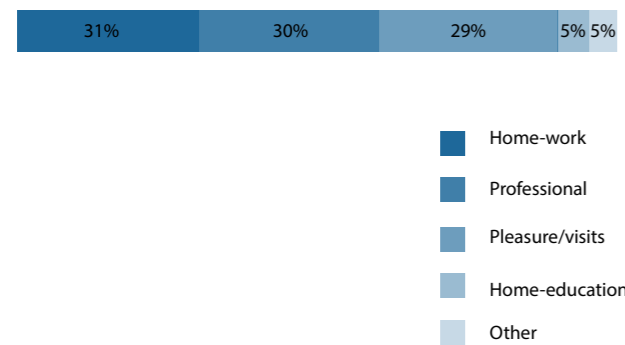


Figure 4: Paris' reasons for using public transport²⁰

(see Figure 4). Walking is the second most common means to get to a station for all stations.

The 8th district of Paris has the most passengers (see Figure 2). 12% of all passengers in France travel to or from this district. This district houses Paris' second biggest station: Saint-Lazare. Therefore, the 8th district is chosen as the location for the site.

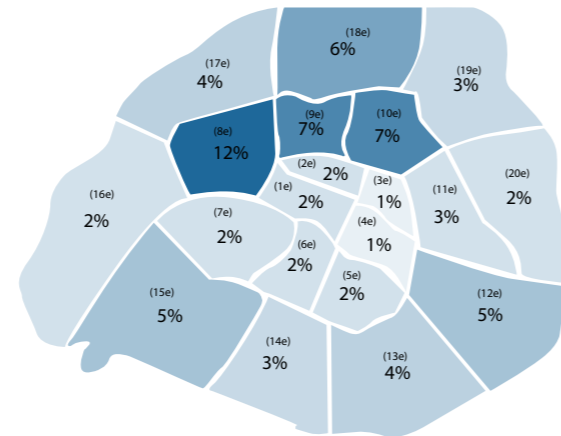


Figure 3: Paris' percentage public transport per district²⁰

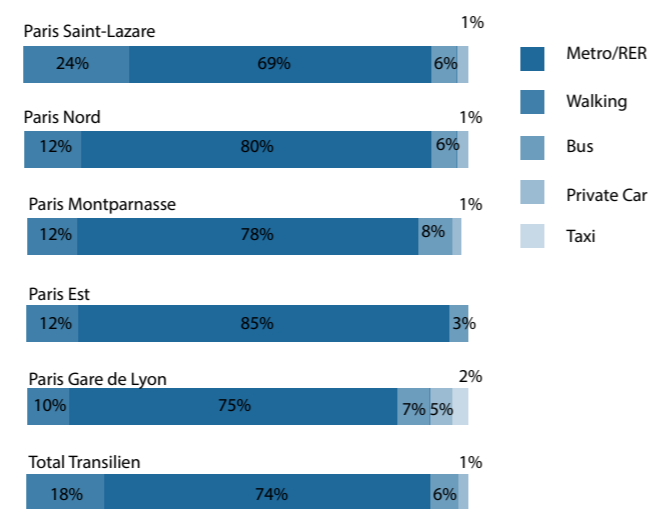


Figure 5: Paris' means used to get to a station²⁰

The 8th district is one of the central business districts of Paris. Together with the 2nd, 8th, 9th, 16th and 18th arrondissements, it forms the QCA, or quartier central des affaires. The QCA houses 30% of all the employees in Paris.²¹

To find a site for the transport hub, a map of the transport in the 8th district was made. The chosen location needed to already house several forms of transport. There are no intersections between train lines, because Paris only has head stations. Because the site should be in a location where transport lines cross each other, the only option for the site was the current Saint Lazare station.

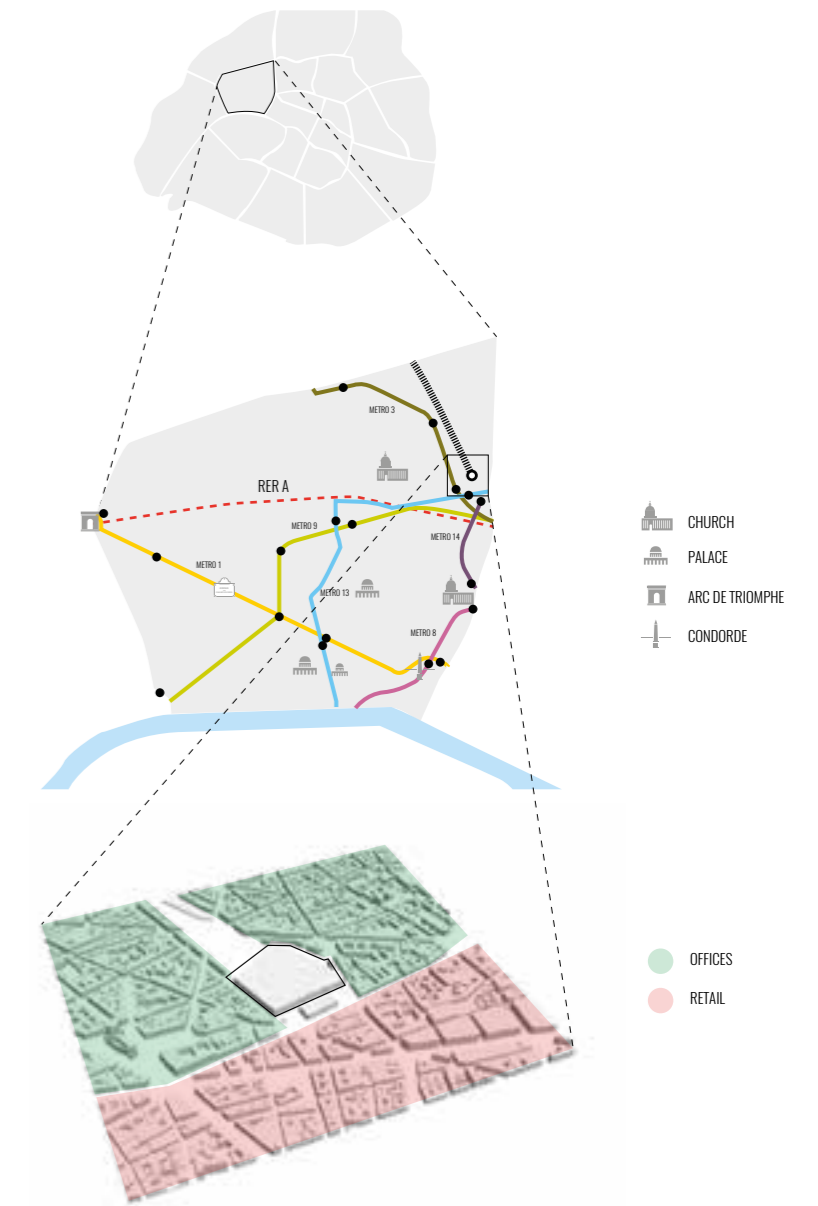


Image 17: Zoom in to the area



LOCATION ANALYSIS

“
What could a station add to the surrounding and how could the surrounding influence the station?
”

The area around the site can give valuable input for the design of the hub. Therefore, a site analysis was performed on the area. The findings of this analysis were used as input for the program and the design.

The subjects of the analysis are railways, roads, green areas, morphology and topography. The underground rails follow the path of the roads. There is also only one rail track that runs underneath the site. There are rail junctions, but they are underneath the intersections of the road in front of the station. This means that it not possible to connect the metro directly to the site—they must be connected by a tunnel. Most of the roads are one way. This needs to be considered when designing the bus terminal.

There are few public green areas or open areas around the site. The new building could add these to the area by incorporating green and public areas in the building. The topography analysis shows that there is a height difference of 15 metres in the site and 25 metres in the entire area. This height difference is important to consider when designing the building.

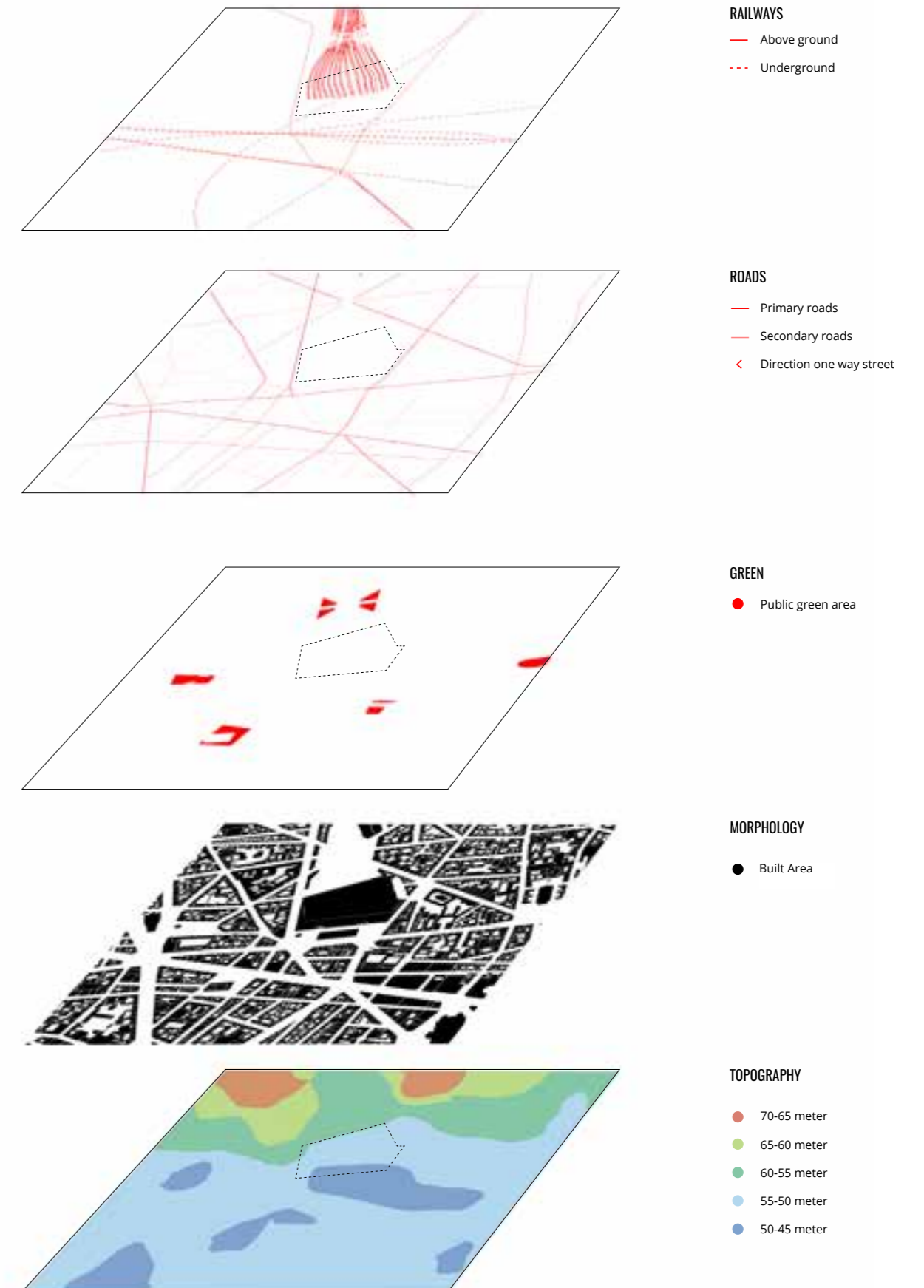


Image 18: Site area analysis

SECTIONS



Section 1

10 METER
|



Section 2

10 METER
|

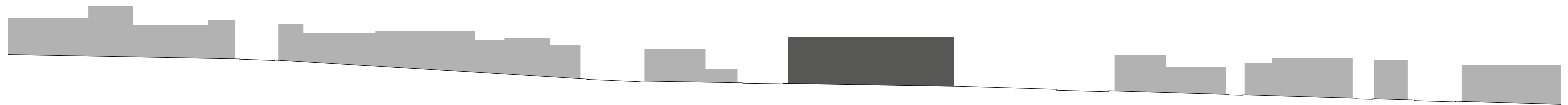


Image 18: Sections of the area

10 METER
|

● Saint Lazare Station



Image 19: Locations of sections

HISTORY OF SAINT LAZARE STATION

Gare de Saint Lazare first opened in 1837 to form a connection between Paris and the suburbs around it.²² The current station originated from three stations that were combined. It started as a temporary station on the place de la Madeleine. The station developed rapidly over the years and in 1841, a second station was introduced. This station housed a line to and from Versailles and was located at Rue de Stockholm. Between 1842 and 1853, a third station was introduced at the corner of Rue d'Amsterdam and Rue de Saint Lazare.

In 1867, the stations began merging. A new building was built that housed all the tracks of the three stations. The building was opened in 1889. The facade of this building is still visible in the current Saint Lazare station. In 1903, the metro lines were added underneath the station. In 2014, the inside of the station was fully renovated, but the exterior remained the same.

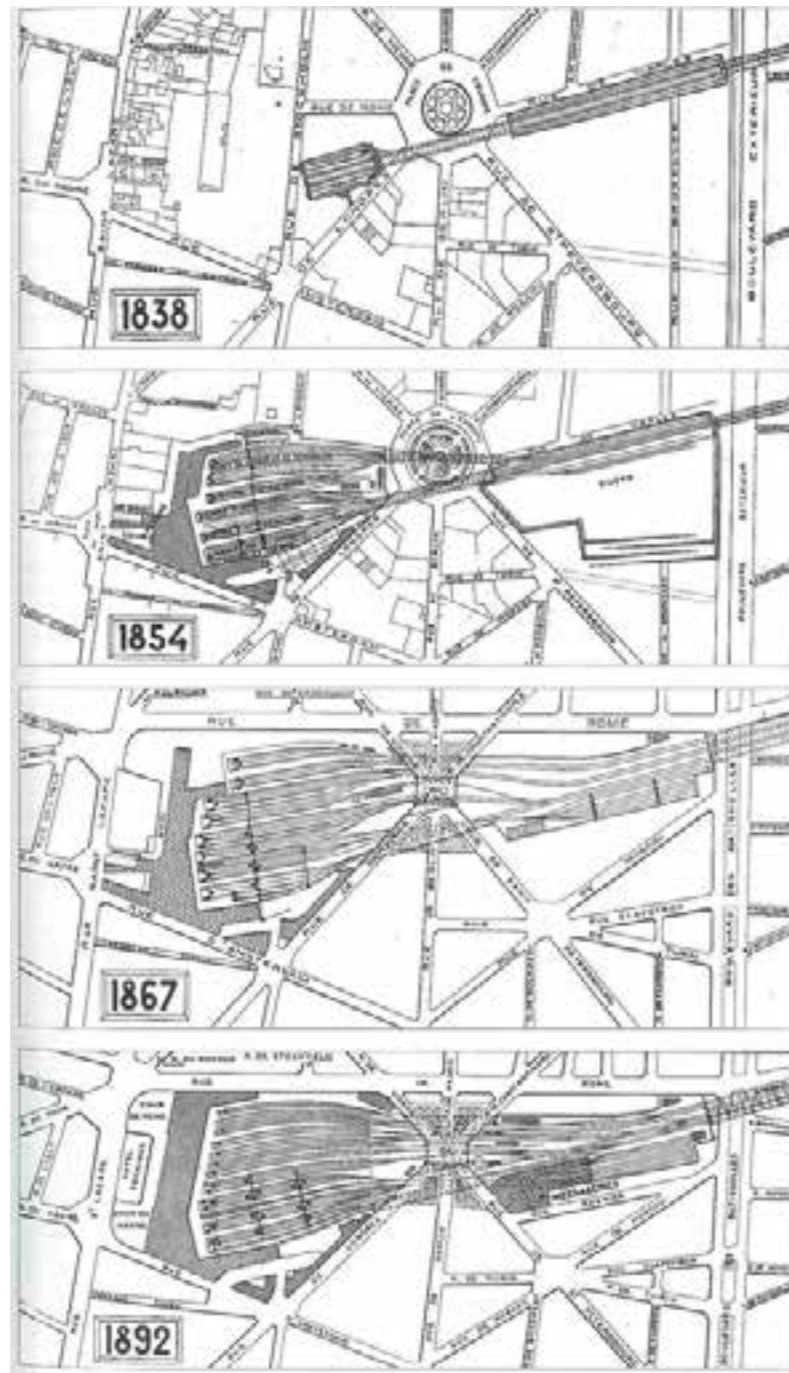


Image 20: Development of Gare de Saint Lazare

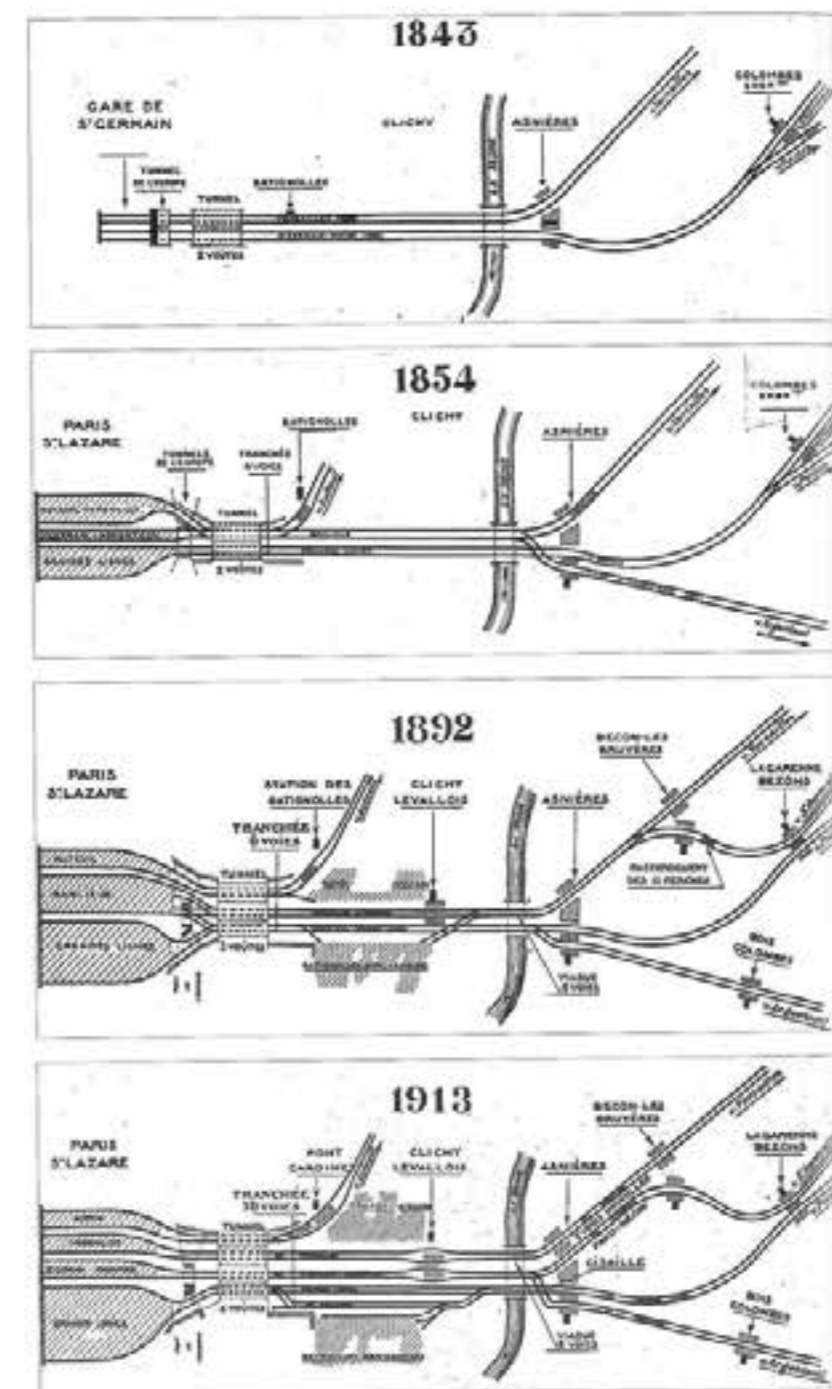


Image 21: Development of the area of Gare de Saint Lazare

In addition, the whole area has been developing as a transport hub. The image shows how the lines originating from the Saint Lazare station have developed. The addition of lines created the need for successive stations. The effect of the growth of the station is transforming the area into a hub.

The history of the development of the station is relevant for predicting its future. How the station developed in the past can indicate how the station could develop in the future. In its first 50 years, the station has grown rapidly, but after 1900, there have been few additions to the network. The station itself has changed in this time, but its size has remained constant.



Image 22: Illustration of Gare de Saint Lazare in 1837



Image 23: Picture of Gare de Saint Lazare in 1920s



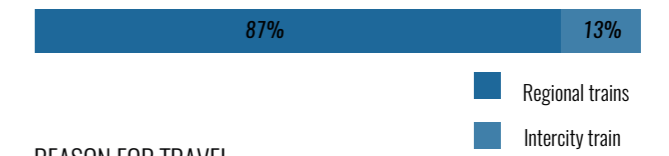
Image 24: Picture of station hall of Gare de Saint Lazare in 1930s

PASSENGER NUMBERS SAINT LAZARE STATION

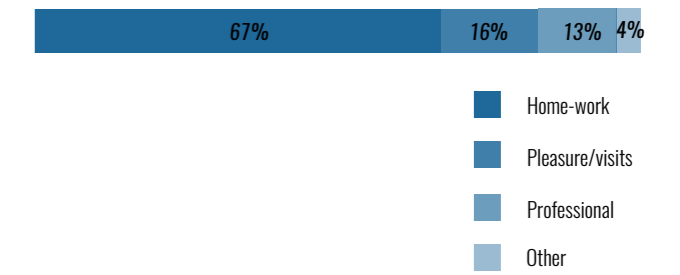
Saint Lazare station is a hub that combines train, metro, taxi and bus transport. There is a direct connection from the station building to the metro. There are multiple bus platforms in the surroundings of the station building.

The figures on the side show the types of train arriving at the station, the type of traveller and the type of transport they take after or before the train. Most of the travellers are commuters. This is consistent with the fact that most of the trains are regional ones. The reason for so many commuters could be that the station is located in a business district. The most used transport before or after the train is the metro. This is consistent with the travellers in Paris, where the metro is the most used form of public transport.

REGIONAL/INTERCITY TRAVEL



REASON FOR TRAVEL



TRANSPORT TYPE BEFORE OR AFTER TRAIN



Figure 6: Passenger numbers for Saint Lazare²⁰

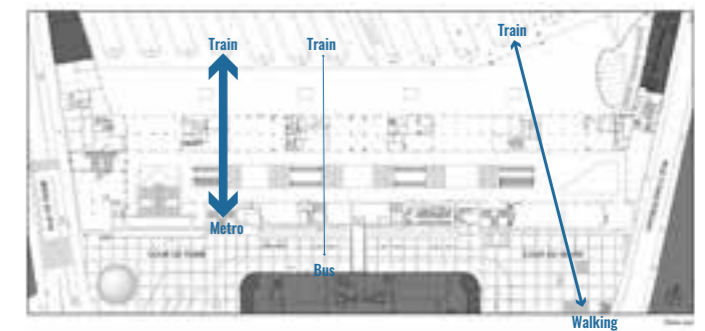
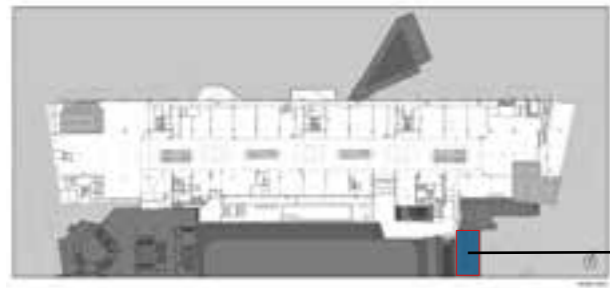


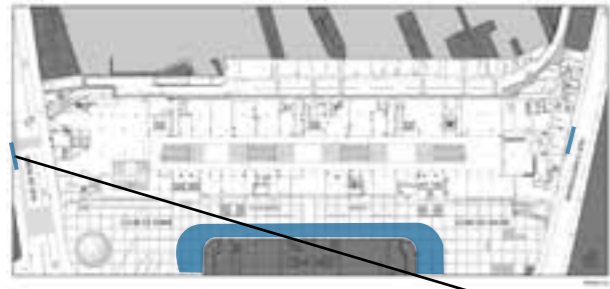
Image 25: Travelers direction²⁰

SITE VISIT

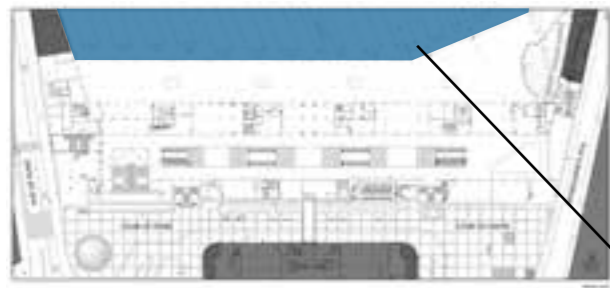
TRANSPORT



UNDERGROUND LEVEL



GROUND LEVEL



FIRST FLOOR

There are three types of transport in Saint Lazare station: train, bus and metro. The trains are located on the first floor. Saint Lazare is a terminus, which means that the train tracks stop at the station. The bus platforms are scattered around the building. The main platforms are on both sides of the station square. The buss routes go around the building before leaving the station. There are platforms on both sides of the station.

The metro is not located directly underneath the station. There are four metro lines that are connected to the station by the means of tunnels.



Metro Platform



Bus platform



Train platform

Image 26-28: Platforms of Saint Lazare

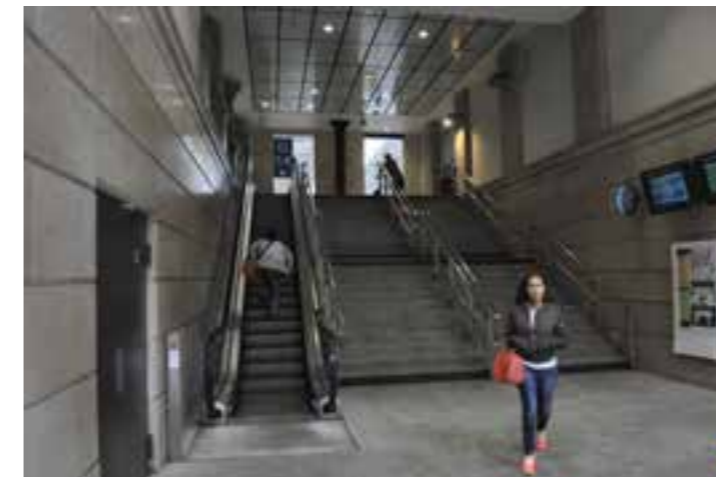
BUILDING ENTRANCES



Main building entrance

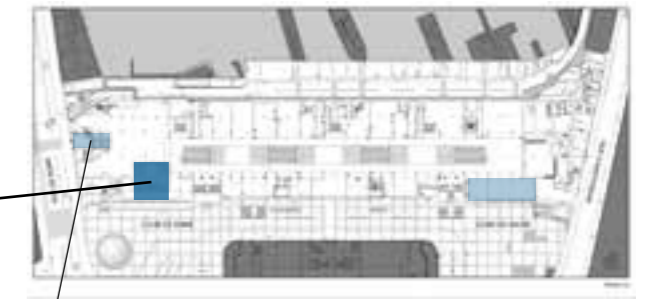


Main underground entrance

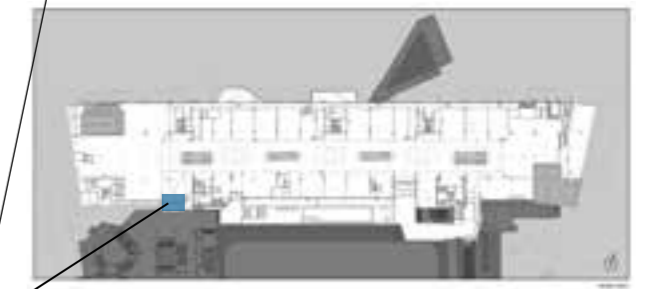


Secondary building entrance

Image 29-31: Entrances of Saint Lazare



GROUND LEVEL

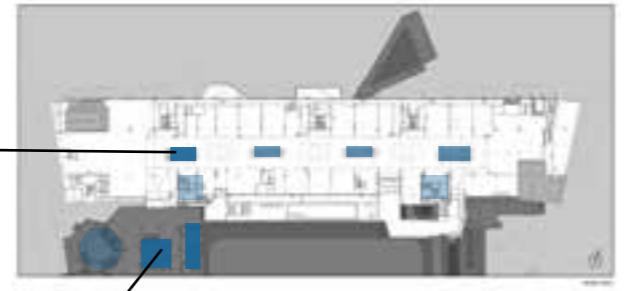


UNDERGROUND LEVEL

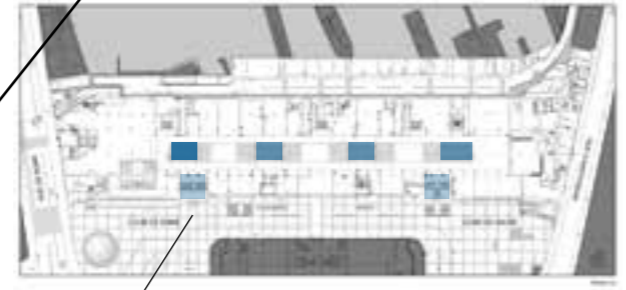
There are two main entrances to the building: one from outside and one from the metro. The entrance from the metro is the most used, since most people come from and go to the metro. This entrance is the only direct connection between the metro and the station. The main entrance from the outside connects the square directly to the first floor, where the trains are located. There are two secondary entrances from the outside. One connects the outside to the first floor and the other to the ground floor.

- Primary entrance
- Secondary entrance

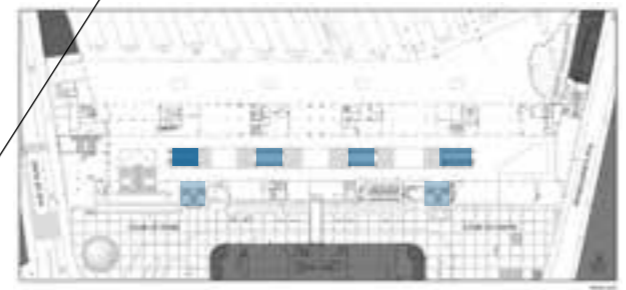
VERTICAL TRANSPORT



UNDERGROUND LEVEL



GROUND LEVEL



FIRST FLOOR

- Primary vertical element
- Secondary vertical element
- Tertiary vertical element

Image 32-34 : Vertical points in Saint Lazare

The most used vertical elements are on the route between the trains and the metro. The vertical elements at the underground levels consist of three escalators and one staircase. The vertical elements in the middle of the building are similar to those in a shopping mall. There are four areas with two escalators

each. The area on the west side of the building is on the route between the busses and the metro. These escalators are significantly more used than the others. There are two vertical elements in the front of the building: a round staircase with an elevator in the middle—the only public elevator in the building.

CROWDS DURING THE DAY

According to the survey about the travellers in Saint Lazare, there is a 90% increase in travellers during the peak hours. To learn how the crowds differ during the day, the location was visited at different times. The pictures on the right show the front hall at different times of the day.

In the morning peak, around 8:00, the station is very busy, especially around the metro. However, no one bypasses the most direct route. Even when there is a line in front of the escalator, travellers don't walk ten metres extra to get to another one. Everyone in the station is moving. The shopping mall area is empty except for the travellers quickly passing through.

In the afternoon, around 14:00, the station is less busy around the platform, but there are more people in the shopping area. The crowds fluctuate depending on the departure of trains, which are not as frequent as in the morning. There are more travellers going long distances and carrying a suitcase.

The evening peak, around 17:30, is comparable with the morning peak. More travellers are boarding trains than leaving them. Most people in the station are on the move, but some are standing or sitting in the small seating area.

At night, around 22:00, hardly anyone is in the station. The only place with small crowds is near the metro area. Some people are hanging around the platform, but there are no trains departing anymore. The shopping mall is empty and the shops are closed. The whole station is dark. The neon signs of the shops are off and there is minimal lighting around the platform.



8:00 Morning peak



13:00 Afternoon



17:30 Afternoon/evening peak



22:00 Evening

Image 35: Station hall Saint Lazare at four times during the day

PRO'S AND CON'S OF THE STATION

The first positive thing about the station is the facade. The facade in front of the station squares is striking and has monument status. It's clear to visitors that this is the entrance of the building. The stairs behind the facade work well in the routing. From the outside of the building, travellers are directly led to the level of the trains.

The hotel in front of the station can be seen as a positive element. The front facade of the station is long (two hundred metres) and the building divides the facade. There is a hotel close to the station.

The first problem found was with the division of the building. In the centre of the building is a shopping mall that separates the platforms from the city and the metro system. To get to the platforms from the city and the metro and vice versa, travellers must cross the shopping mall. The shopping mall does not look or feel like a station. It's also hard for travellers to orient themselves, because the stores signs overshadow the station signs.

The second problem is at the platforms. Because the platforms are narrow, the travellers can't stand at their platform, but must wait in the front hall. All the passengers need to get out of the train before the travellers going into the train can enter the platform. However, the hall isn't big enough for the travellers waiting for the train and the travellers coming out of it. The travellers coming out of the train have to push through a crowd of waiting people.

The third problem is the vertical transport in the building. The route between the trains and the metro is busy and not all the rise points can handle the crowds. During the peak hours, there is a traffic jam at the two escalators from the ground level to the trains on the first floor.

“
The hotel in front of the station is a plus and a minus at the same time. It adds something to that station but at the same time there is a building right in front of the station.
”

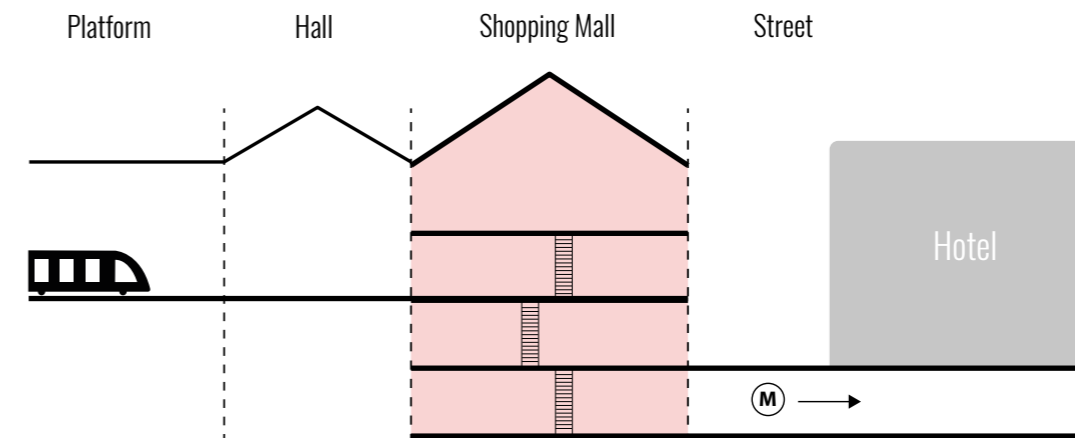


Image 36: Scheme of shopping mall inside station

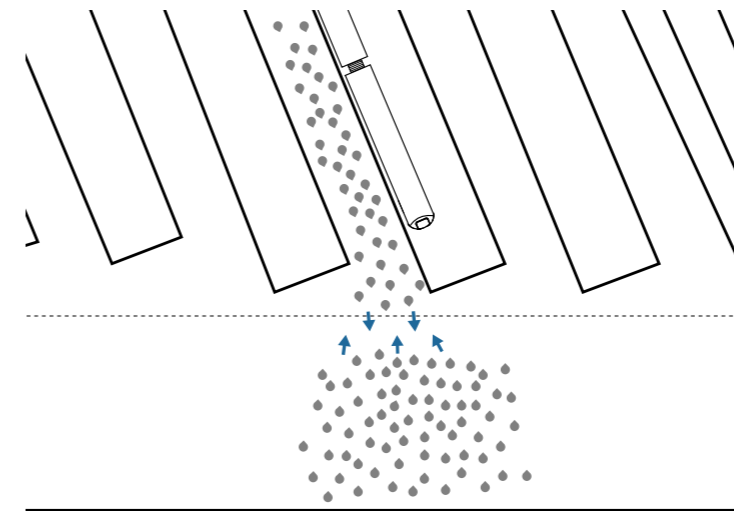


Image 37: Scheme of clash between crowd

GARE DE L'EST

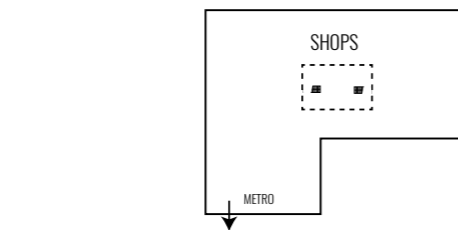
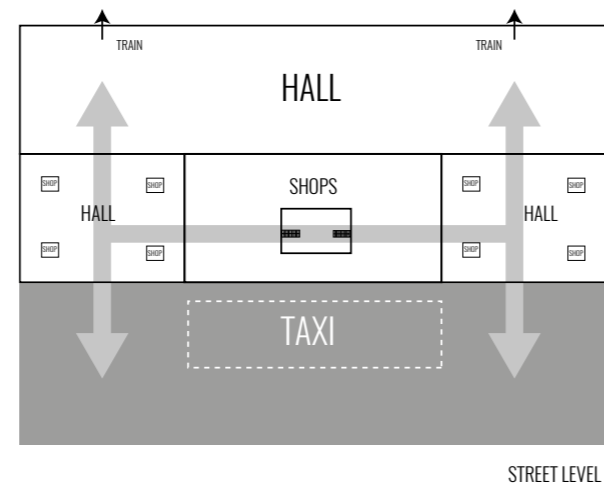


Front facade



Passing Hall

Image 38 & 39: Pictures of Gare de l'Est



■ Station square
← Route

Image 40: Scheme of Gare de l'Est

GARE DE LYON



Front facade



Hall 1

Image 41 & 42: Pictures of Gare de Lyon

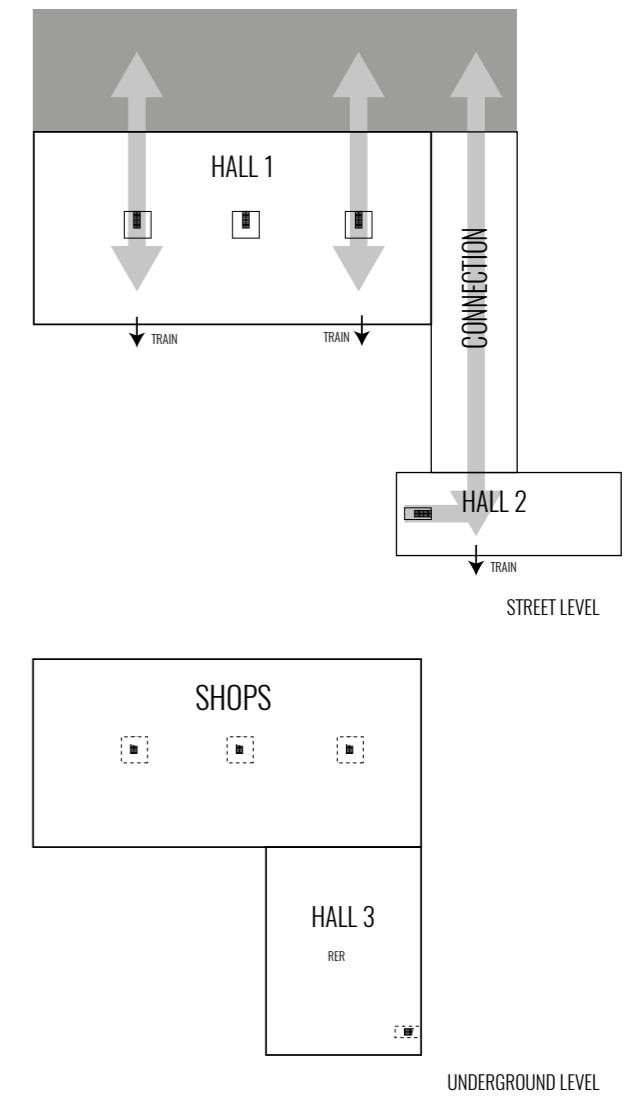


Image 43: Scheme of Gare de Lyon

“
This is how i would like my station to work.
”

“
The transport is separated in different halls but still connected in one building.
”

GARE DU NORD



Front facade



Hall

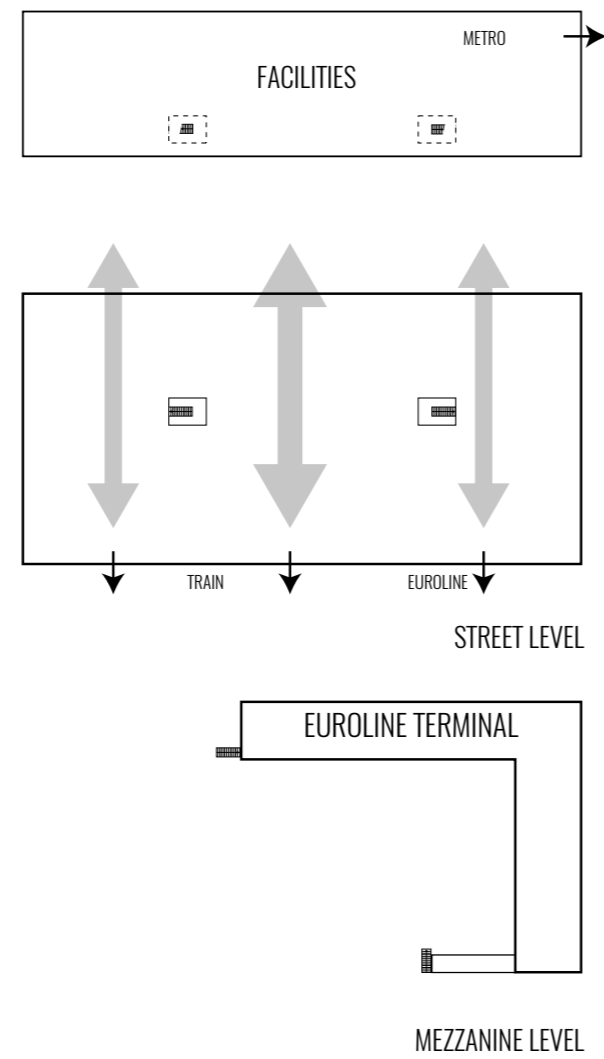


Image 46: Scheme of Gare du Nord

Image 44 & 45: Pictures of Gare du Nord

“
Inside there is a nice clear overview of the station but there is a collision of traffic outside.
”



TRANSLATION RESEARCH

TRANSLATION RESEARCH

ORGANISATION

The domains described in the station concept are a helpful tool to analyse different stations. For future research, the domains could be a subject for case studies on different stations.

The domains are also valuable for the generic design concept. However, I want to alter the domains. In the station concept, the surrounding domain houses other types of transport, like busses and trams. Because I want to combine all these types of transport, I will place all types of transport in the travel

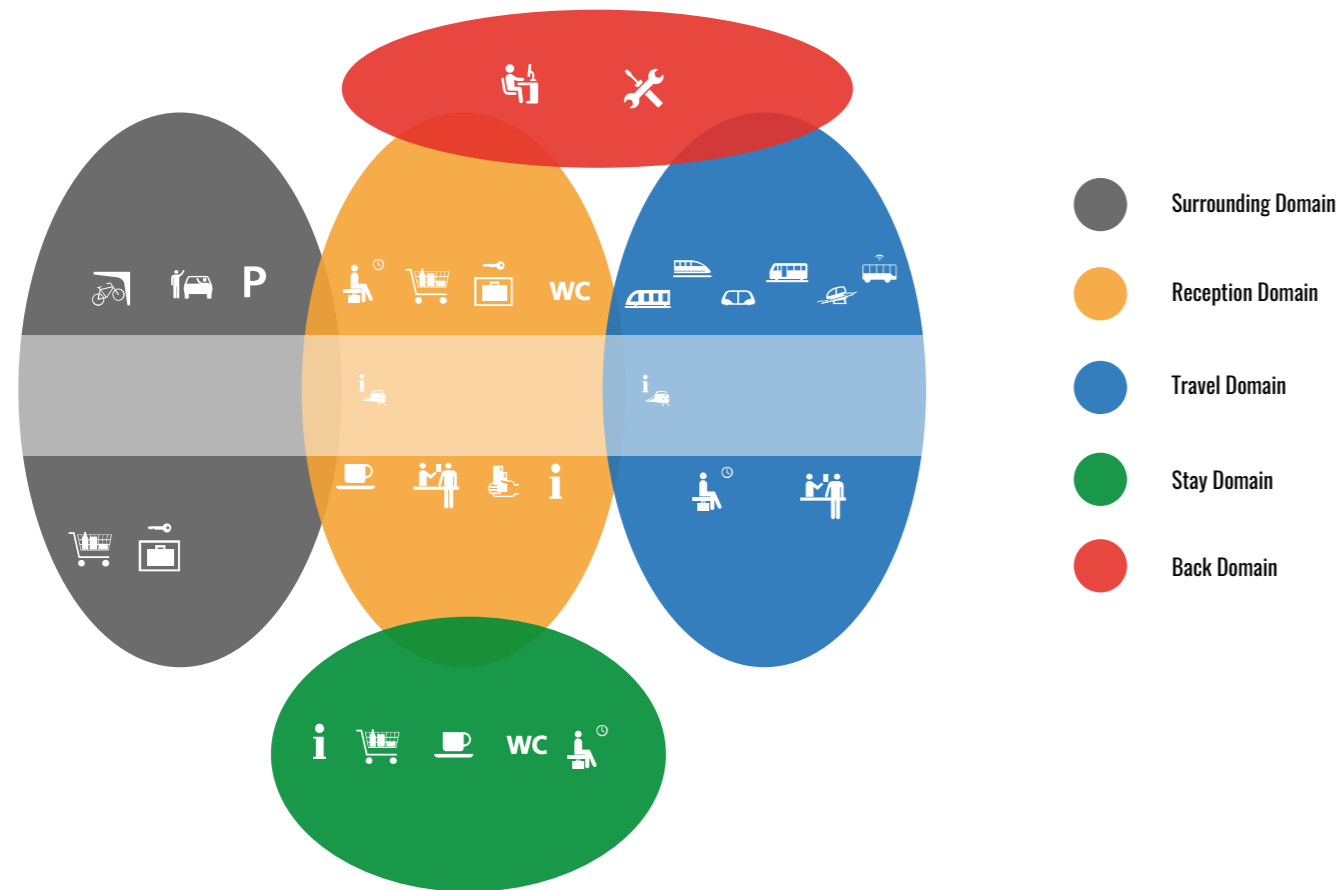
domain. This means that the public transport will move to the travel domain and that the remaining functions will stay in the surrounding domain.

I will also add a fifth domain: the back domain. The four domains describe all the spaces that a passenger sees, but in a station, there are also spaces a passenger doesn't see. To use the domains as a design tool, all the spaces of the station need to be included. This domain includes offices and maintenance areas.

FUTURE

According to the research, four types of transport will be commercially ready by 2030: maglev trains, autonomous busses, PRT and drone taxis. This doesn't mean that all the current transport types will disappear, although busses might be replaced by autonomous busses, since there is no change necessary for the infrastructure and the experience of the traveller. The maglev train would be a valuable addition to the train network, but because it works best for long distance, the current regional trains will likely stay unchanged. The metro system is the most used transport type in Paris, and this is probably not going to change in 10 years. PRT could be a good addition to the metro because it can sort the passengers according to destination and thus shorten the trip. Drone taxis bring a new concept to the station: air traffic. This is an addition to the transport network, but it will be expensive, and thus best implemented on a small scale.

The smart systems could impact the design of the transport hub. Travellers wouldn't be as dependant on information at the station, because they would have the information themselves. The access control could change as well; there could be gates in front of the transport that react to an app or even to travellers' faces. There would still be a need for information at stations for the travellers who are not connected to the system or if the smart system malfunctions.



- | | | | |
|-------|-------------------|---------------------|--------------------|
| Metro | Food services | Bicycle Parking | Waiting Area |
| Train | Service | Drop of and pick up | WC Toilets |
| Bus | Information Point | Parking | Offices |
| Tram | Ticket Sale | Retail | Maintenance |
| | | Facilities | Travel information |

Image 47: Domain Scheme

USERS

The specific needs for each user are important to keep in mind, because the building is designed for them. The user research is supported by the numbers of the current Saint Lazare station. The needs and expectations of each user type that are currently in the station helped determine a program for the future transport hub.

BACK OF THE STATION

Four subjects for the back of the station were derived from the research. Design of the transport hub, train staff, building, and transport types. For the design of the transport hub, I want to focus on the logistics of the back of the station. The separate routing for the logistics is important for the smooth running of the station and needs to be implemented in the design.

For the train staff, I want to have a general layout for the office. After the research I'm not sure how these offices work, so I want to create a general plan that can be adapted to the train staff.

Because I'm not specialised in building physics or the technique behind the transport types, I don't go too deeply into this subject.

LOCATION

The Saint Lazare station is in a business district and is mostly used by commuters. This means that the station is most used for professional traffic. This provides an opportunity for an added function in the station that could focus on this group. This will be implemented in the program.

The transport systems at Saint Lazare are mainly short distance. There is an opportunity to add more long distance and international travel into the program of the station. New transport types in particular make this possible.

The area around the site provides input that needs to be implemented into the design. The distance between the aboveground and underground tracks needs to be taken into consideration. The height differences need to be reviewed and could offer an interesting feature in the design.

There is also an opportunity to add public space and green space into the design, since there is a lack of these spaces in the area.

Lastly, the problems of the current building need to be addressed. Transport, not retail, needs to be central in the building. There can still be retail or other functions in the building, but they need to be separated from the travel.

The capacity issue of the platform also needs to be addressed. There needs to be enough space for the travellers waiting for the train and the travellers getting of the train.

GOALS

The goal of my graduation project is to design a transport hub for 2030 that combines current and future forms of transport. This goal is split into themes that I find important for a transport hub for the future.

The first theme is that I aim to contain **all the types of transport under one roof**. This way, travellers don't have to leave the building when switching between types of transport. This requires connections in the building between the types of transport.

The second theme is that the inside of the building is **flexible**. This means that the inside is able to be modified. To make this possible, the roof will be separate from the inside to create a flexible interior. The building will be designed for the 2030 and beyond. The future can change, and the building needs to be able to adapt to this change.

The third theme is the **combination between the new and the old building**. The chosen location will be an existing station. Therefore, the relationship between the new and old building needs to be defined. Most of the current building will be redesigned, but the facade at the Rue Saint-Lazare will be kept. Even though the new station will be mostly new construction, the exterior lines of the old building will be retained.

The last theme for the project is to create a **cathedral-like station hall**. I believe a station is defined by its hall. This is the place where departing travellers enter the building and where arriving travellers are introduced to the city.

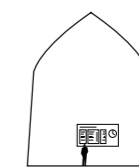
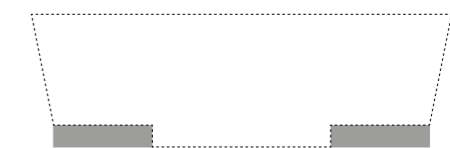
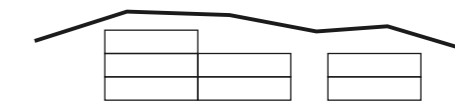
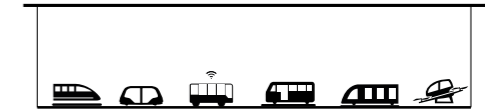


Image 48: Concept images of goals for the project



PROGRAM

This chapter describes what will be in the transport hub. It starts from the point of the current station and will transform into a program for a transport hub for the future. The program of the transport hub will be arranged in the domains stated above. Additionally, this chapter discusses the goals of the transport hub, which are the foundation of the design.

PASSENGERS

The basis of the program is the number of passengers that the transport hub will transport. The current passenger numbers are transformed according to the needs of the future.

In the future, more diverse transport will be needed. The direction of the travellers is current from and to the trains. The trains will become more diverse with the addition of the regional train. This will increase the number of intercity passengers. Additionally, the types of transport to and from the transport hub will be increased with the addition of PRT and drone taxis. This will decrease the number of regional trains, because the new types of transport will offer an alternative.

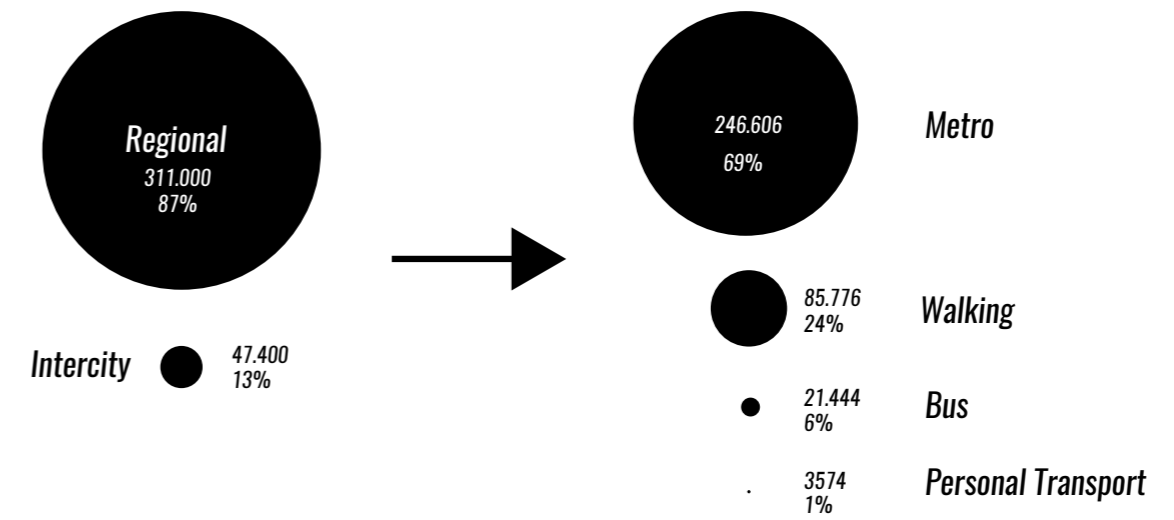


Image 49: Current passenger numbers for Saint Lazare station

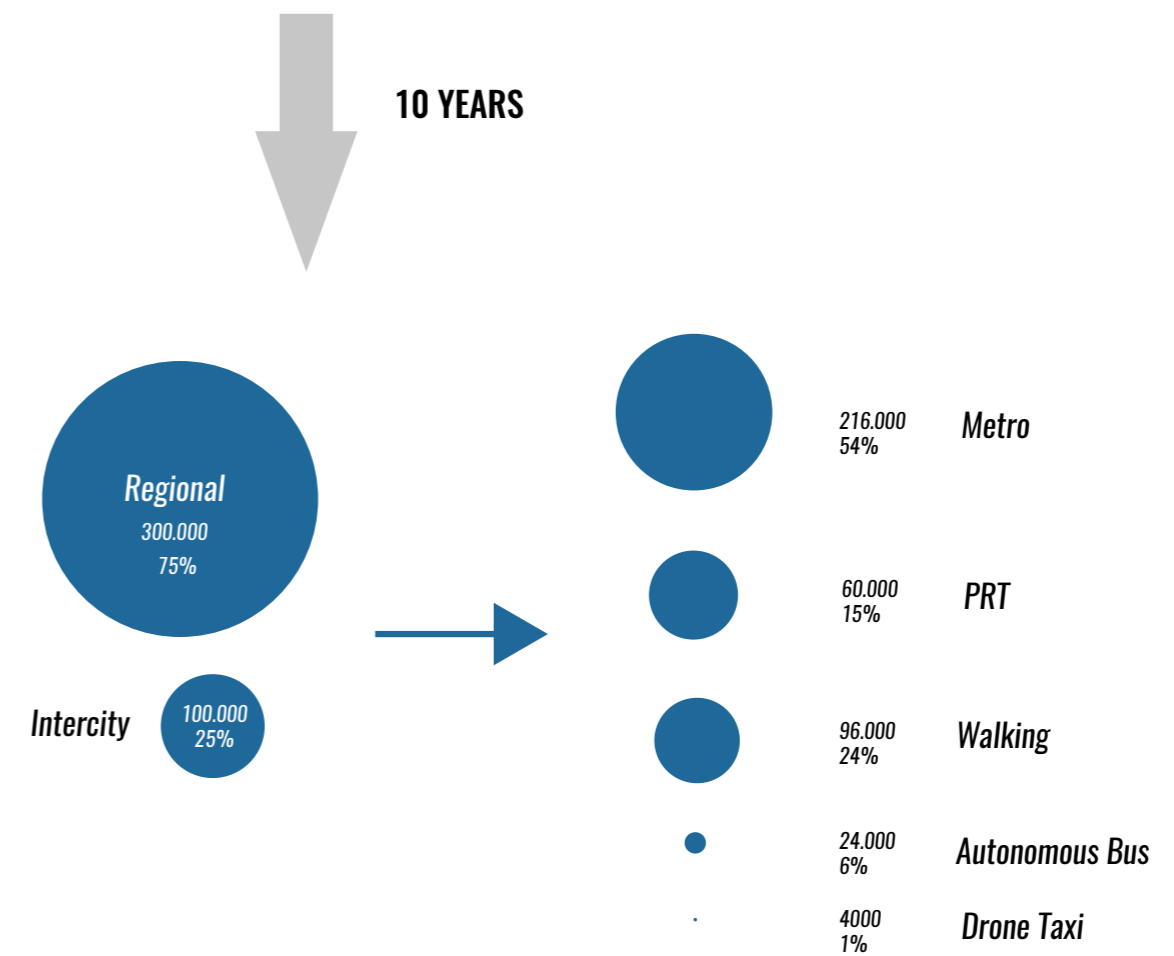


Image 50: Future passenger numbers for the Transport Hub

PROGRAM

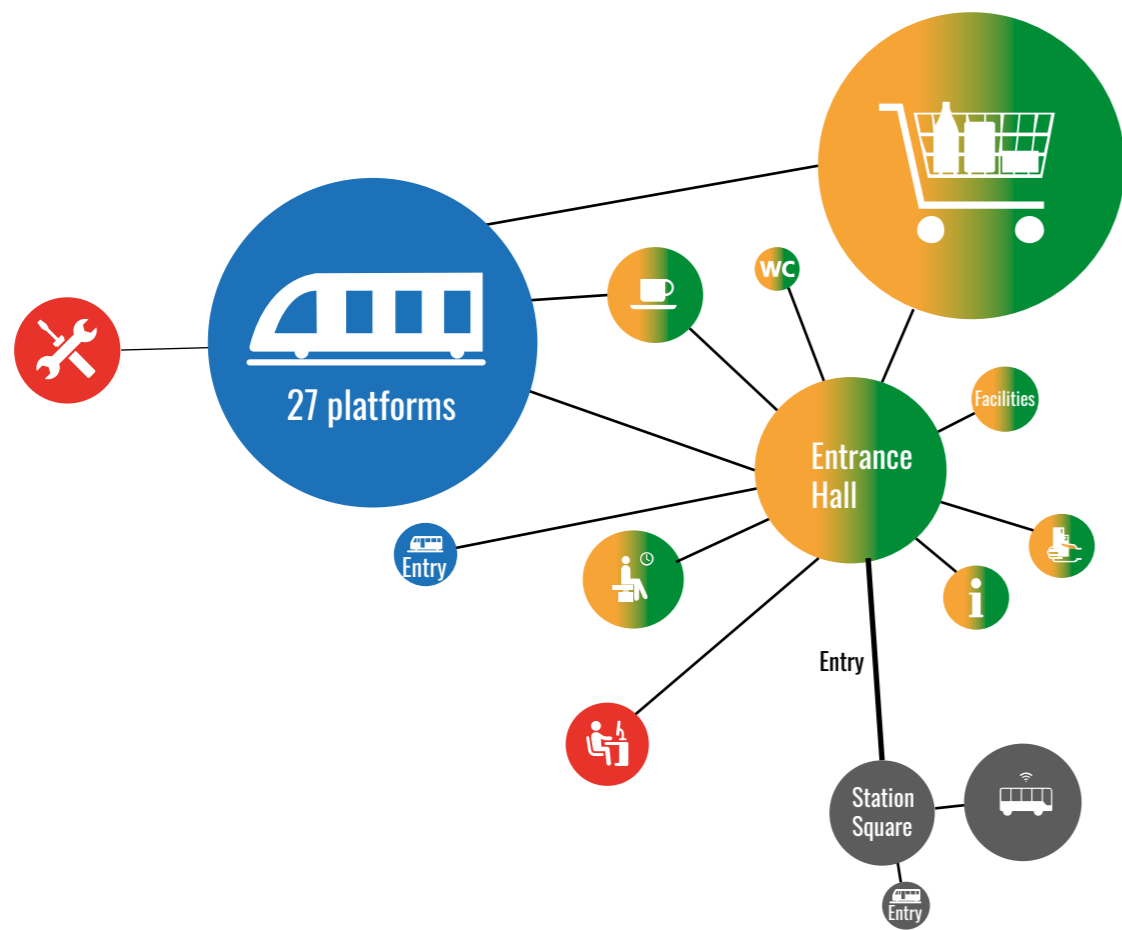
The transport numbers will form the base for the program scheme of the transport hub. The number of platforms will be determined based on the number of passengers. The number of platforms for the trains will not change. This is partly because there is no space to create extra tracks in the surrounding, but mainly because the trains in the future will follow up each other faster. Therefore, no more tracks will be needed.

The stay domain of the transport hub will change its function. The emphasis won't be on retail, but on workspace. The location analysis shows that most travellers are commuters and that the district is a place of work. A conference space and workspaces add functions that are relevant for the area and will improve the station. These spaces will be particularly valuable in the future, since people are increasingly working from home

or other workspaces. In addition, start-ups and other small businesses could use these workspaces. Small meeting rooms can give people from all over the city a central meeting place without having to leave the station. The retail in the stay area will focus on the workspaces and conference space. The shops will aim to provide for working people, for example, print and office supply shops.

The back domain will include more office space. North of the stations is an office building from the French railway company. These offices will be incorporated into the transport hub. This will give the employees a connection to the transport.

- Surrounding Domain
- Reception Domain
- Travel Domain
- Stay Domain
- Back Domain



10 YEARS

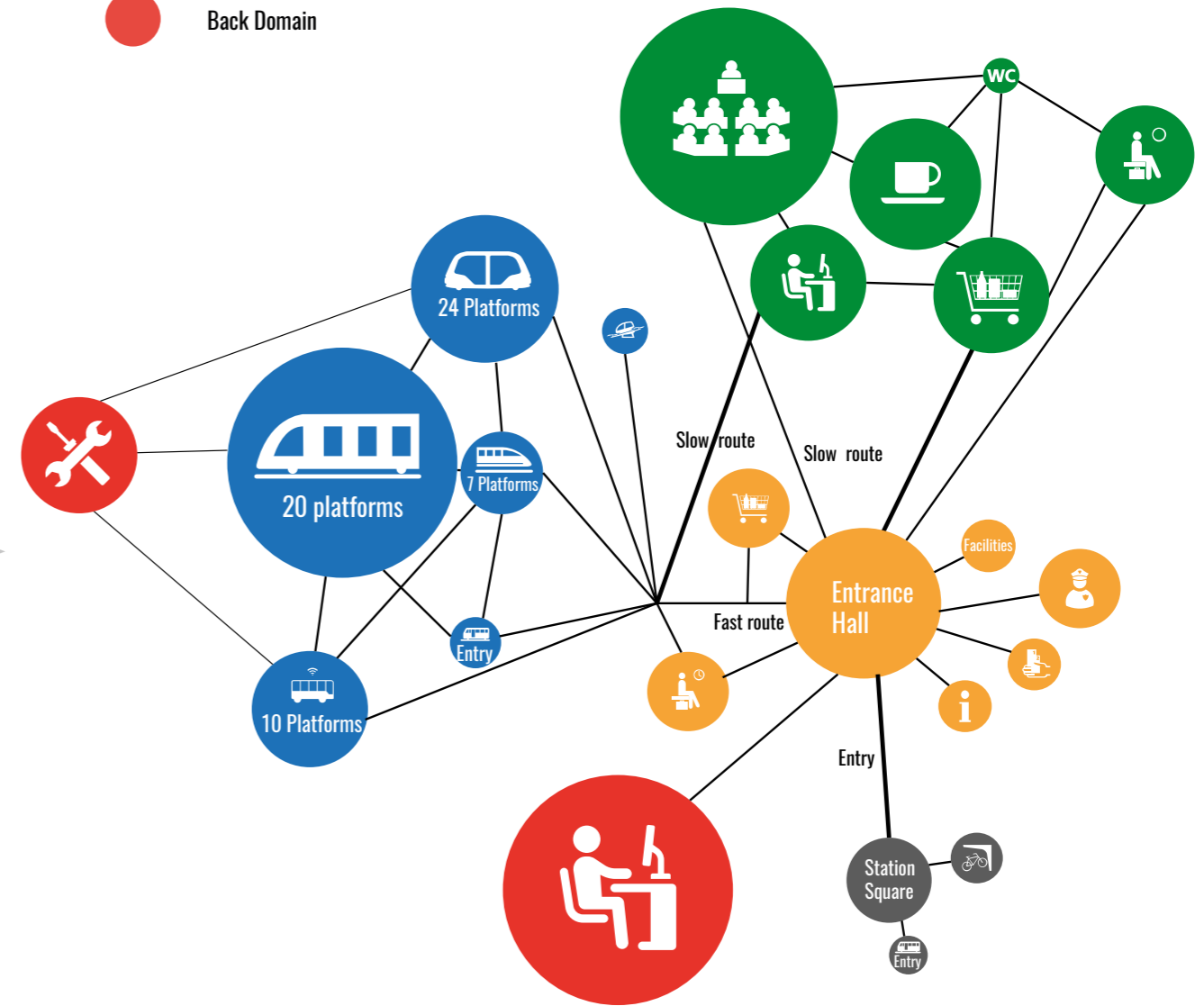


Image 51: Program of Saint Lazare station

Image 52: Program of the Transport Hub

The first step of turning the program into a design is to put the program on the site. The location of the metro and the train is already fixed. The other forms of transport are arranged around the fixed transport types. The transport types are located on different levels around a central hall. The functions of the back domain are located at the edges of the building. The reason for this is to have the functions connected to the reception domain and have a connection to the outside.

The functions of the stay domain are placed above the reception domain. The stay area is separated to create a calm area without passengers running by. The offices are placed above the stay domain.

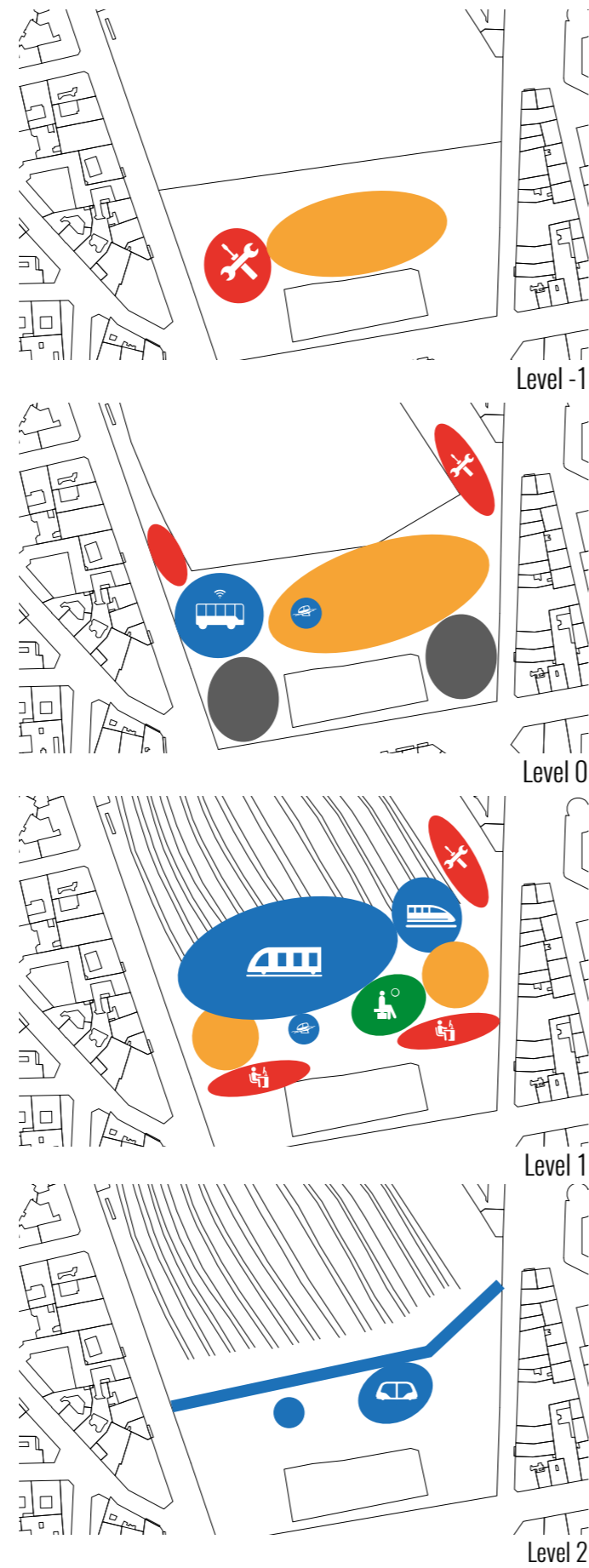
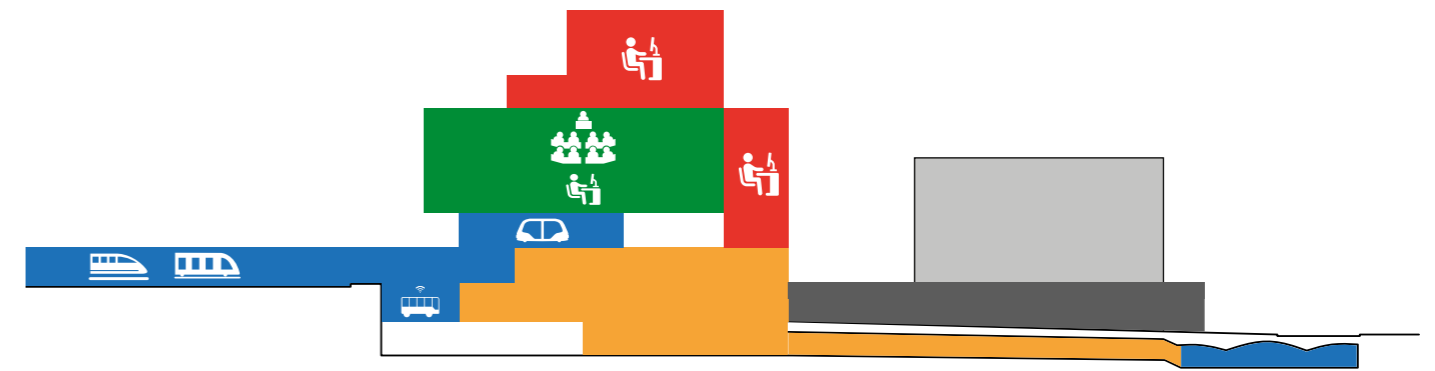
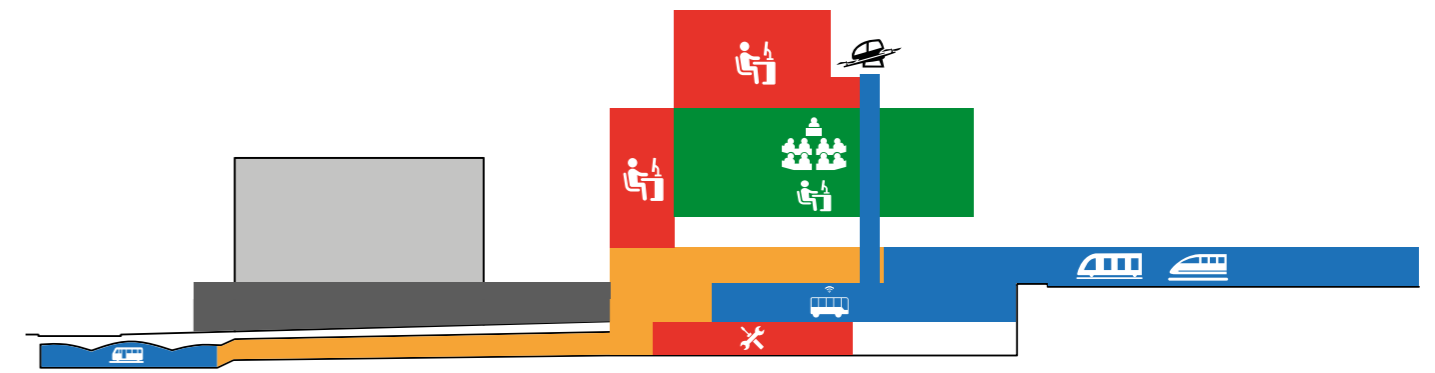


Image 52: Scheme plan of domains on the site



Section to the east side



Section to the west side

Image 53: Scheme section of domains on the site

PASSENGER ROUTES

To design the transport hub, it is necessary to know where people are moving to and from. Firstly the transport was placed in the building. Together with the passenger numbers and the user research, it is possible to sketch an idea of how a type of user would move through the building. The passenger numbers were calculated for the peak hours. As mentioned before, during the peak hours the number of passengers increases by 90%. To anticipate this peak, the average number of passengers is doubled. This will give an estimate of how

many passengers will be moving around the transport hub at the peak hours.

When all the types of users are combined, the complete flow of people becomes visible. The biggest traffic nod in the scheme is where the metro crosses the trains, as the flow of people is highest to and from the metro. This flow needs to go up or down multiple levels, which creates places where traffic point can originate.

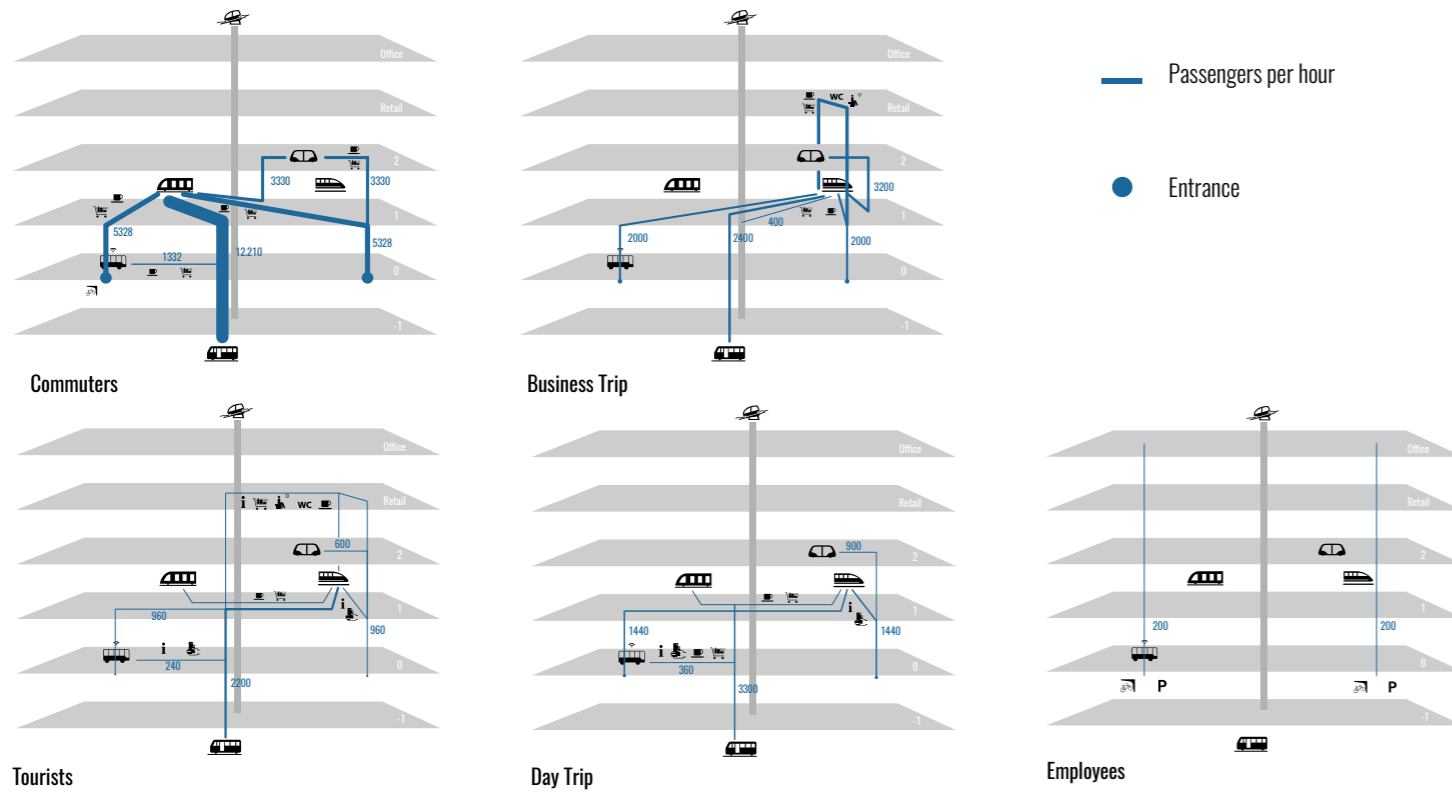


Image 54: Scheme of routing and facilities per user

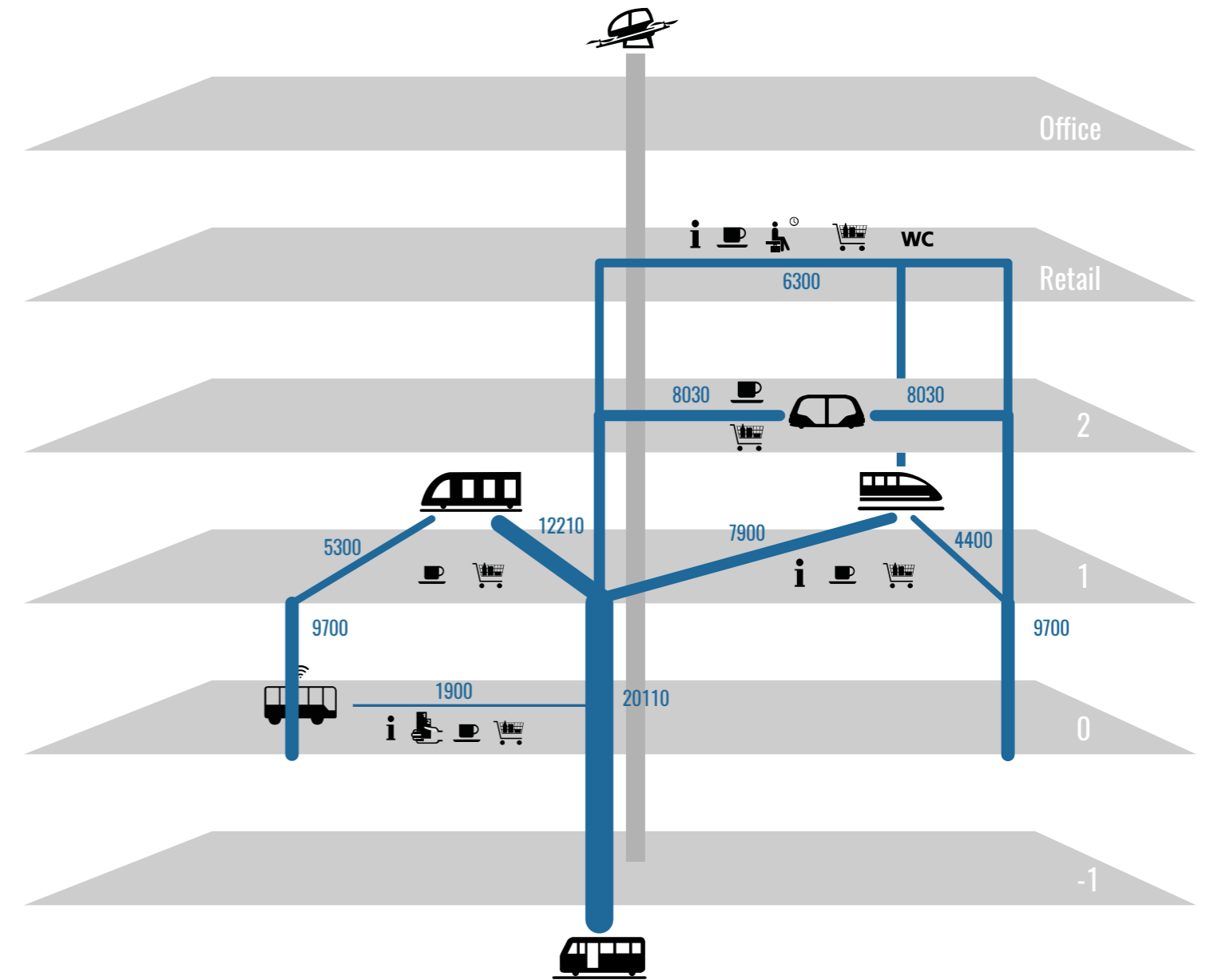


Image 55: Scheme of routing and facilities for all users

ARCHITECTURE

A building is not just the placing of functions in a space. Spaces have different atmospheres that add to the experience of the building. The architecture of a space gives it a specific atmosphere. The transport hub has various users who want diverse experiences. Therefore, different part of the transport hub will need different atmospheres. The transport hub can be divided into three sections.

First is the travel section, which is a public area. This section contains travellers and people visiting the building or meeting in it. The travel section needs to be an **open and inviting** space. The travel section is where travellers enter and exit the city and needs to welcome them. There is a lot of movement in this section, which makes it important that the spaces are open and clear.

The second is the conference and public work section. This is a semi-public space—it is public, but people need to rent or reserve the spaces. This section needs a **comfortable**

atmosphere for work and good acoustics. It has a warm and luxurious expression. This section has a visible connection to the travel section to give the users the experience of the station without entering the travel section.

The third is the office section. This section includes the offices of the French railway company (SNCF). The offices are private spaces. The offices will be a **generic design that can be adapted** to the needs of the SNCF.

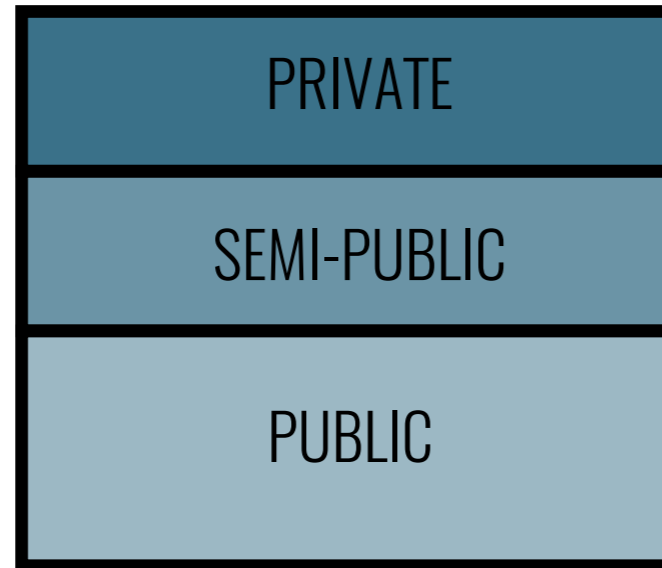


Image 56: Scheme of division between private and public

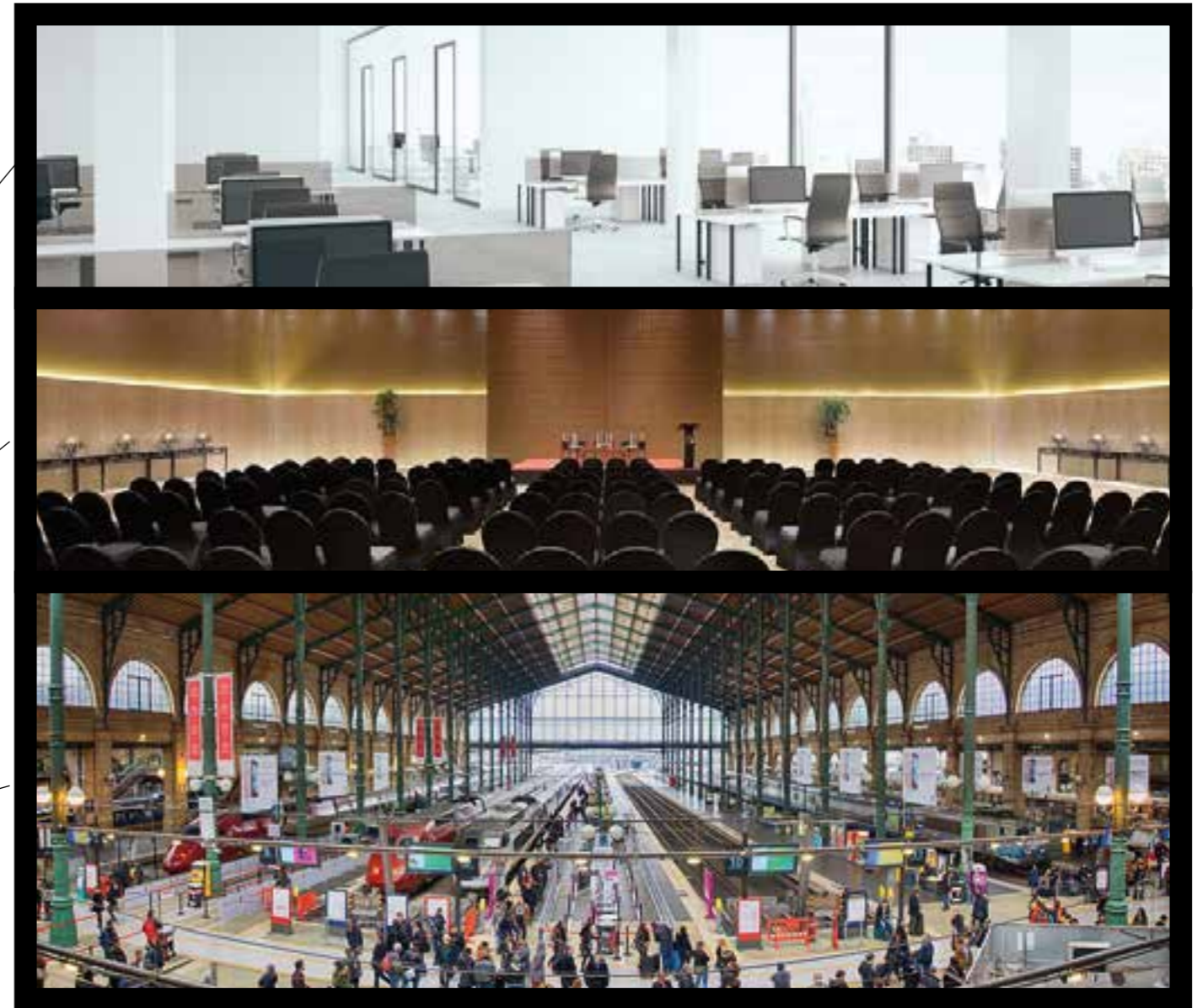


Image 57: Different atmospheres in the transport hub



DESIGN

TRANSPORT CONCEPT

This chapter discusses the design process of the transport hub. It shows how the design came about and the result.

The building was designed from the inside out. One of the design goals is to separate the interior and the exterior of the building. This means that the process starts with designing the interior spaces. Starting with the transport. The most important aspect of the design is the transport. The first step in the design process is to arrange the transport within the building.

The starting point was to put the transport on the level that it runs on. That meant the ground level for the busses and PRT, because they run on the street, and the top level for the drones. To make the station reflect the complexity of the diverse transports of the future, the scheme of the location of the transport types has transformed. The slope of the area

was used to create a difference in the levels of the transport types—the PRT is raised above the level of the trains. The track stays on the same level, while the road level rises until they meet (see image 59).

The placement of the drones has shifted from the top of the building to come into the building. There are landing platforms on the roof, but the travellers will not board the drones from the roof. There are vertical lifts that will bring the drones into the building. The travellers can enter the drones on multiple levels in the building through the lifts.

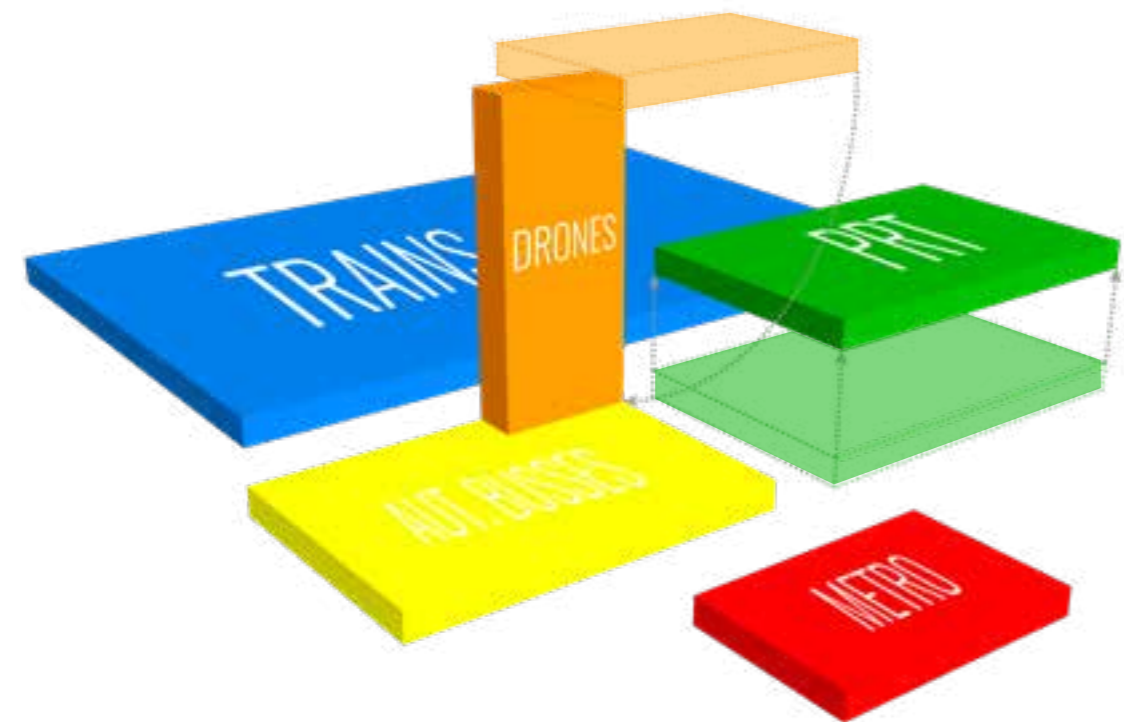


Image 58: Scheme of placement of the transport

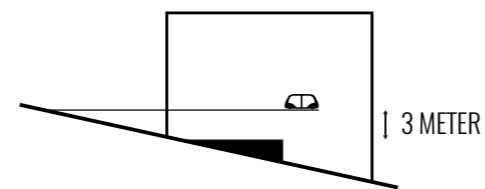


Image 59: Scheme of placement of PRT track

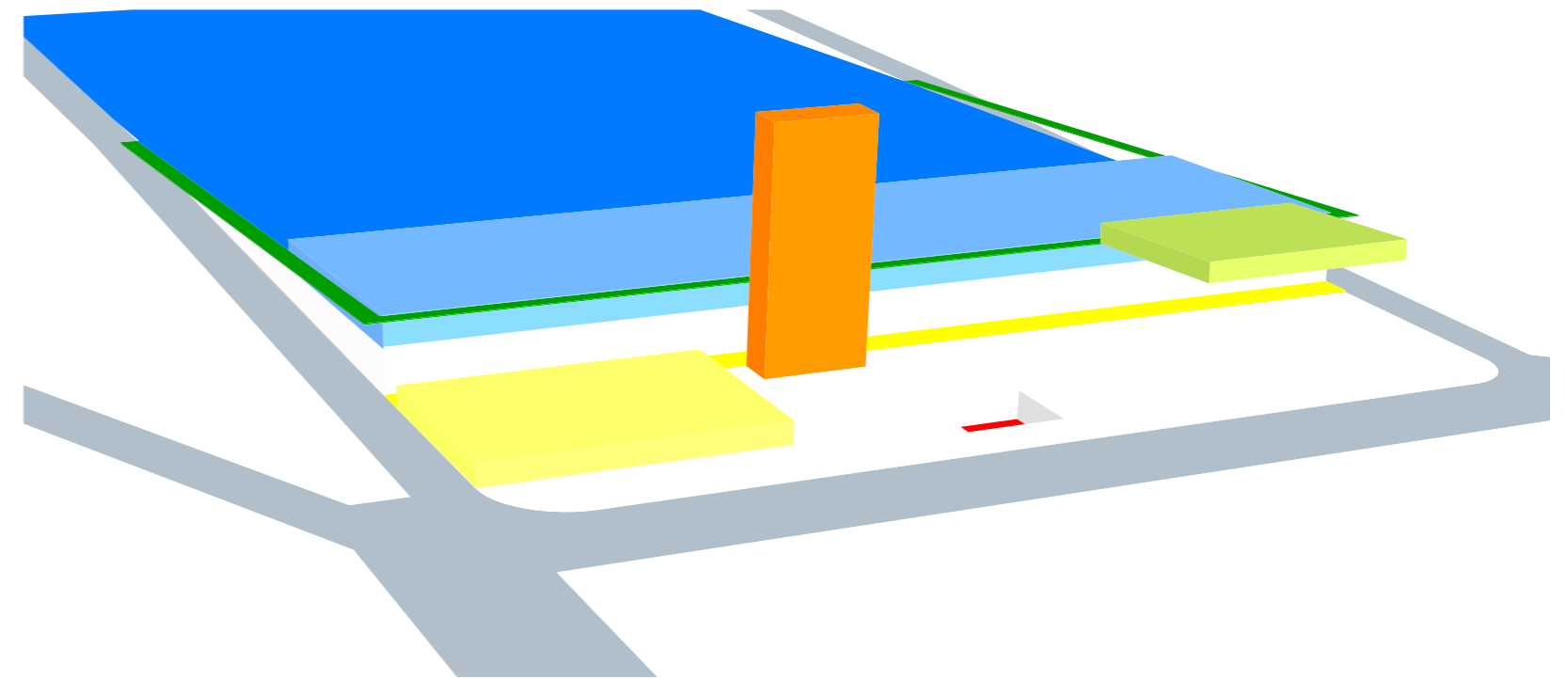


Image 60: Scheme of placement of the transport and its platforms

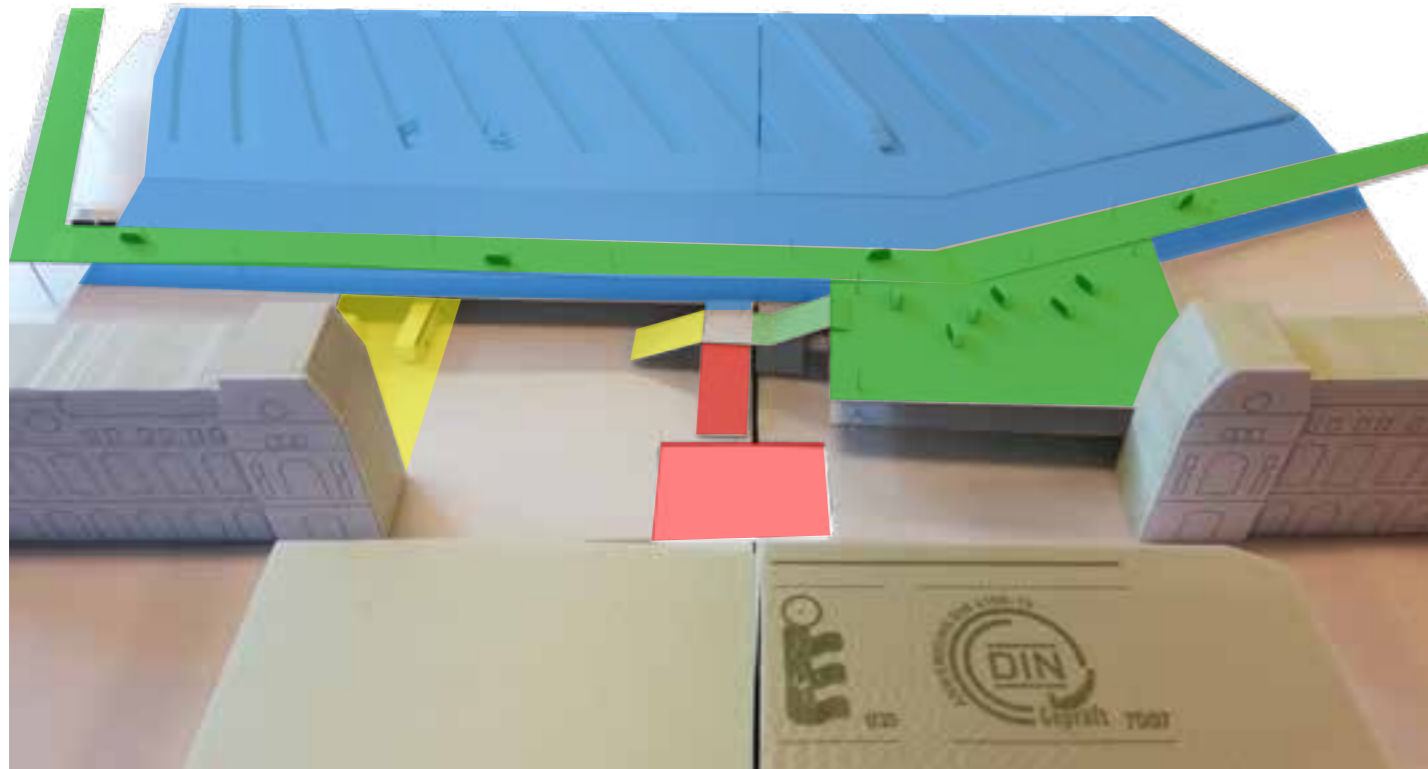


Image 61: Model with vertical elements to the transport

Vertical transport becomes an important factor in a building when it contains movement between levels. Because the transport in the transport hub is spread across several levels, the travellers must be able to easily move between levels. The program showed that the biggest traffic nod was in the middle of the building. This nod is created in the building as

an intersection with a platform where all the transport routes meet. The crossing was designed using a scale model of the site and creating bridges between the levels. Besides a vertical element, the intersection of stairs will function as an architectural element in the central hall.

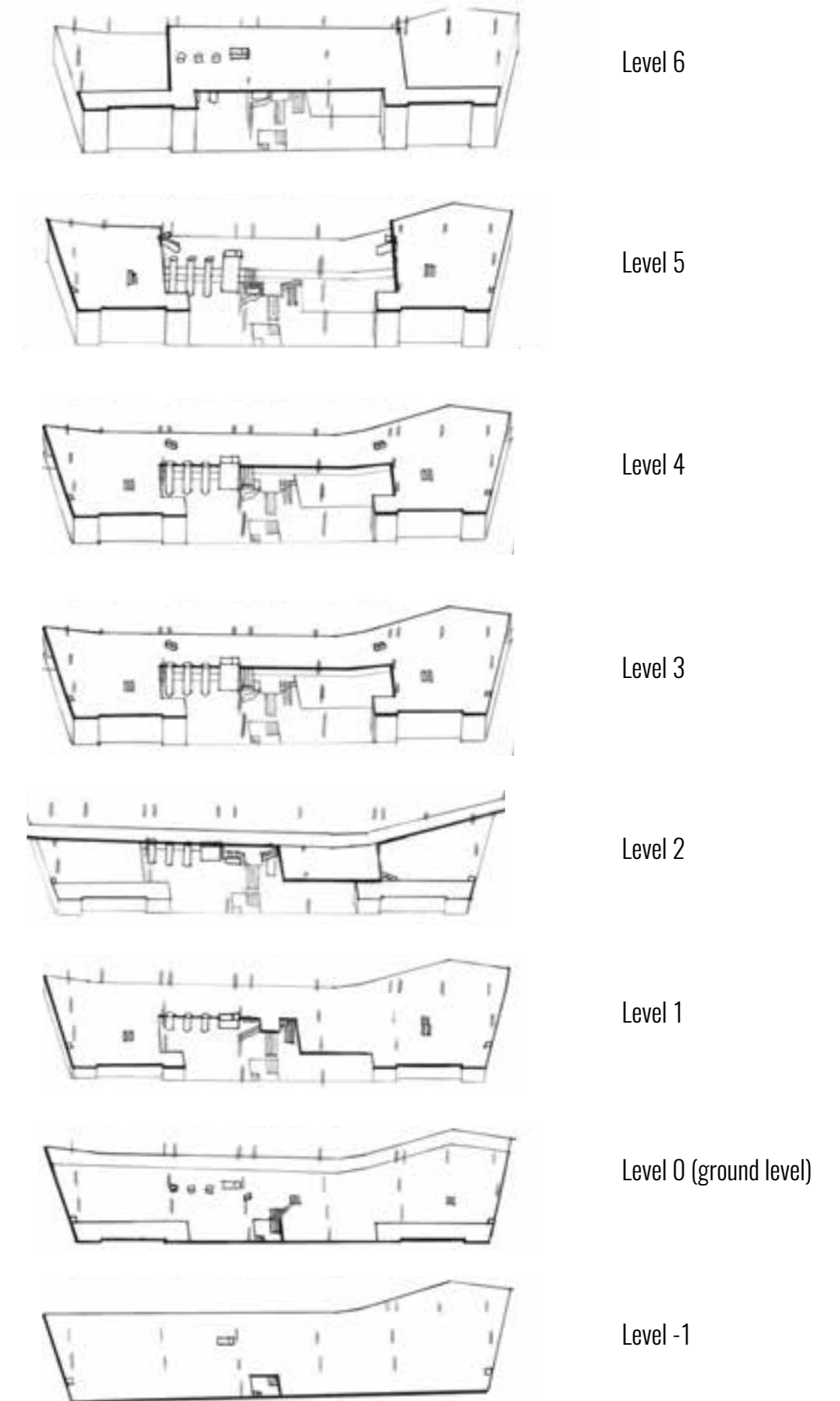


Image 62: Sketch of floor plans

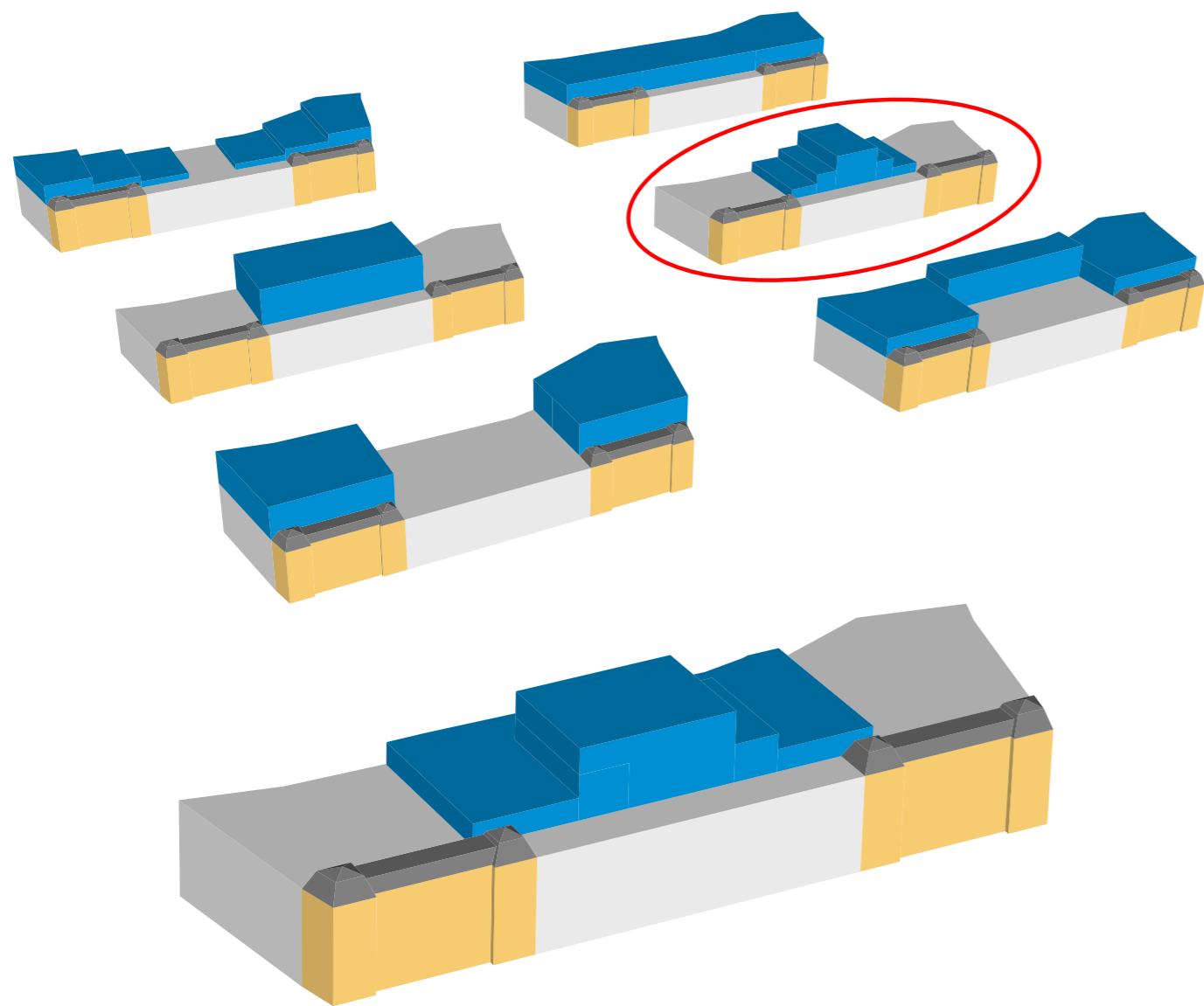


Image 63: Form study

The transport hub will house additional functions besides the transport. One of the set goals is to keep the building within the site lines of the old building. This means that the additional functions will be added on top of the transport section. There are several possibilities for this addition. I chose the option

where the volume raises in the middle. This volume connects the two parts of the old building. The transport hub will be more visible, because the addition in the middle of the hub extends above the building in front.

- Vertical element
- Transport
- Public work space
- Conference
- Private office

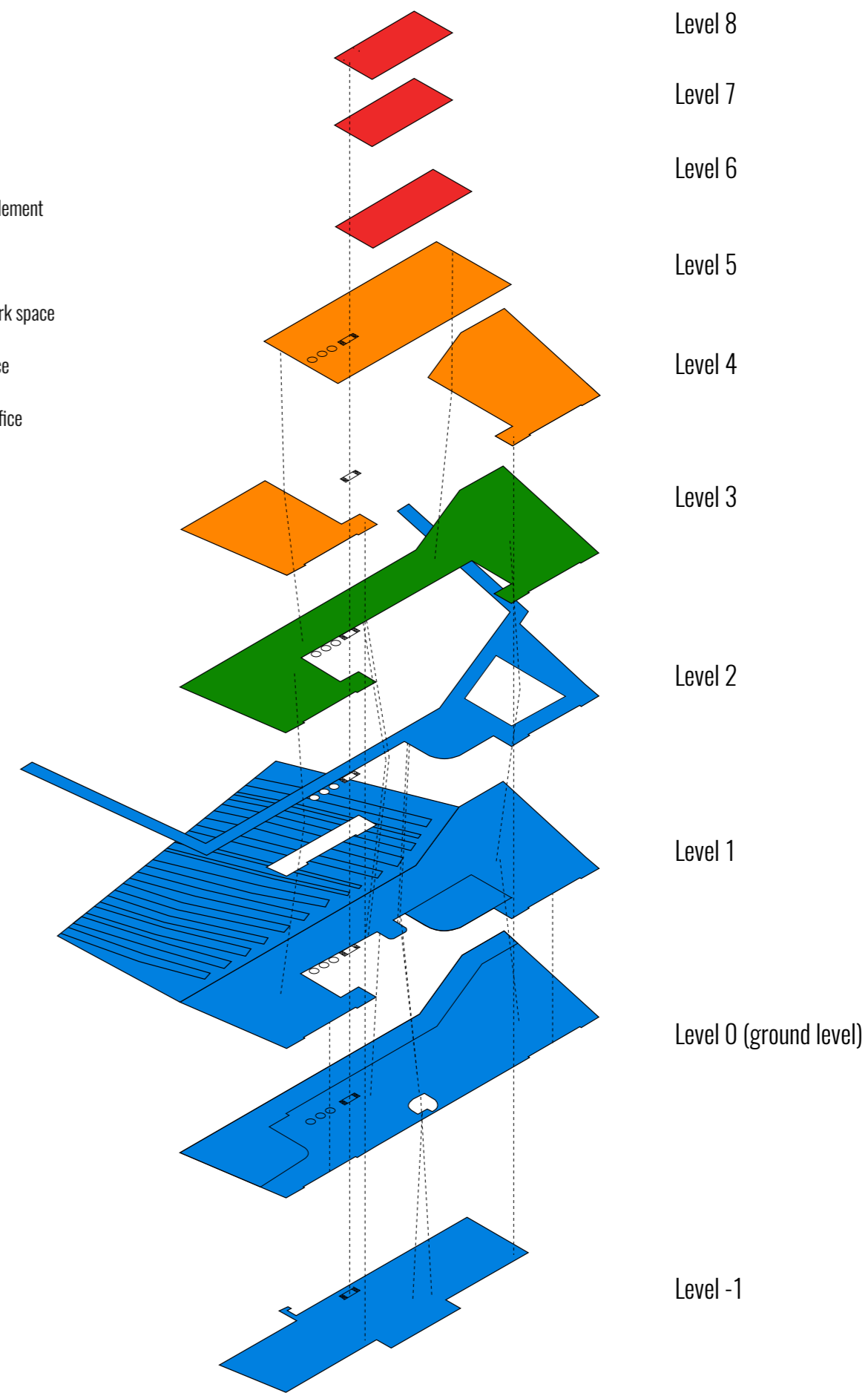


Image 64: Scheme of major functions

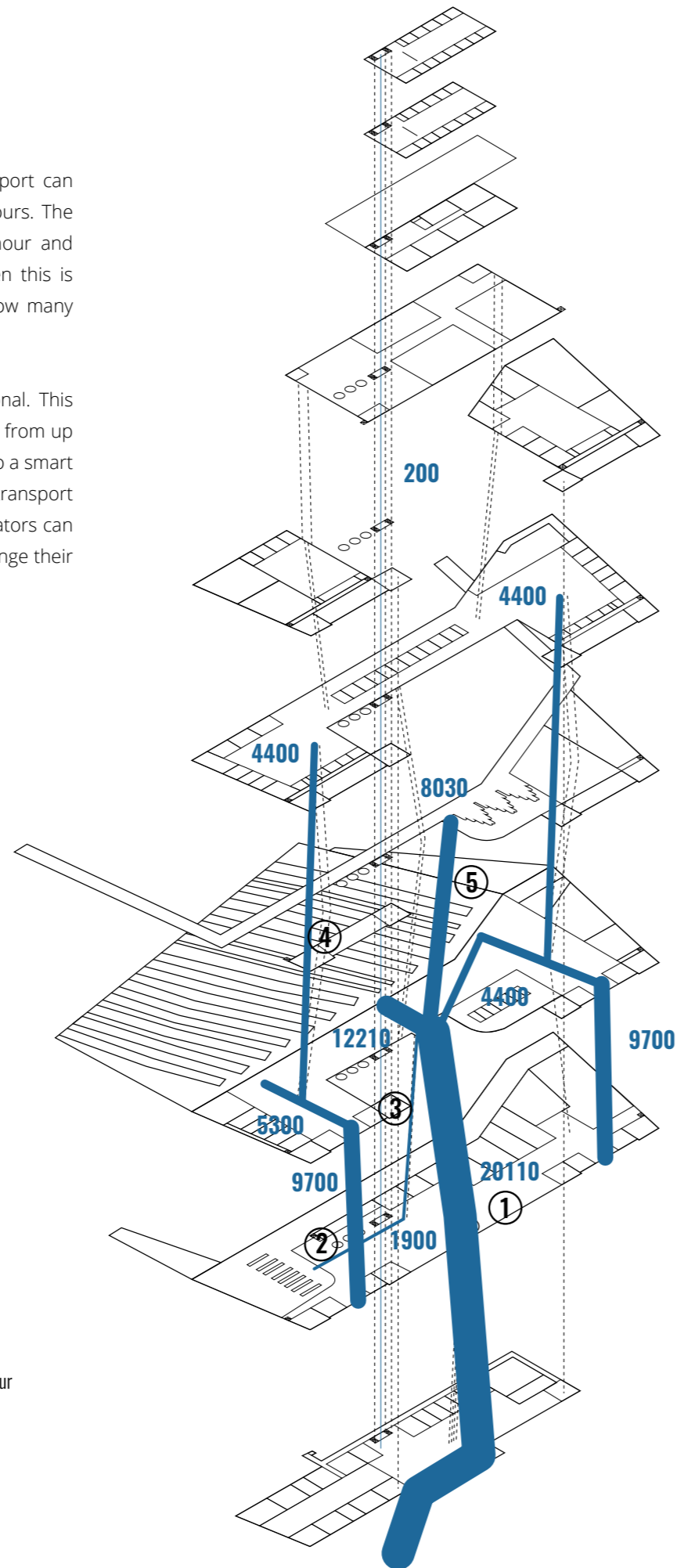
VERTICAL TRANSPORT

For the building, it is crucial that the vertical transport can handle the number of travellers during the peak hours. The program calculated the number of travellers per hour and showed how they move through the building. When this is combined with the floor layout, I could calculate how many vertical elements are necessary.

The escalators in the building will be multi directional. This means that the direction of the escalator can change from up to down. In the future, the station will be connected to a smart system that knows how many passengers are on the transport types and what direction they are moving. The escalators can anticipate to the direction of the passengers and change their direction accordingly.

The elevators are not taken in consideration in some of the vertical routes, because only 5% of the passengers use the elevator. Every transport type must be accessible through elevator, but each transport doesn't need its own elevator. The program calculated how many elevators are needed in the entire building, taking the upper floors into account.

The users of the upper levels, like the conference floors and private office floors, are primarily using the elevator. These users are also more likely to arrive at the same time. To take this into account, the total capacity is used as the people flow per hour.



Capacity of vertical elements

| Element | Size | Use by passengers | Persons per hour |
|-----------|---------------|-------------------|------------------|
| Escalator | 1 meter wide | 80% | 6000 |
| Stair | 2 meters wide | 15% | 6000 |
| Elevator | 17 persons | 5% | 950 |

Table 4: Capacity of vertical elements ²³

1: Metro to Train - 20110 persons per hour

| Element | Number | Persons per hour |
|--------------|--------|------------------|
| Escalator | 3 | 18000 |
| Stair | 1 | 6000 |
| Elevator | - | - |
| TOTAL | | 24000 |

2: Building Entry- 9700 persons per hour

| Element | Number | Persons per hour |
|--------------|--------|------------------|
| Escalator | 2 | 12000 |
| Stair | - | - |
| Elevator | - | - |
| TOTAL | | 12000 |

3: Autonomous busses 1900 persons per hour

| Element | Number | Persons per hour |
|--------------|--------|------------------|
| Escalator | 1 | 6000 |
| Stair | 1 | 6000 |
| Elevator | - | - |
| TOTAL | | 12000 |

Table 5: Vertical elements needed per area

4: PRT - 8030 persons per hour

| Element | Number | Persons per hour |
|--------------|--------|------------------|
| Escalator | 1 | 6000 |
| Stair | 1 | 6000 |
| Elevator | - | - |
| TOTAL | | 12000 |

2: Work area - 4400 persons per hour

| Element | Number | Persons per hour |
|--------------|--------|------------------|
| Escalator | 2 | 12000 |
| Stair | - | - |
| Elevator | - | - |
| TOTAL | | 12000 |

Elevators

| Function | Persons per hour |
|----------------------|------------------|
| Transport | 2000 |
| Conference | 4000 |
| Office | 200 |
| Total persons | 6200 |

→ 7 Elevators

FUNCTION LAYOUT

UNDERGROUND

The underground level is the connection between the metro and the transport hub. This level houses functions for the passengers coming to and from the metro, like an information desk and shops for small purchases. The baggage storage and lost and found are placed in the underground level, because they require a big space and don't need to be in the direct route of the travellers. The logistical part of the back domain is located on this level, because it's out of sight of the travellers and close to the ground level where the goods come in.

INTERNATIONAL TERMINAL

Because the maglev train will have international connections, an international terminal is required. This is not necessary for every connection, but is for Great Britain, because they are not part of the EU. The terminal starts at the first floor, with a check-in that's connected to customs. From the customs, the travellers go up the stairs to a waiting area. This area has a separate connection to the train tracks.

OLD BUILDING

The functions in the existing building are helpful to the employees. These areas are convenient, because they have a vertical routing separate from the central hall. The second and third floor houses canteens and offices for the employees of the transport hub. The fourth floor contains functions that support the conference hall. Functions are, for example, offices and storage.

CONFERENCE

The conference area is spread over three areas on two different levels. All these parts have an open reception area where food can be facilitated, which allows the parts to function separately from each other.

OFFICE

The first of the office floors functions as the control centre of the transport. All the transport runs autonomously, but the systems that drive the transport need to be regulated. Each transport type has a control room where people observe and regulate the transport.

SPACES TO BE DETERMINED

The buildings are in front of the train platforms. To connect them, spaces are created on the side of the platform. These spaces create a logical shape of the building envelope and will help create a logical roof shape. These spaces are not a part of the transport hub, but can be used for functions related to transport of that can be used by the travellers.

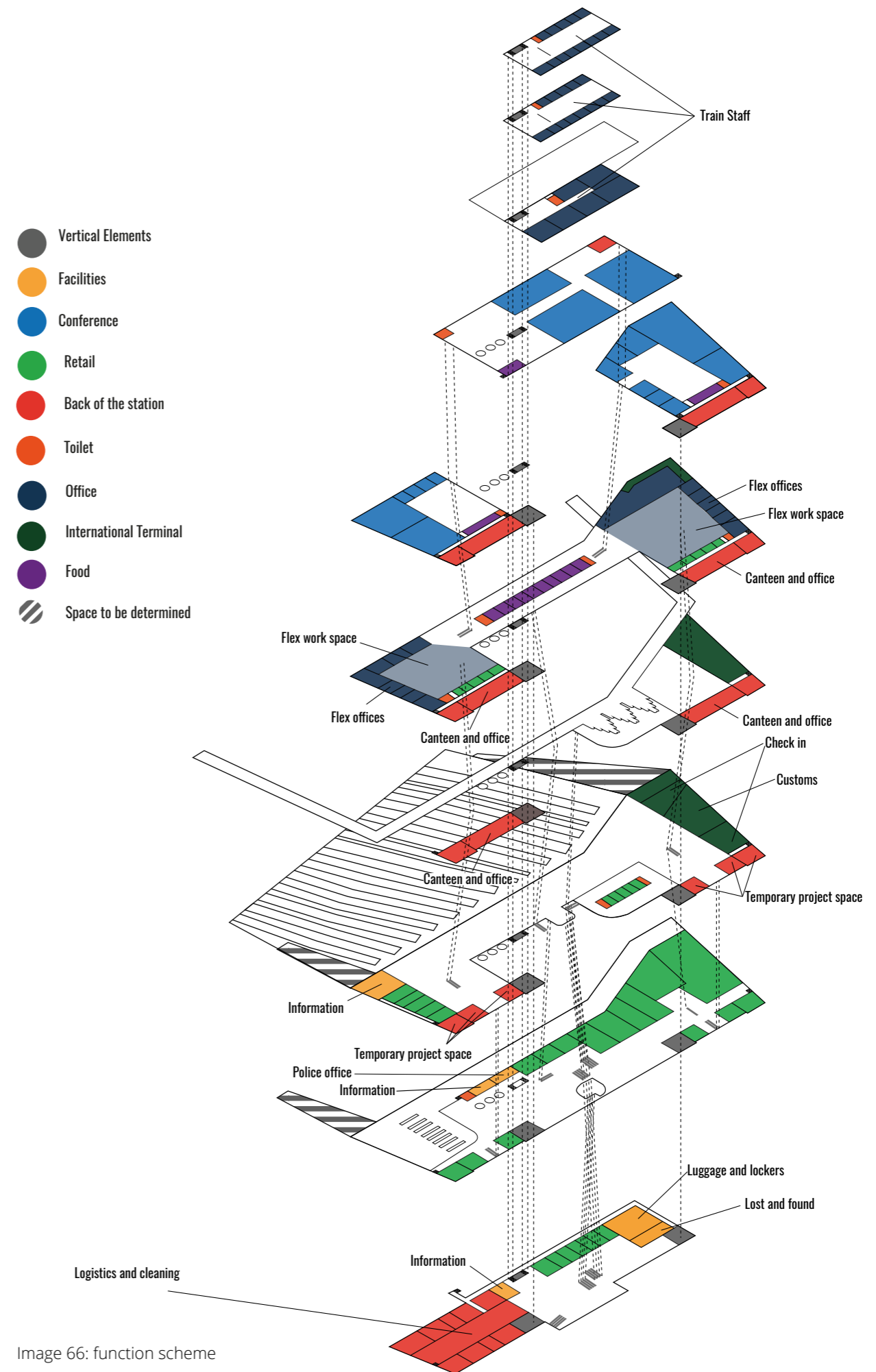
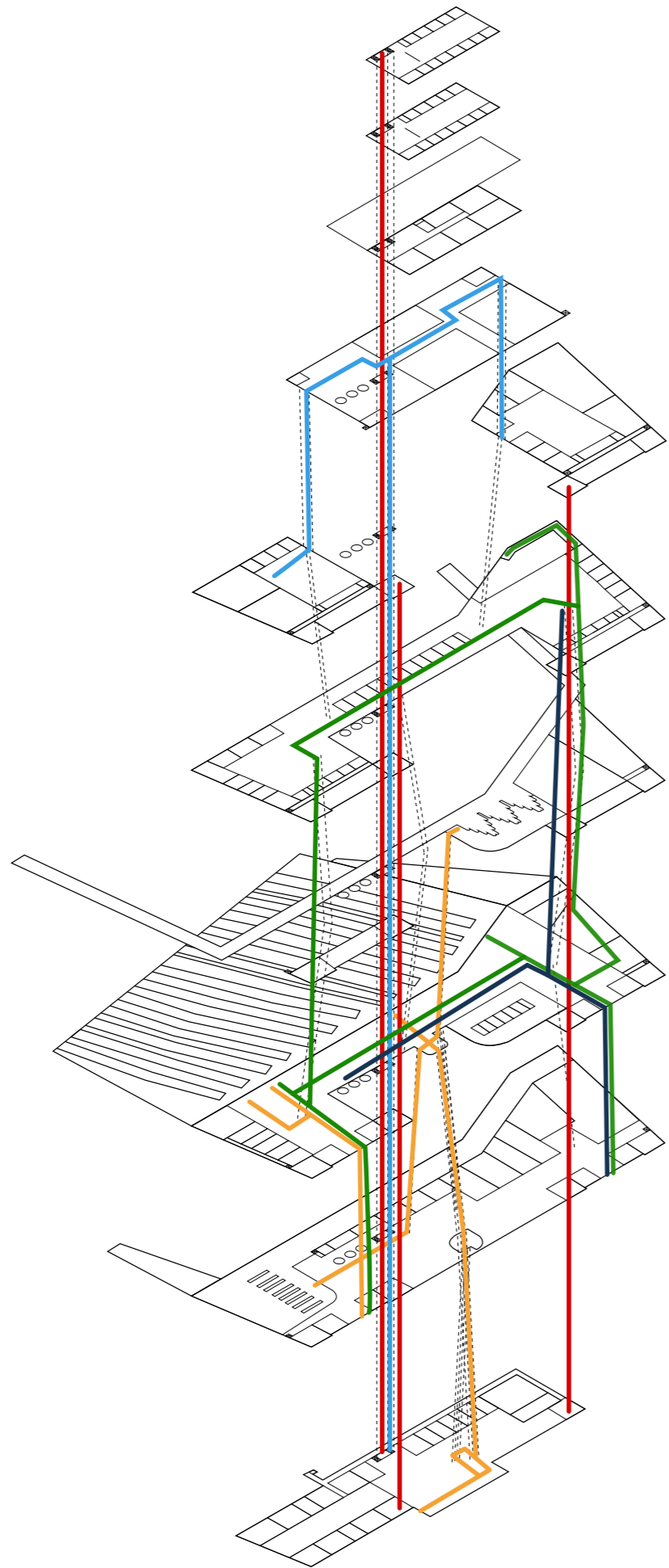


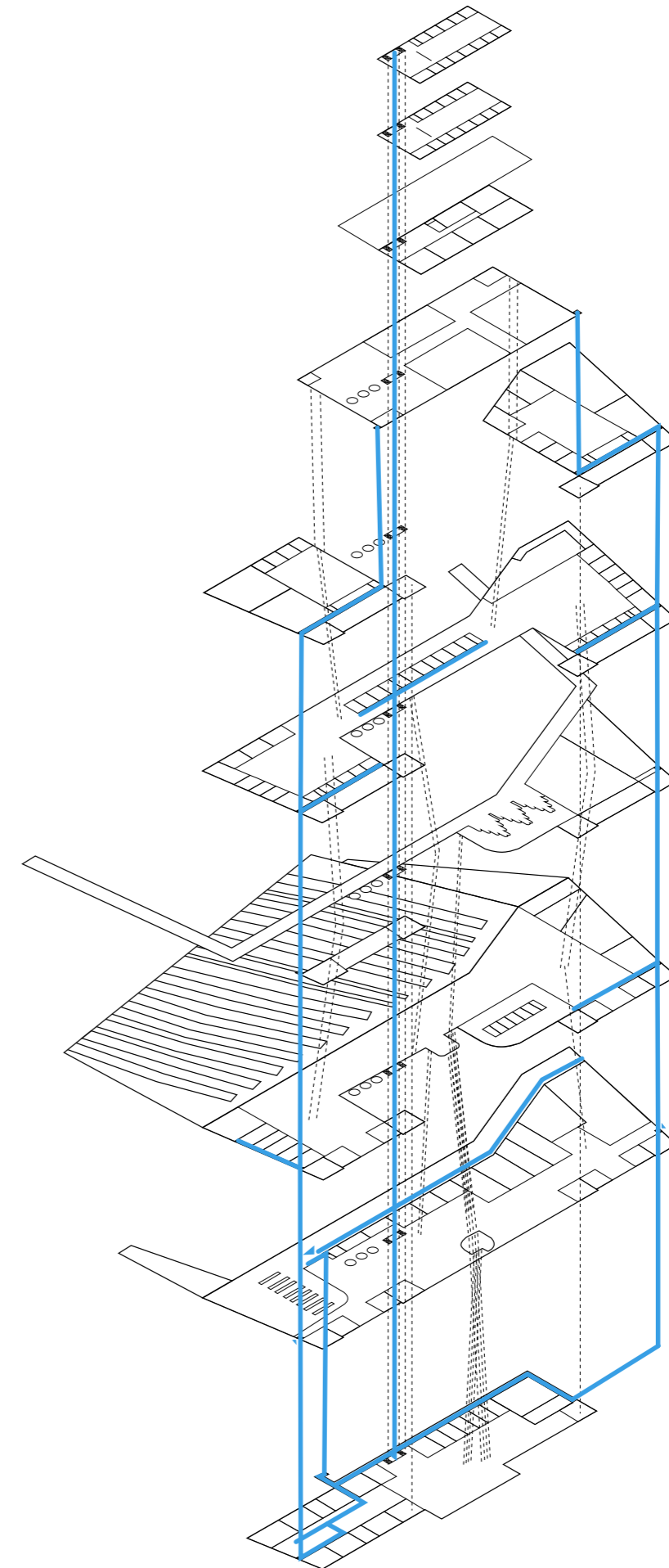
Image 66: function scheme

ROUTING



- Commuters
- Conference
- Employees
- Business trip
- Tourist and day trips

Image 67: User routing scheme



- Logistics Routing

Image 68: Logistical routing scheme

EXTERIOR

Now that the interior design of the transport hub is established, it is time to design the exterior of the building. The goals of the project state that the roof is a permanent element that is separate from the interior of the building. This means that it has to have a separate structure not supported by the interior. The initial idea for the roof was that the roof would be a blanket that falls over the interior. There was experimented with different materials that could form the 'blanket'. The tight cover seen at the top in the image was chosen to continue with because it created the most interesting and challenging shape. When the shape of the roof was further developed problems occurred. The shape of the front of the building was difficult

to achieve, because the roof needed to go down from the top of the building to the ground in a short distance. The second problem was that the right covering shape didn't fit the goals of the project. The goal was to have a permanent roof with a flexible interior. But the interior is not flexible when it is tightly covered.

The solution is that the roof doesn't have to cover the whole building, only all the transport. Specifically, the offices don't need to be covered by the roof. The roof can start from the top of the conference levels. This way it can be a more generic shape, which is easier to build and gives the interior more flexibility.

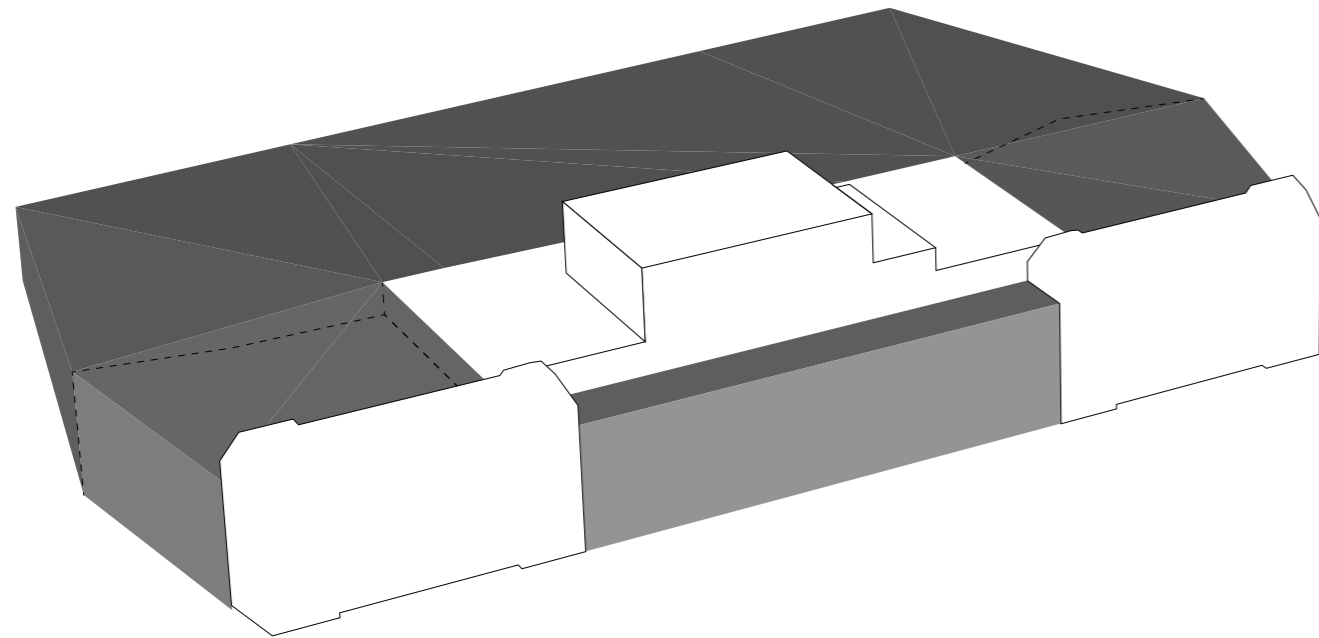


Image 69: Roof shape



Image 70: Test models for the roof

The roof is constructed of a space frame structure that is closed by panels. A space frame structure is a truss like structure that connects triangles in multiple directions, which makes the structure rigid. Its advantage is that it can be used over large spans with few supports. The structure is finished with planes that form the roof. There are two kind of panels in the roof: transparent and opaque. The opaque ones are solar panels. Because the transport of the future is electric, it is important that the building can generate energy. The transparent panels will allow daylight to enter the building at specific points. These panels are placed above open spaces, like the platforms of the trains. The panels are interchangeable, which means that if the interior of the building is changed, the panels can be changed accordingly.



Image 71: Space frame in Station Almere centrum

The exterior facade is a glass curtain system that is connected to the roof. The structure of the facade doesn't lean on columns that stand on the ground, but hangs from the roof. The trains and other transport vehicles cause vibrations in the ground, but because the facade can move freely, it can move with the vibration. This principle is used at Utrecht central, where it has been very effective. Because the roof is a space frame, it can carry the load of the facade.

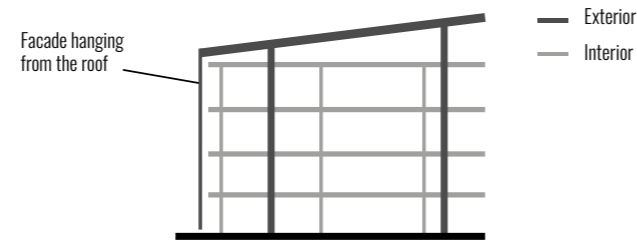


Image 72: Scheme of separation between Interior and exterior

On the side of the autonomous busses of the building (west), the facade ends on the first floor. The ground floor has a separate facade, which is foldable; this makes it possible to open up the facade. The autonomous busses can enter the building this way. The facade can close after the busses stop running.



Image 73: Column of facade at Utrecht Central Station

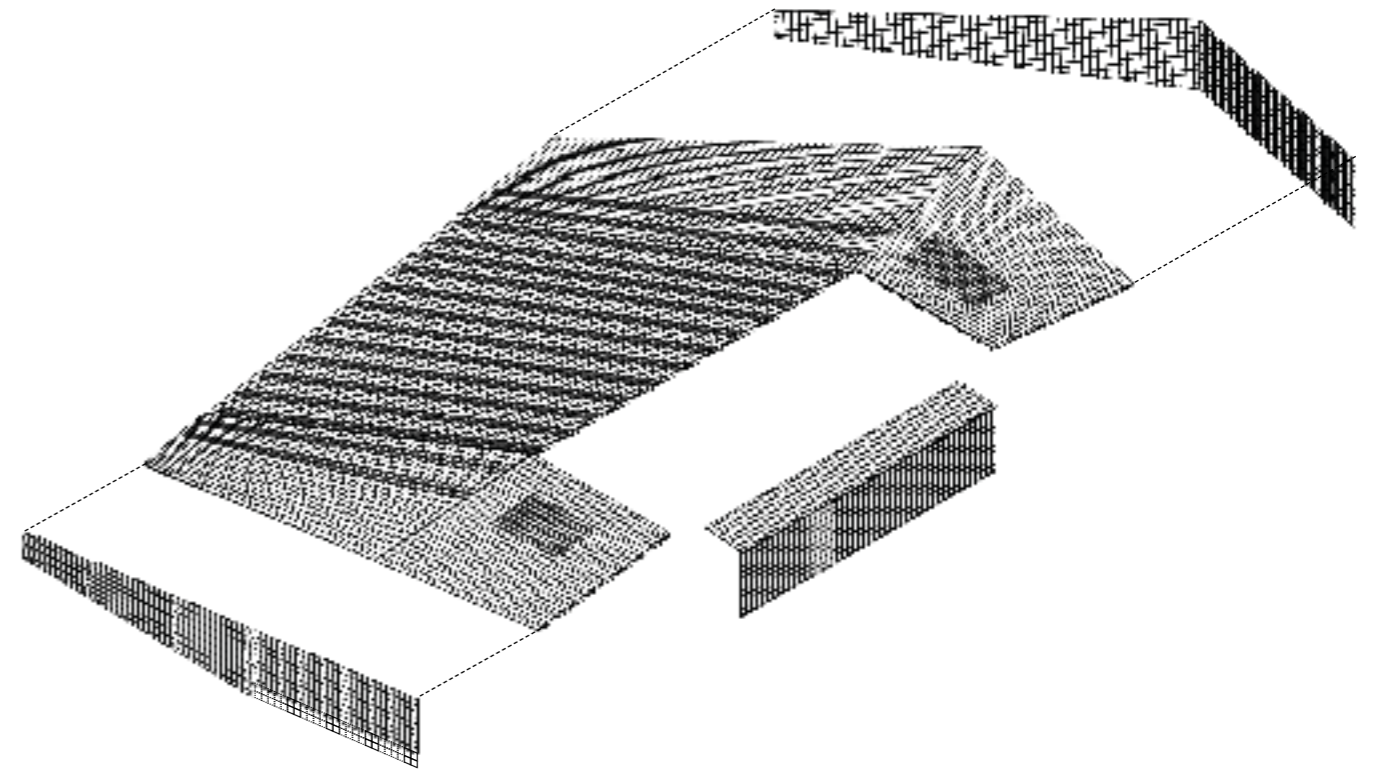


Image 74: Exterior of the building

STRUCTURE

The structure of the transport hub contains of two parts: the structure of the interior and the structure of the roof. The structure of the interior consists of round steel columns and rectangular steel beams. The floors are constructed of hollow-core slabs.

The challenge in designing the structure was the support of the floors above the central hall. Because there are multiple floors on top of the central hall and the span between the columns

was fairly large, the beams needed to support a lot of forces. The solution was to create a story high truss, constructed by rectangle steel elements. Next to the structural advantages, the truss also has an architectural advantage. The truss is visible in the façade, which creates a bridge that connects the two parts of the old building. It also creates a contrast between the old building parts and the modern structure of the truss. The columns that support the space frame roof are tree columns that split into two branches.

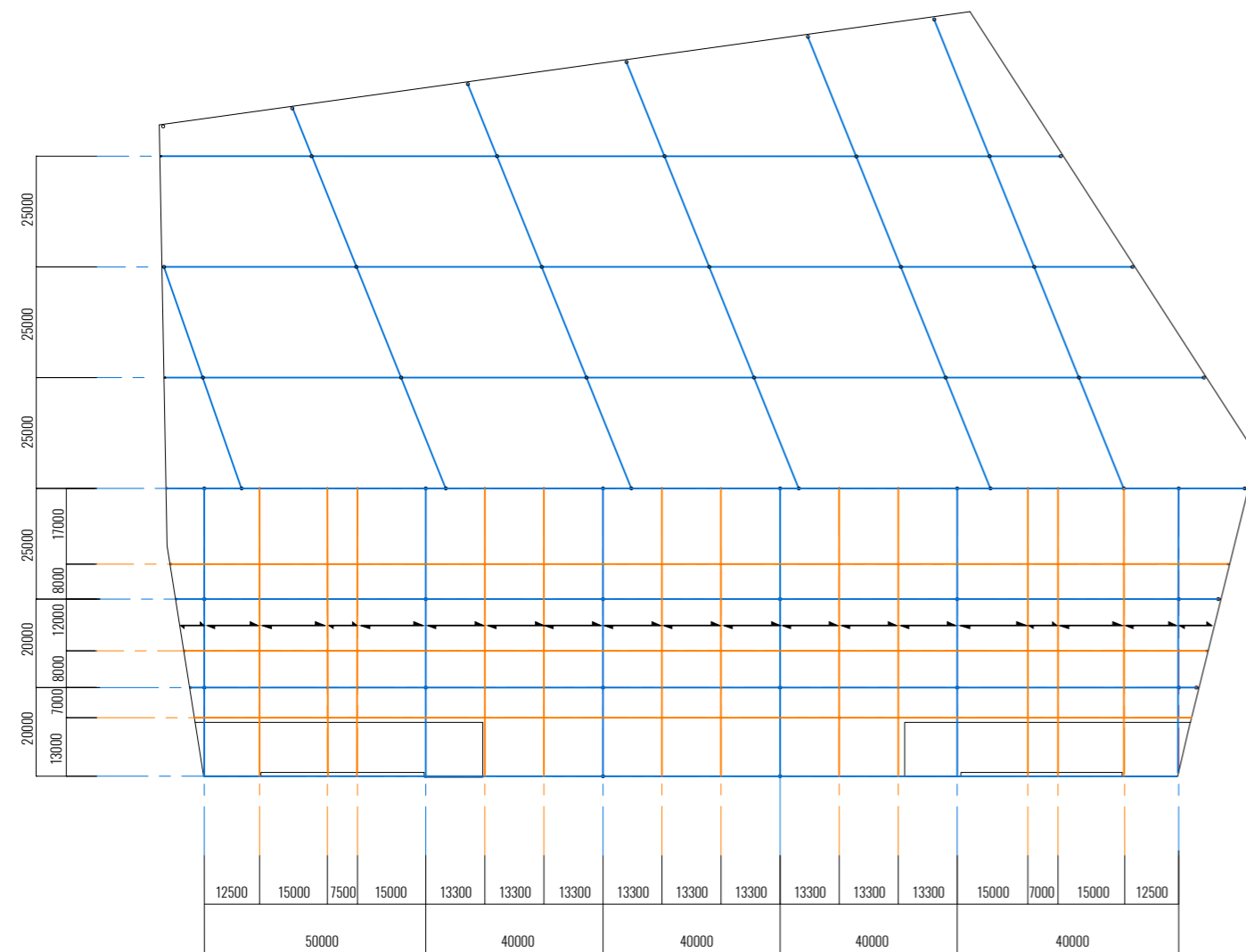


Image 75: Plan of the grid of the structure

— Grid of exterior structure
— Grid of interior structure

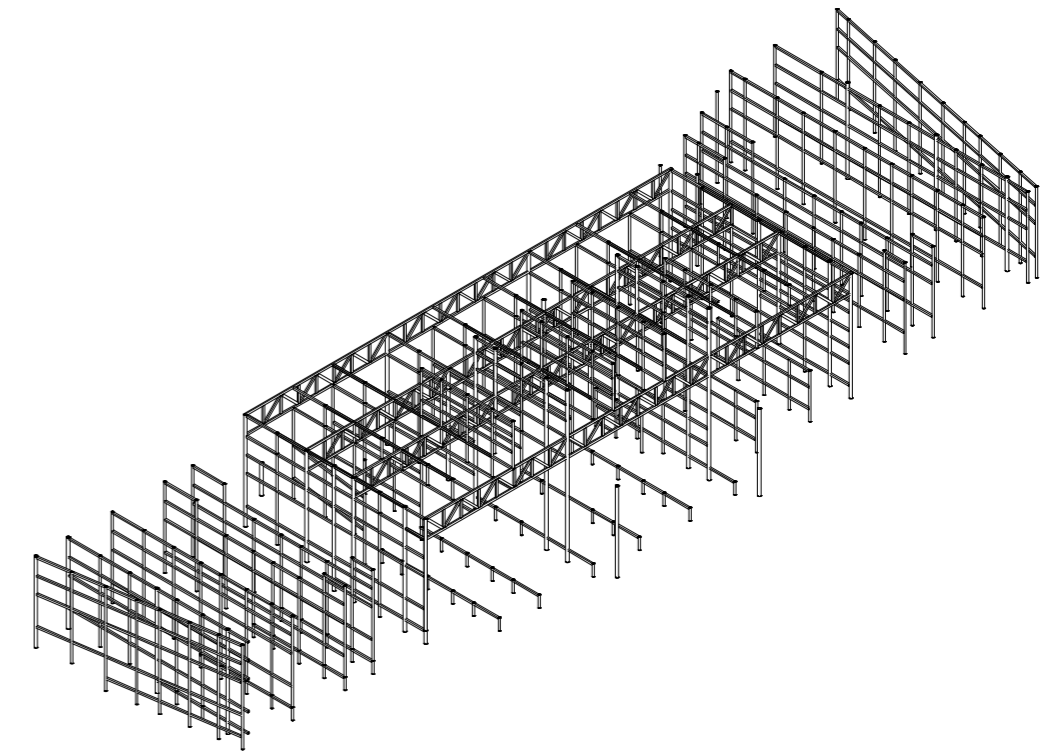


Image 76: Interior structure

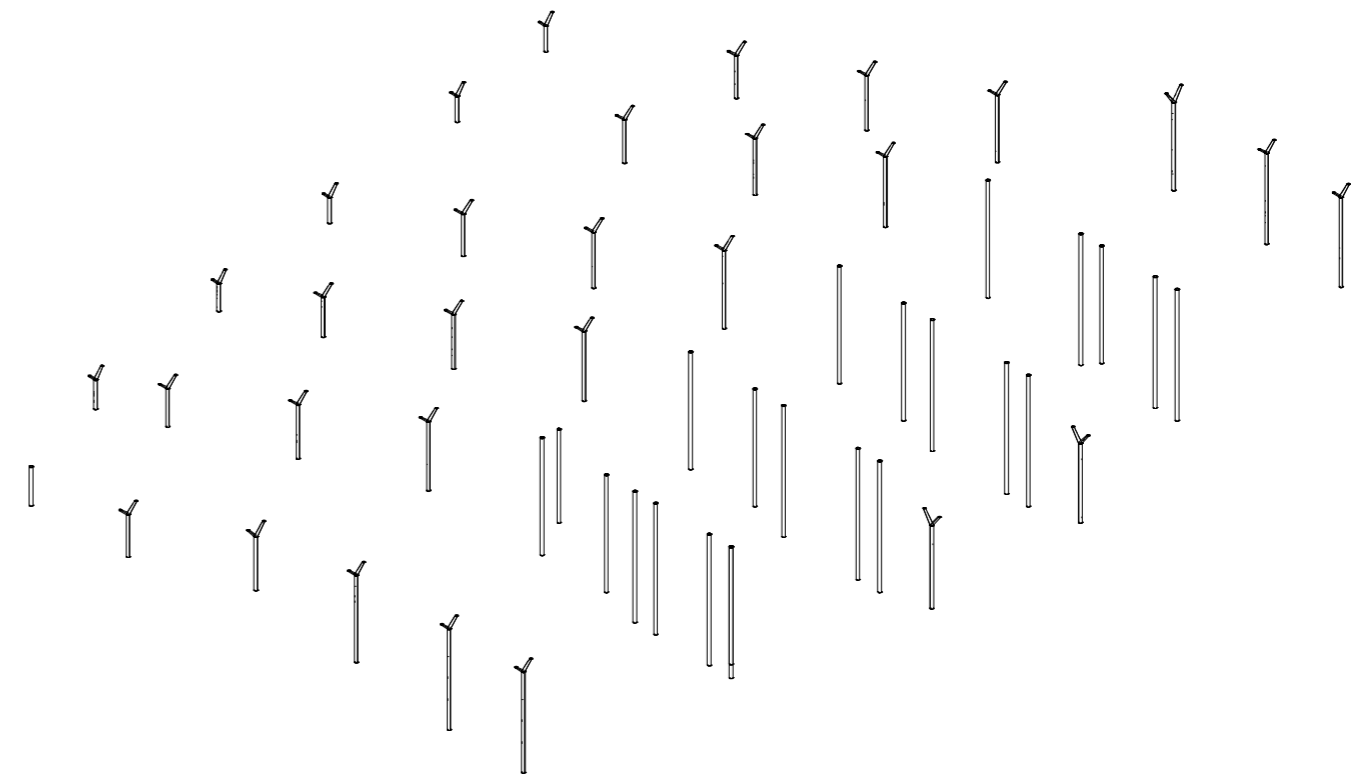
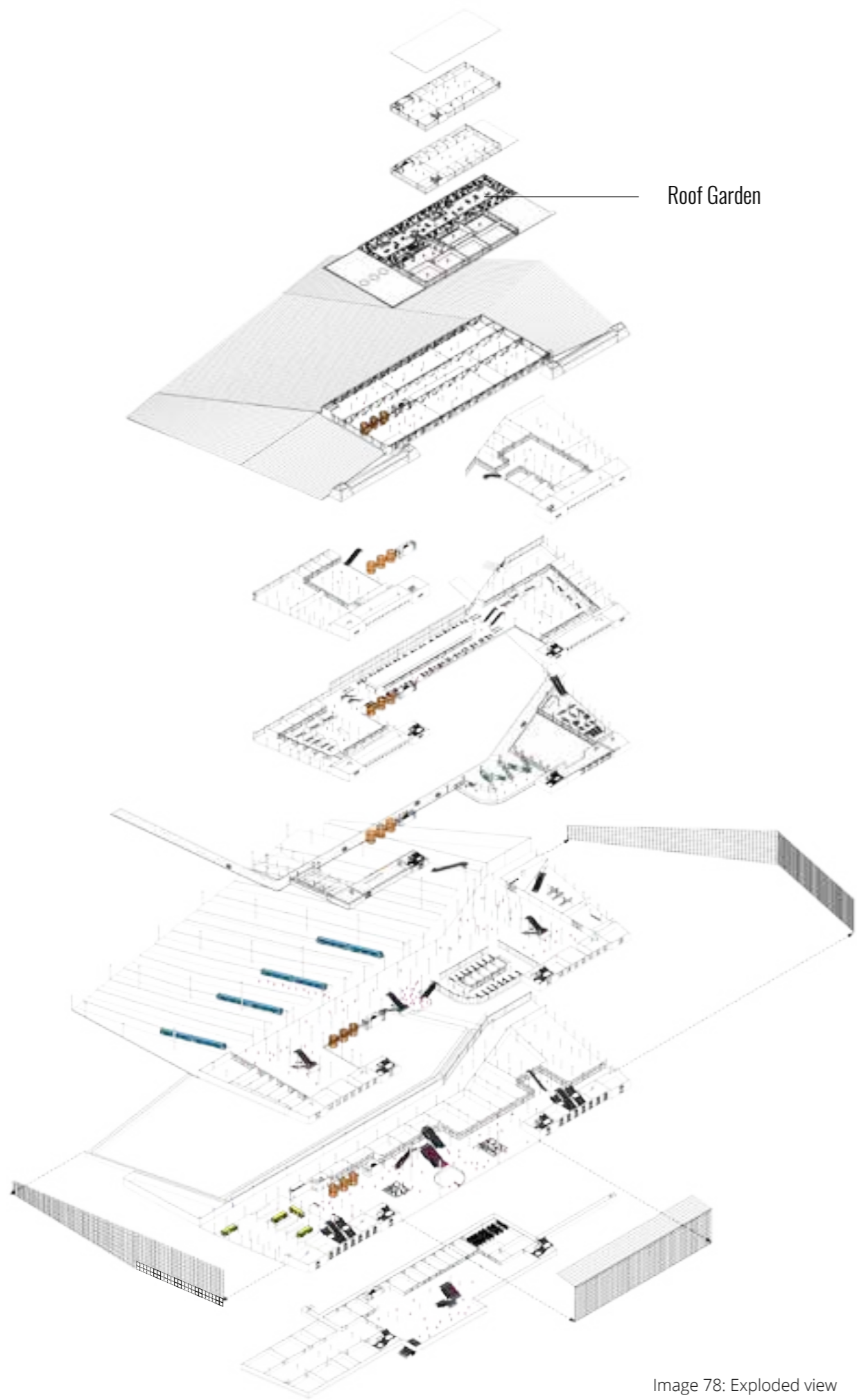


Image 77: Exterior structure



Roof Garden

Image 78: Exploded view

DETAIL

EXTERIOR FACADE AND ROOF DETAIL

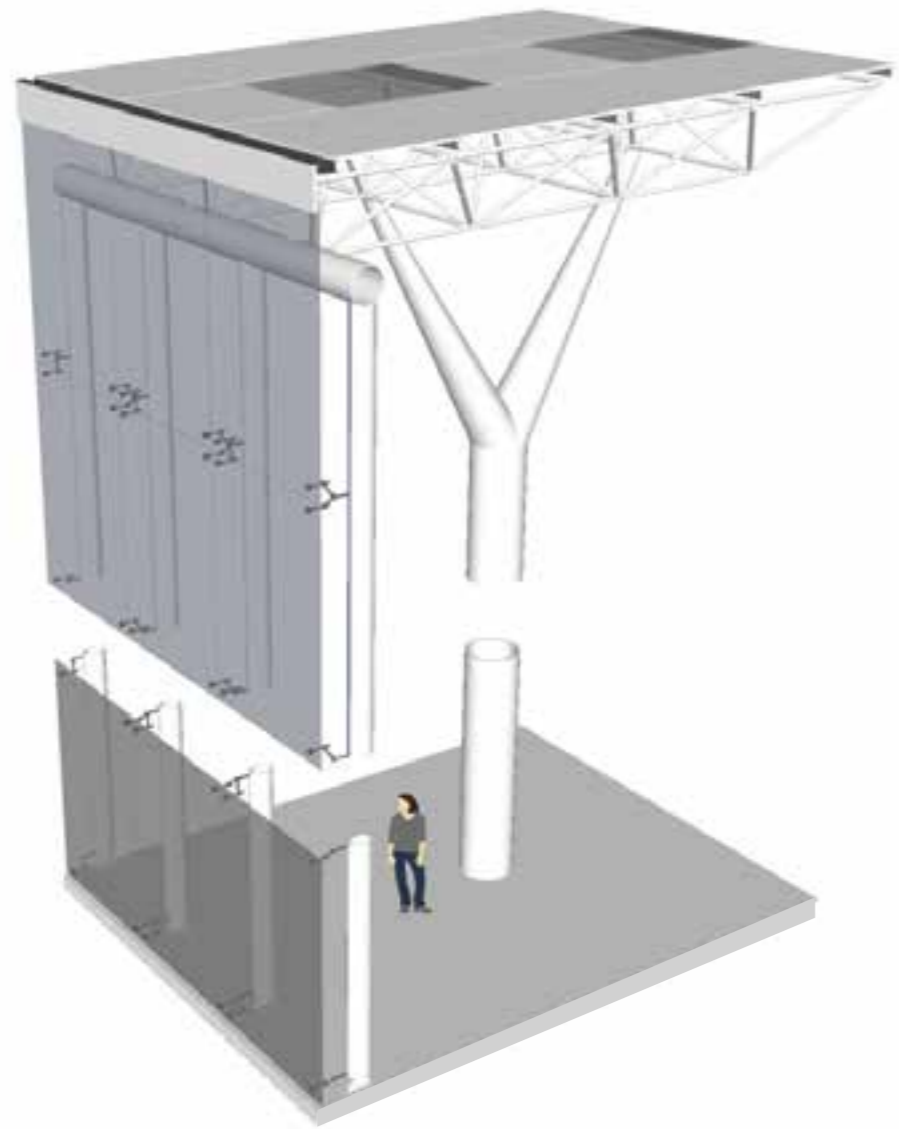


Image 79: 3D Section detail of exterior structure

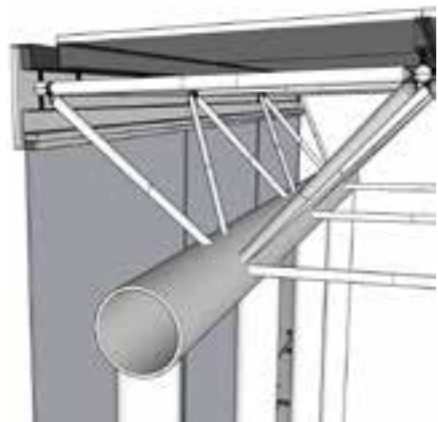


Image 80: Detail of gutter

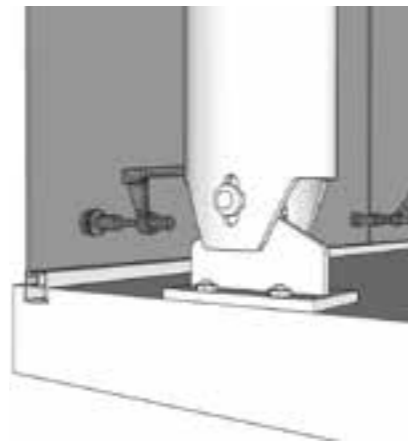


Image 81: Detail of the foot of the column

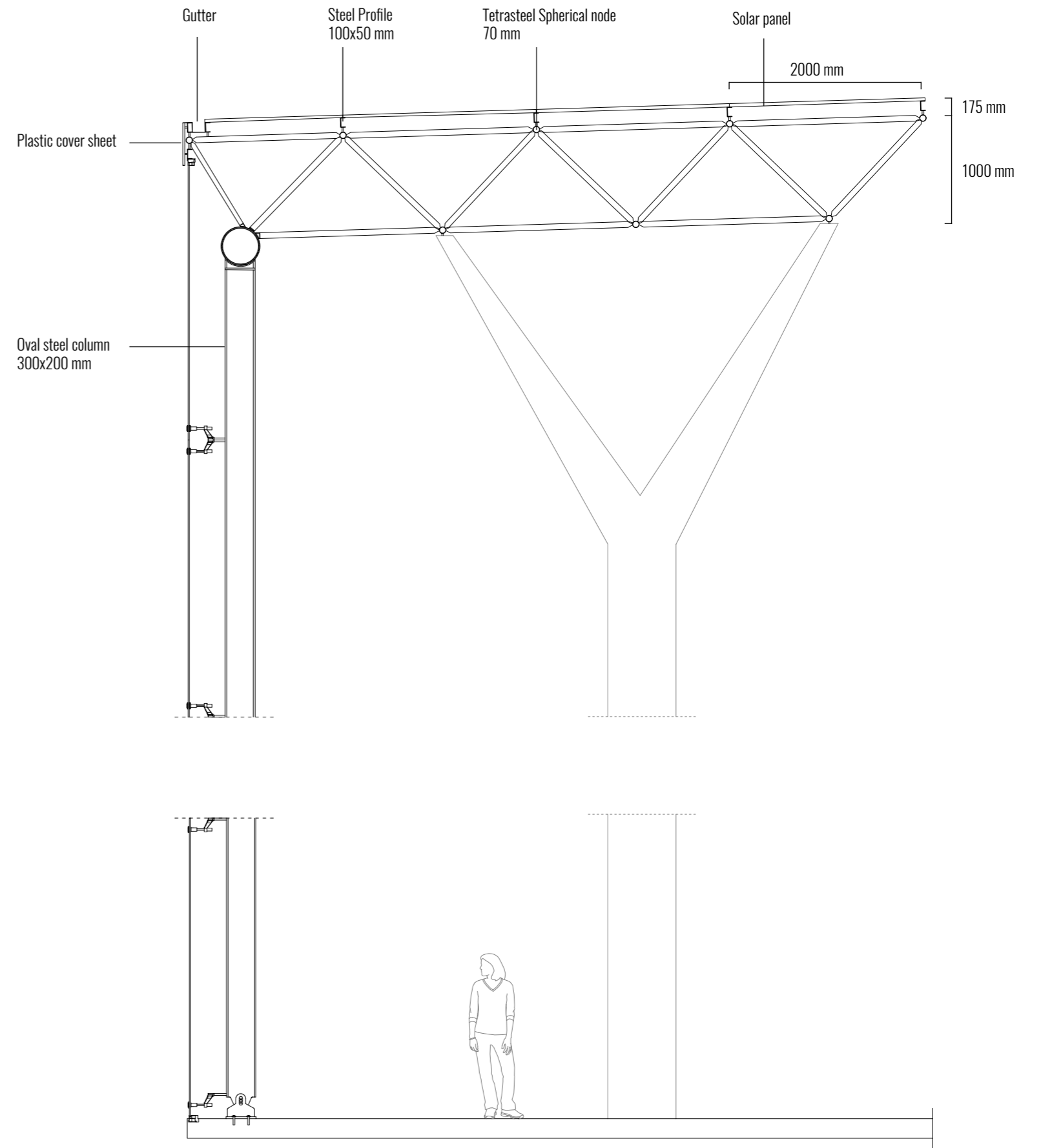


Image 82: Section detail of exterior structure

Scale 1:50

INTERIOR FLOOR AND ROOF DETAIL

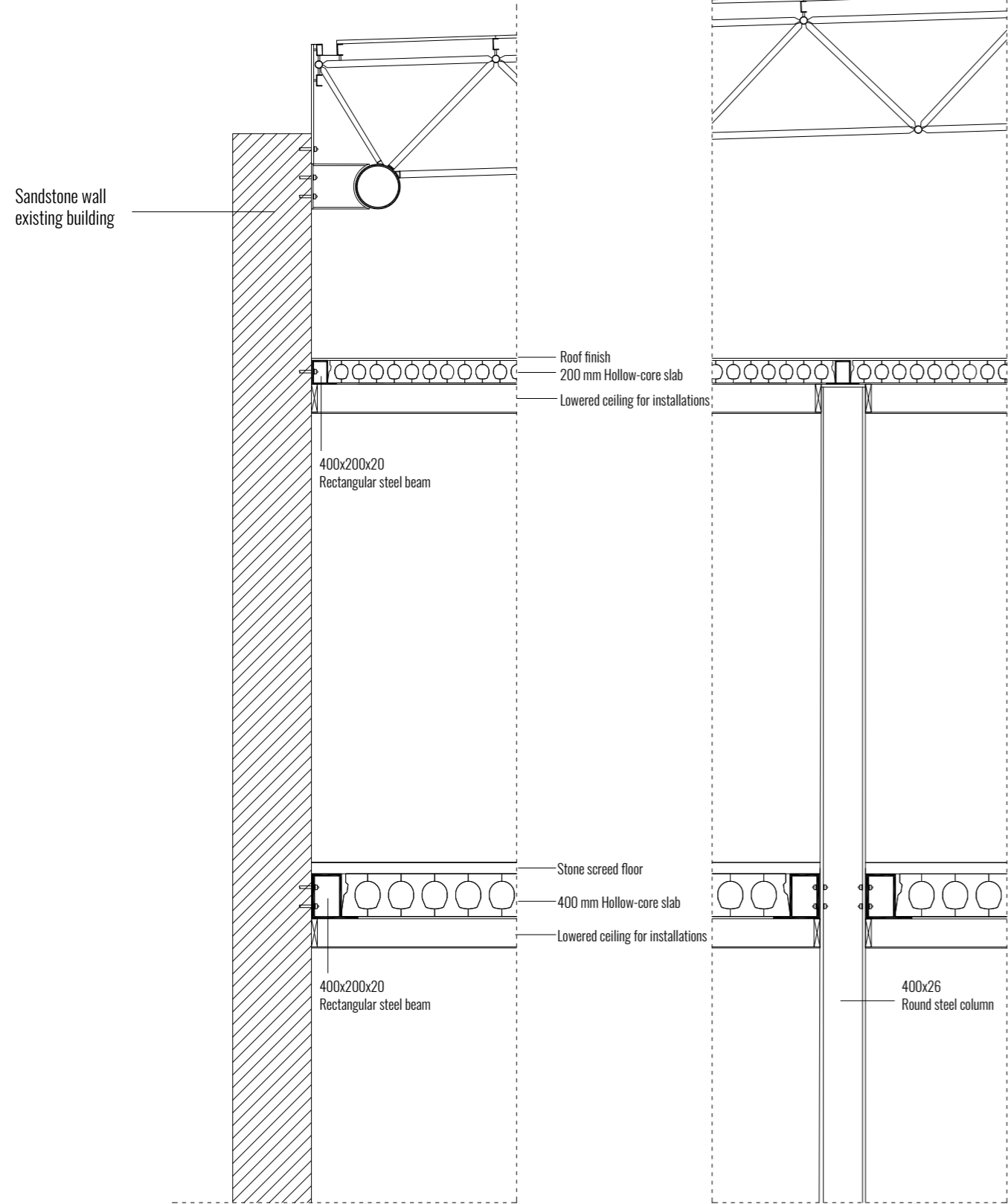
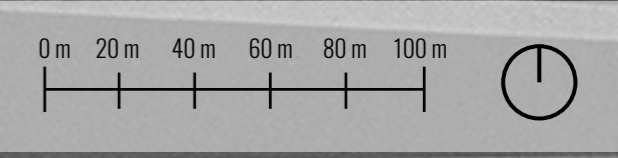
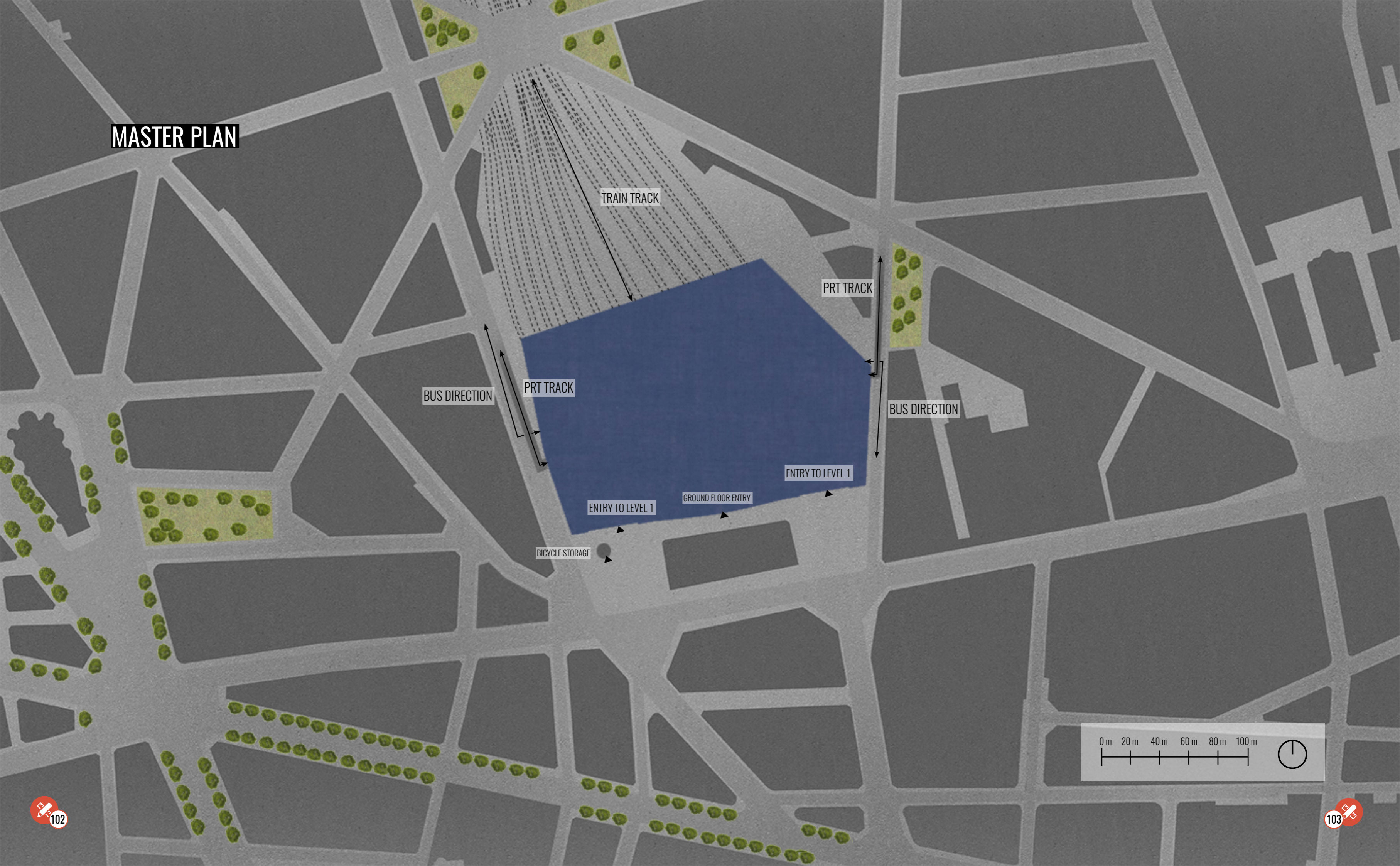


Image 83: Section detail of connection interior structure to existing building

Image 84: Section detail of interior structure

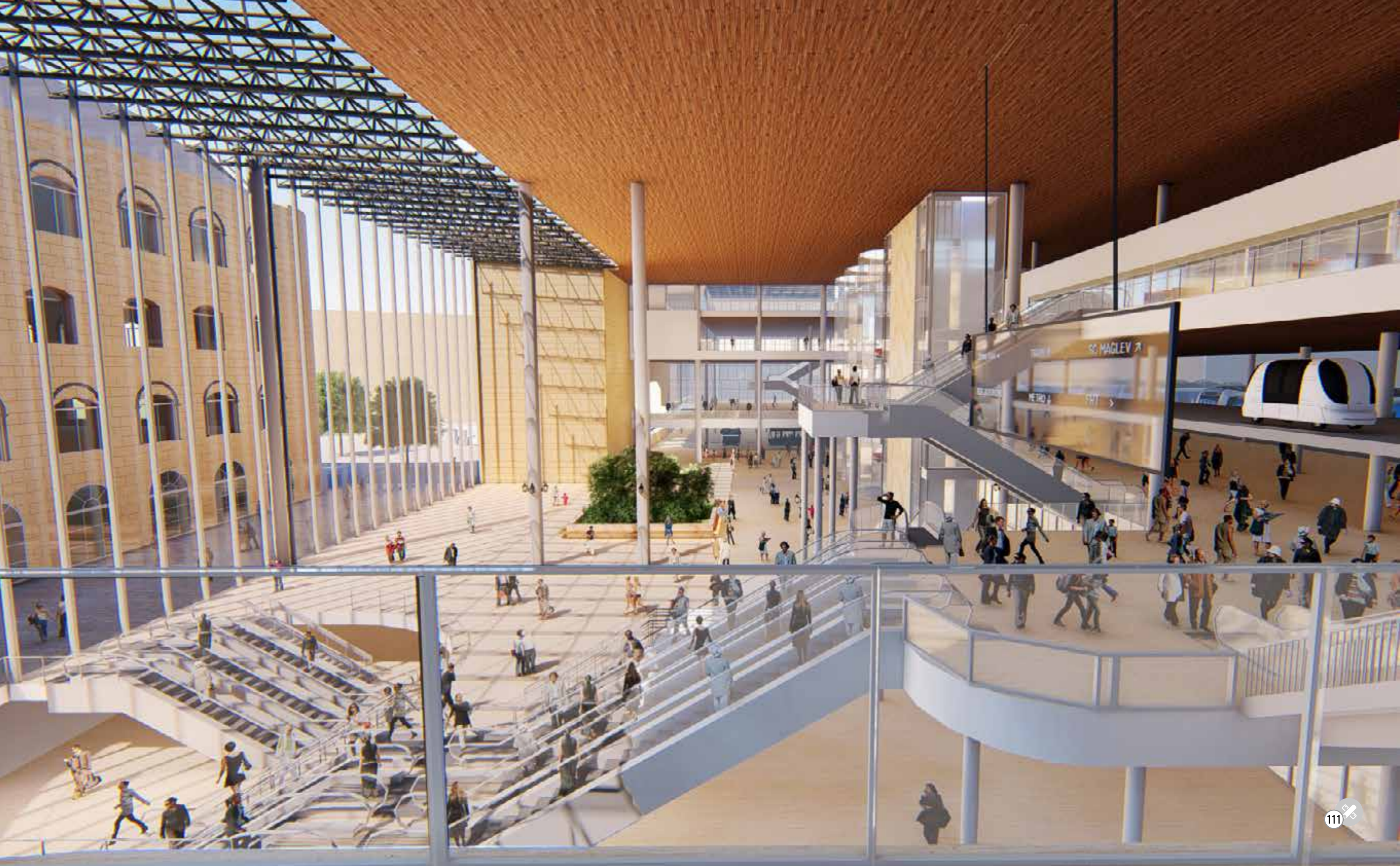
MASTER PLAN







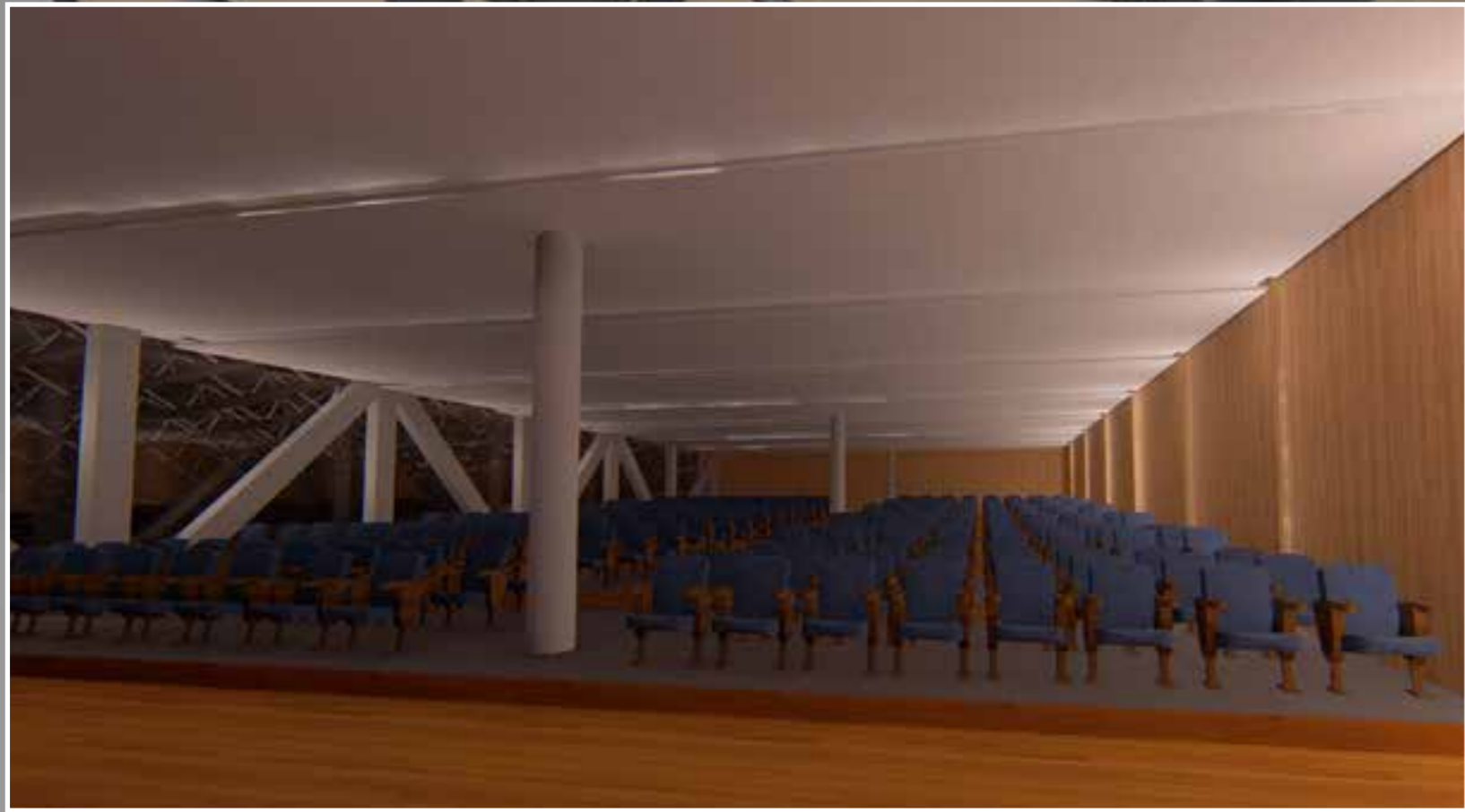






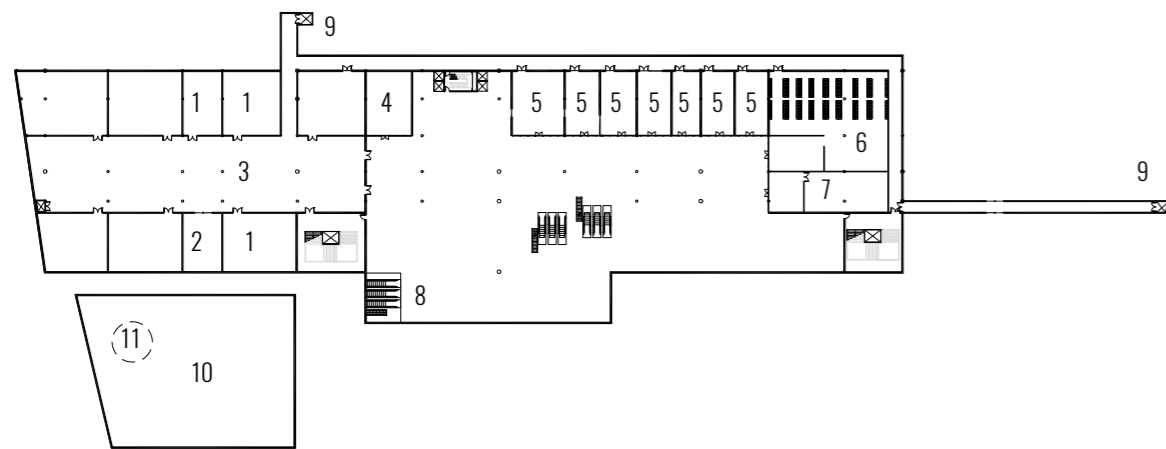






FLOORPLANS

Floor -1

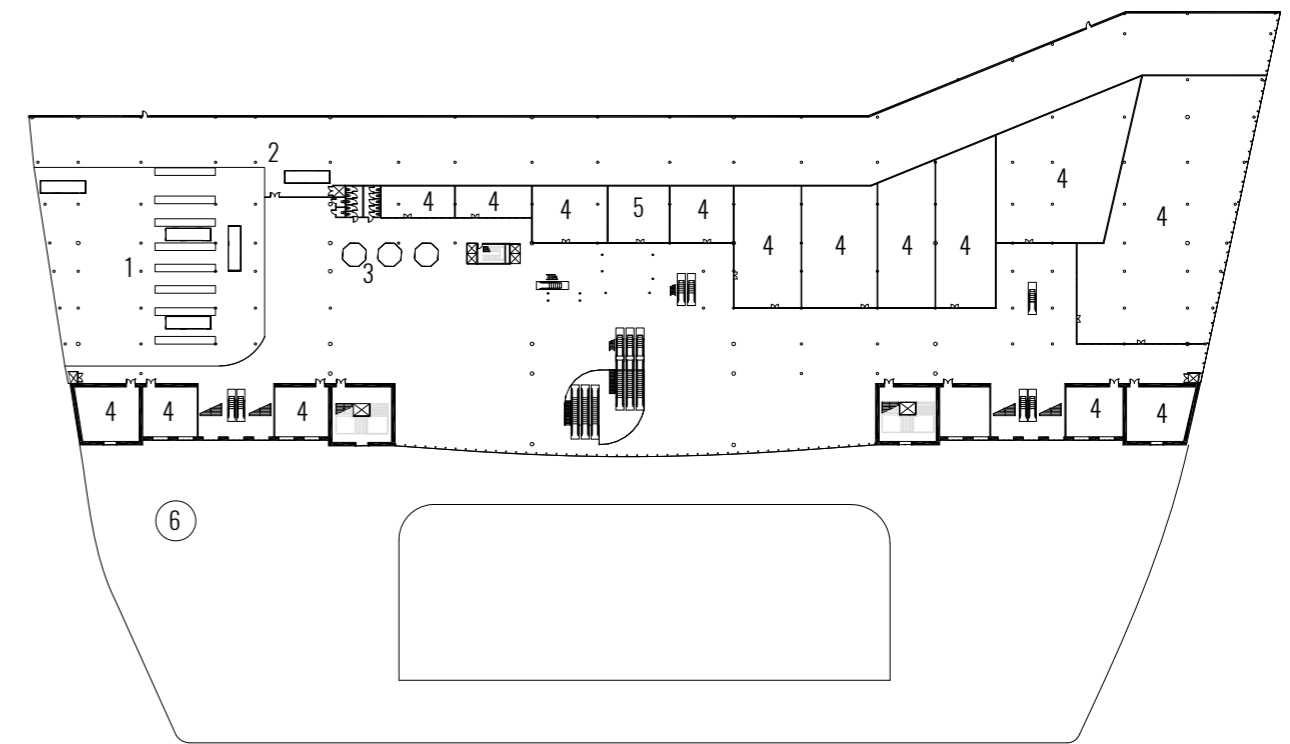


Scale 1:1500



- 1. Cold Storage
- 2. Storage
- 3. Logistical space
- 4. Information Point
- 5. Shop
- 6. Lockers
- 7. Lost and found
- 8. Route to Metro
- 9. Goods elevator
- 10. Bicycle storage
- 11. Autonomous parking system

Floor 0

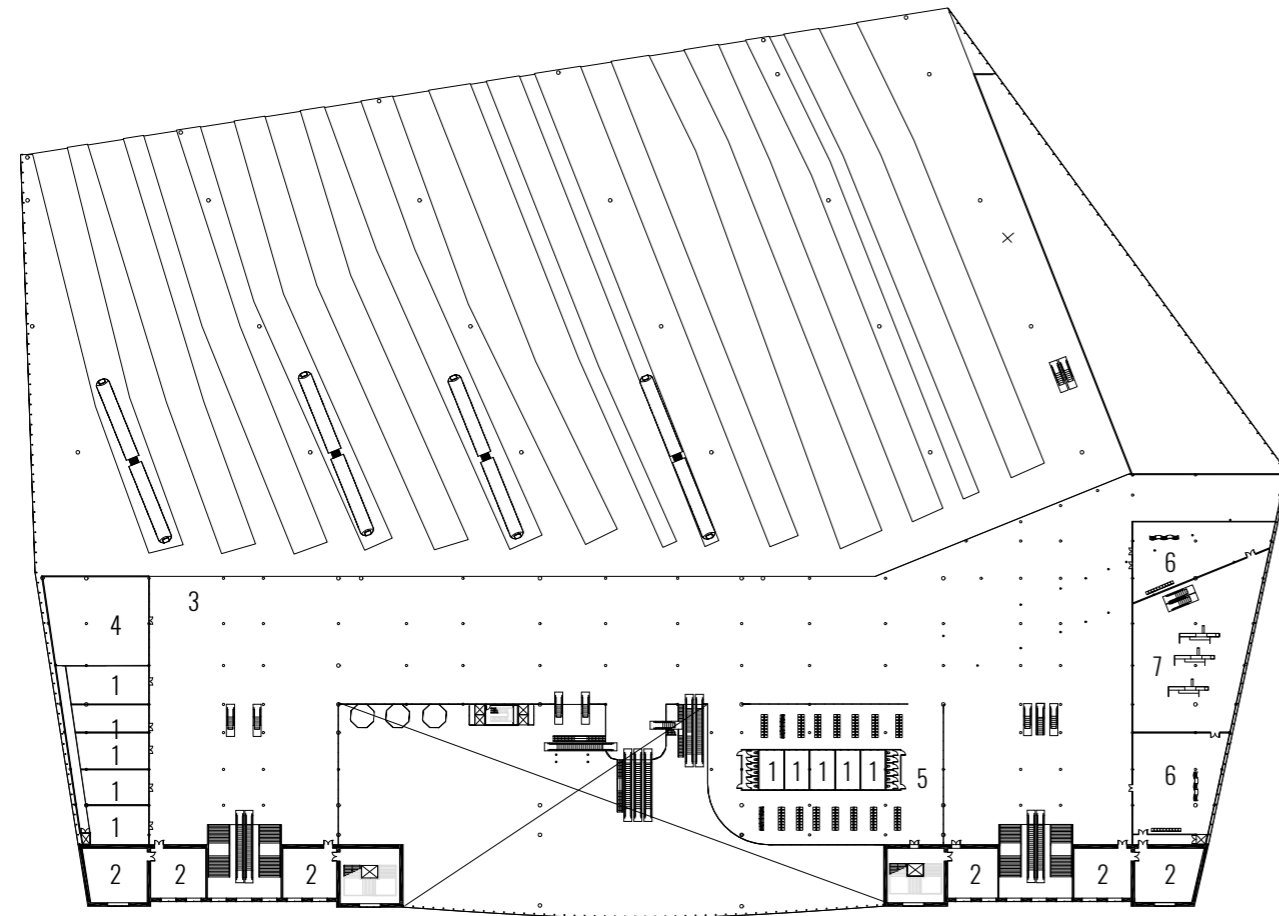


Scale 1:1500



- 1. Bus platforms
- 2. Loading and unloading
- 3. Drone Taxis
- 4. Information Point
- 5. Shop
- 6. Autonomous parking system

Floor 1

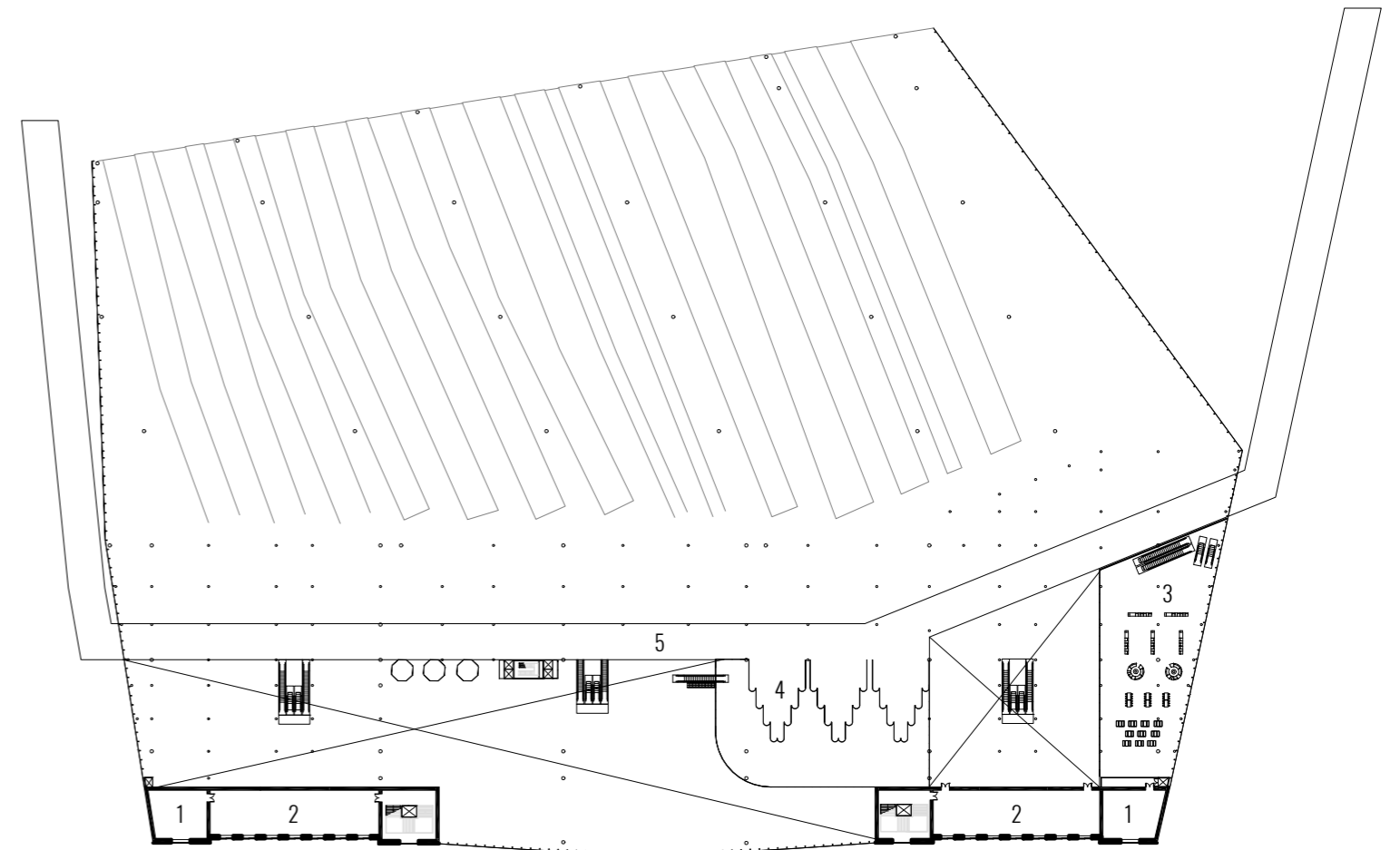


Scale 1:1500



- 1. Shop
- 2. Project office
- 3. Platform entry gates
- 4. Information Point
- 5. Seating area
- 6. Check in
- 7. Customs

Floor 2

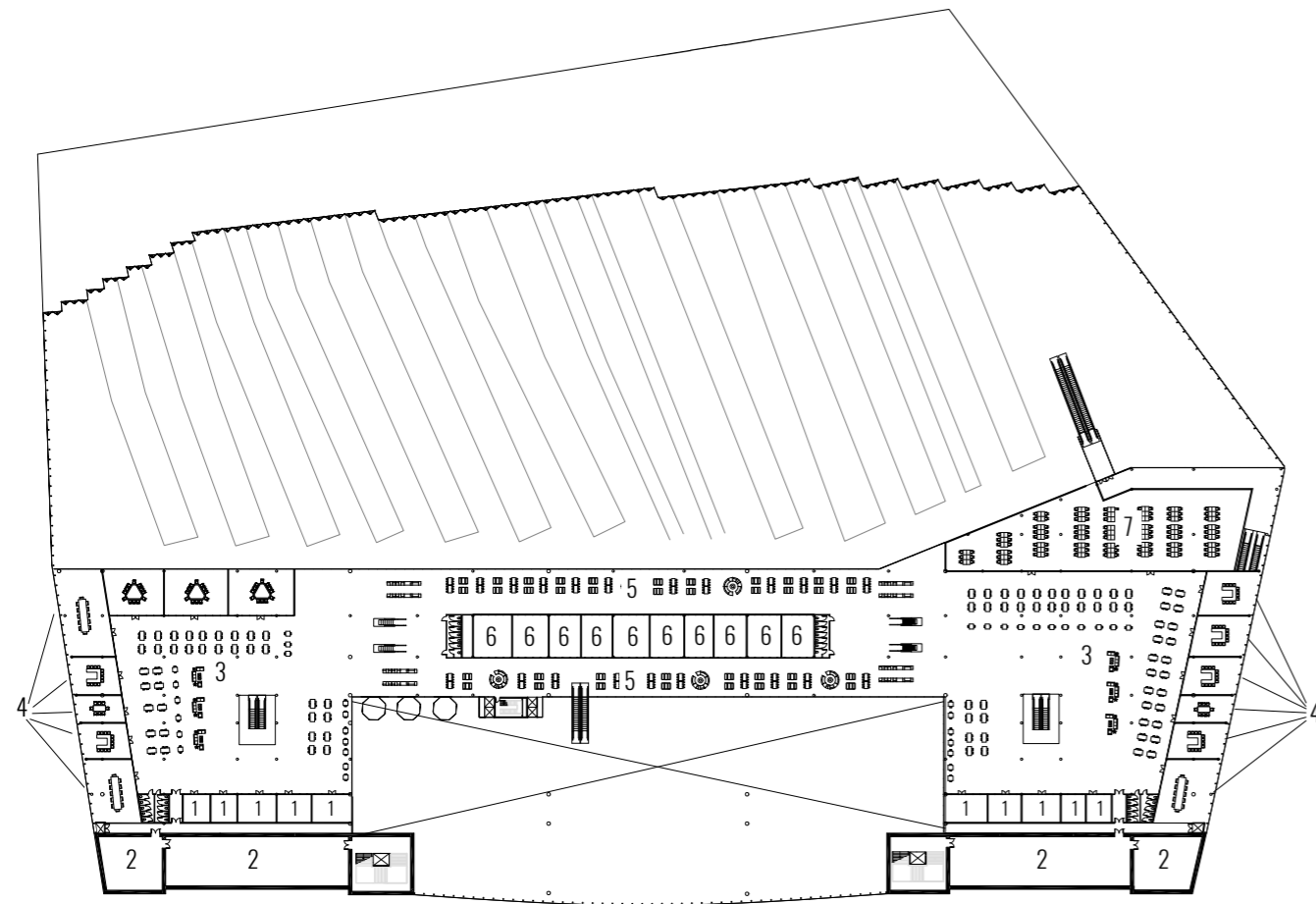


Scale 1:1500



- 1. Office
- 2. Canteen
- 3. International wait area
- 4. PRT platform
- 5. PRT road

Floor 3

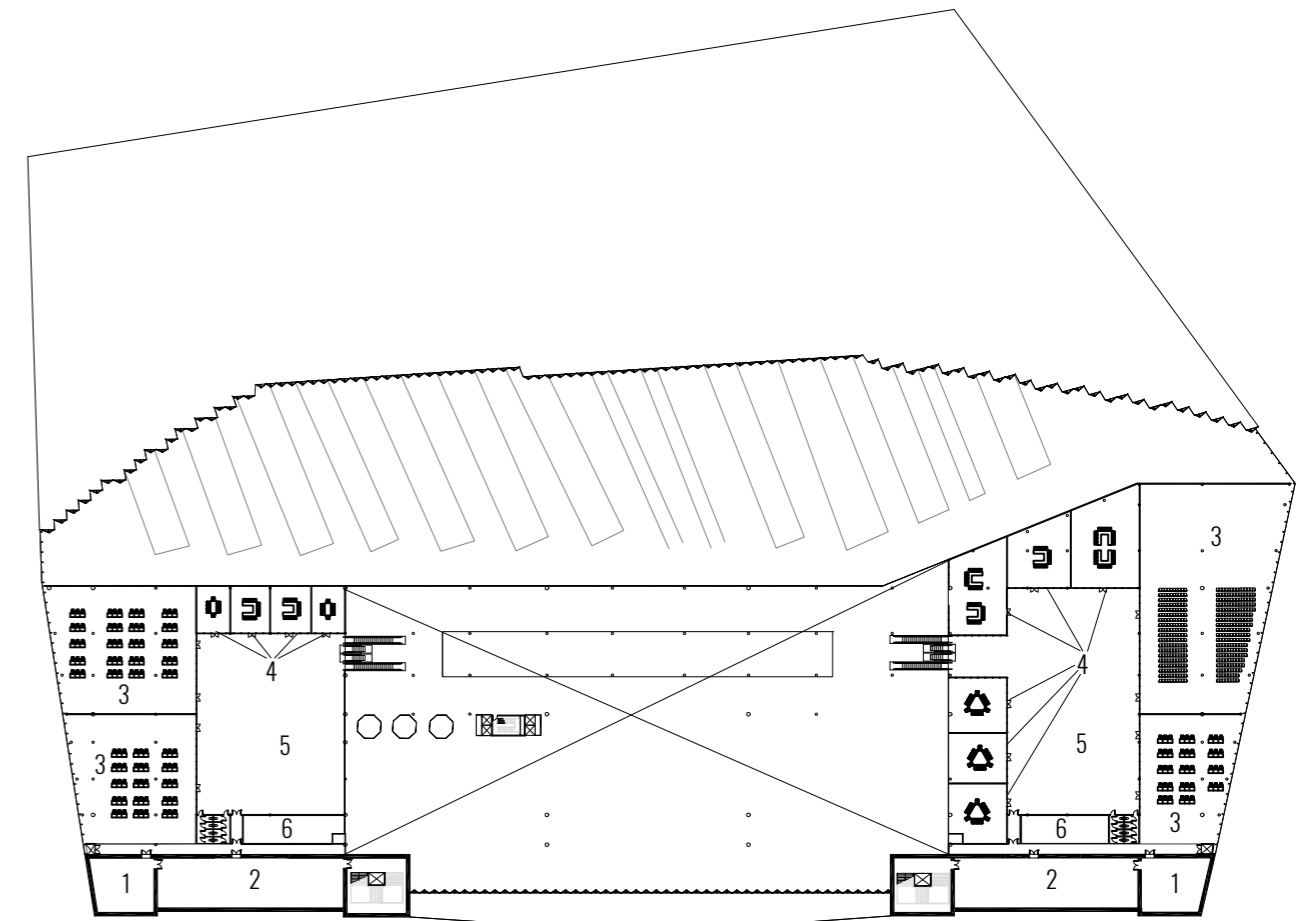


Scale 1:1500



- 1. Shop
- 2. Office
- 3. Flexible work space
- 4. Flexible meeting room
- 5. Seating area
- 6. Restaurant
- 7. Computer area

Floor 4

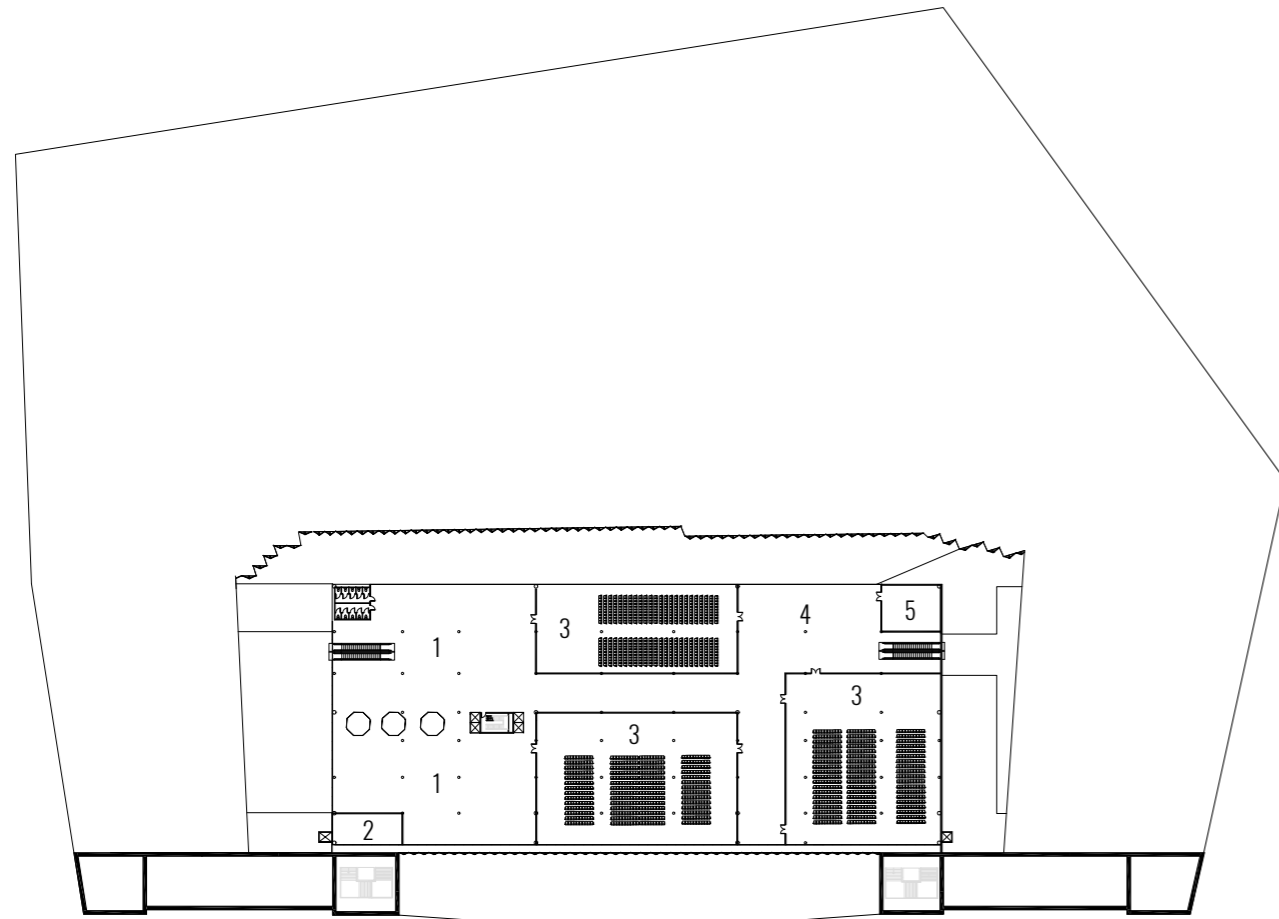


Scale 1:1500



- 1. Office
- 2. Storage
- 3. Conference hall
- 4. Conference room
- 5. Reception area
- 6. Restaurant

Floor 5

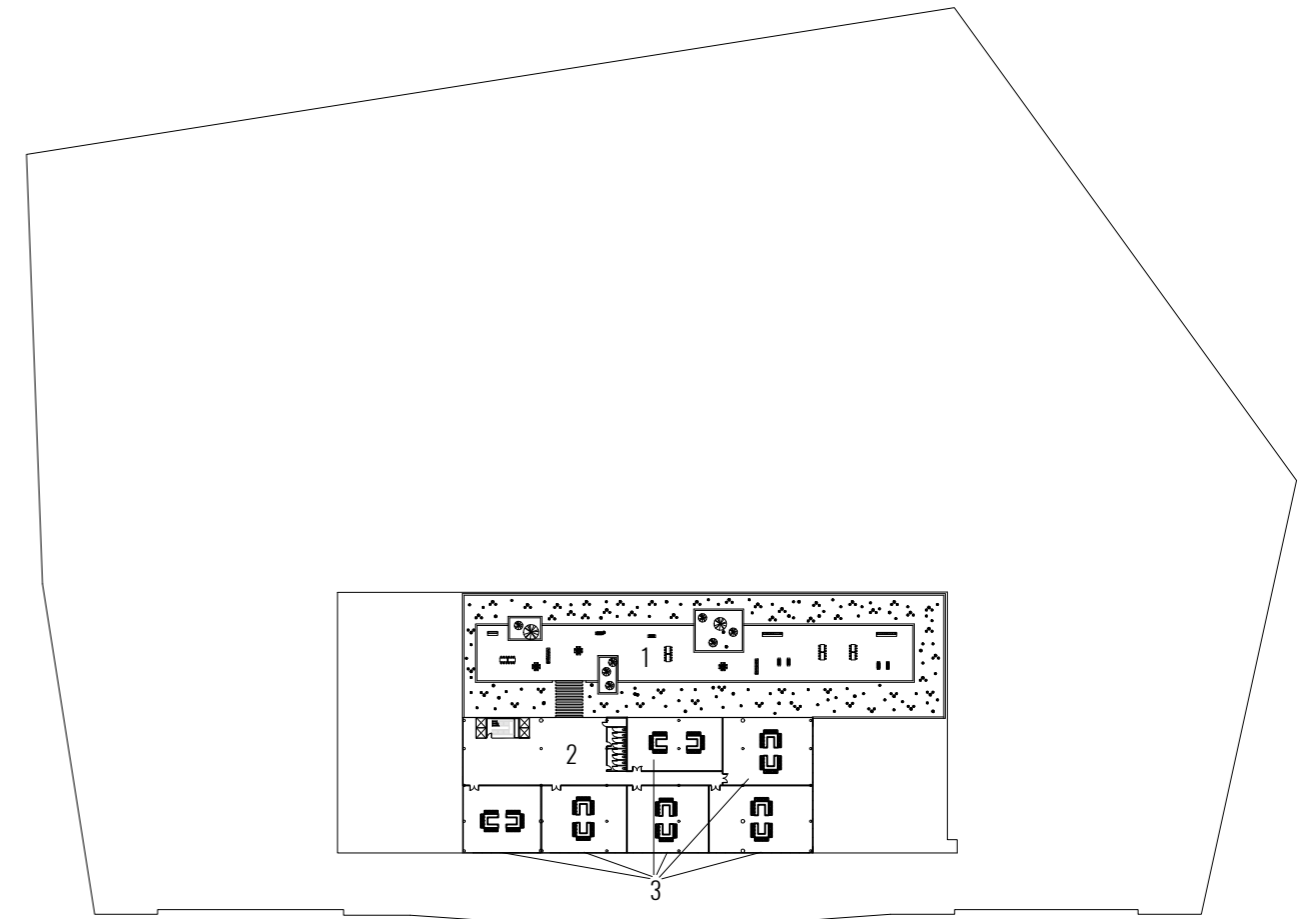


Scale 1:1500



- 1. Reception area
- 2. Restaurant
- 3. Conference hall
- 4. Seating area
- 5. Storage

Floor 6

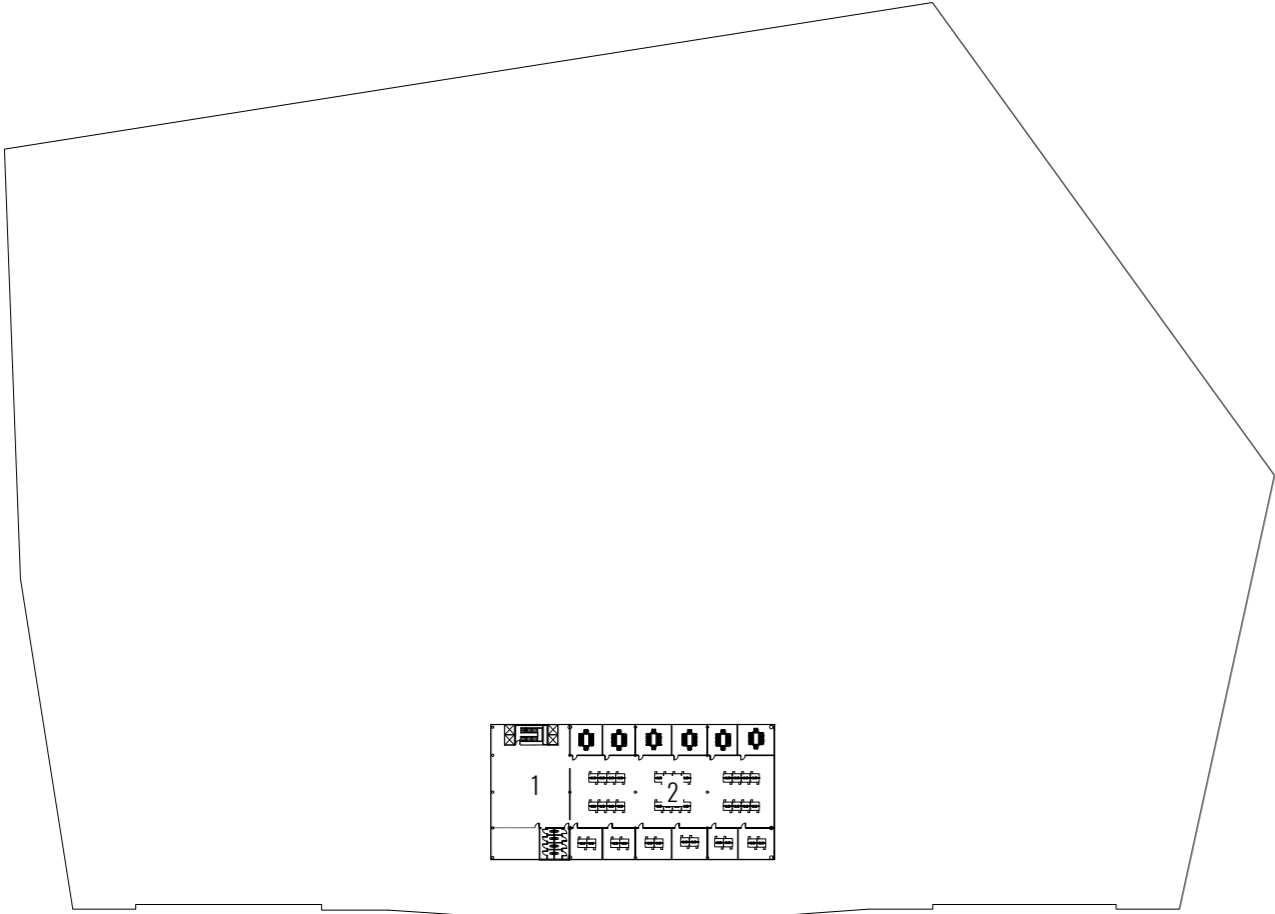


Scale 1:1500



- 1. Roof garden
- 2. Reception area
- 3. Transport control room

Floor 7&8

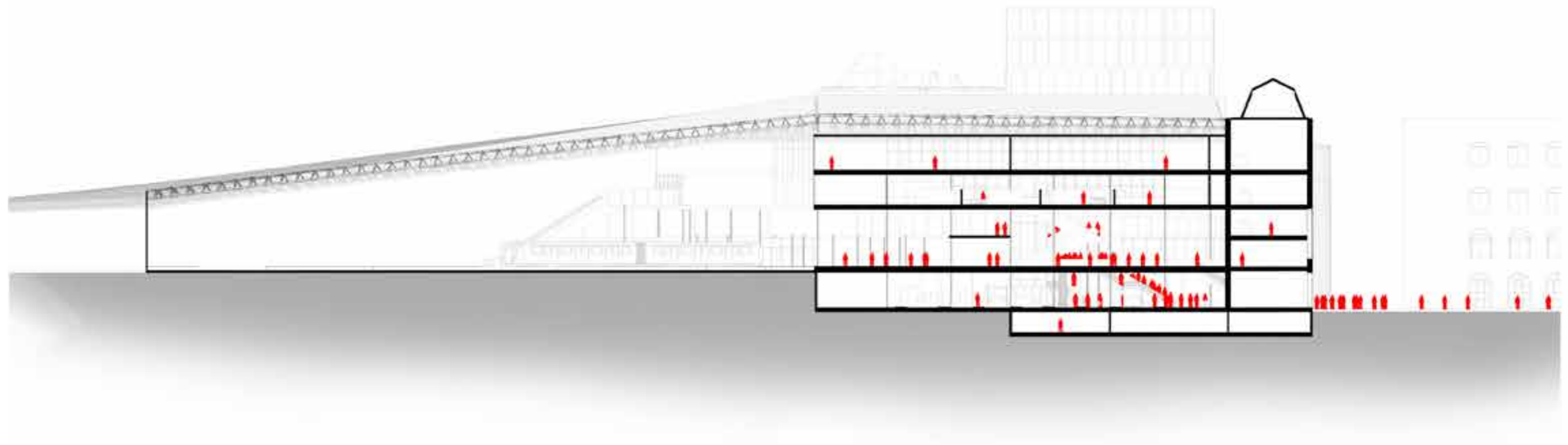


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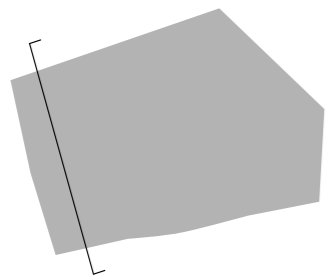


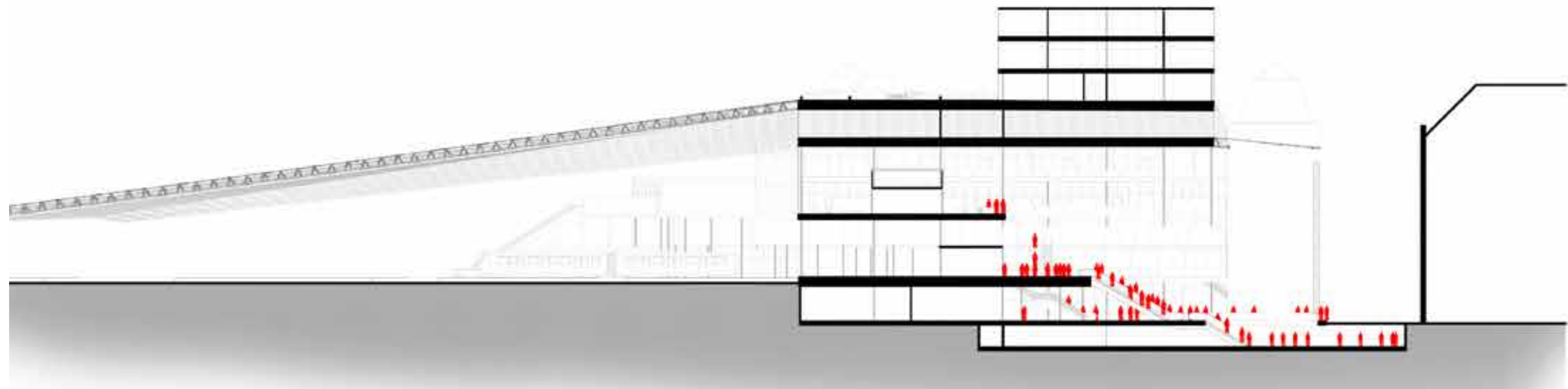
1. Reception area
2. Work area

SECTIONS

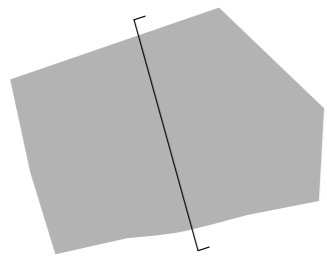


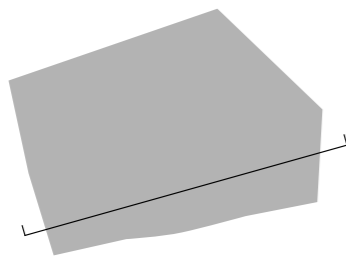
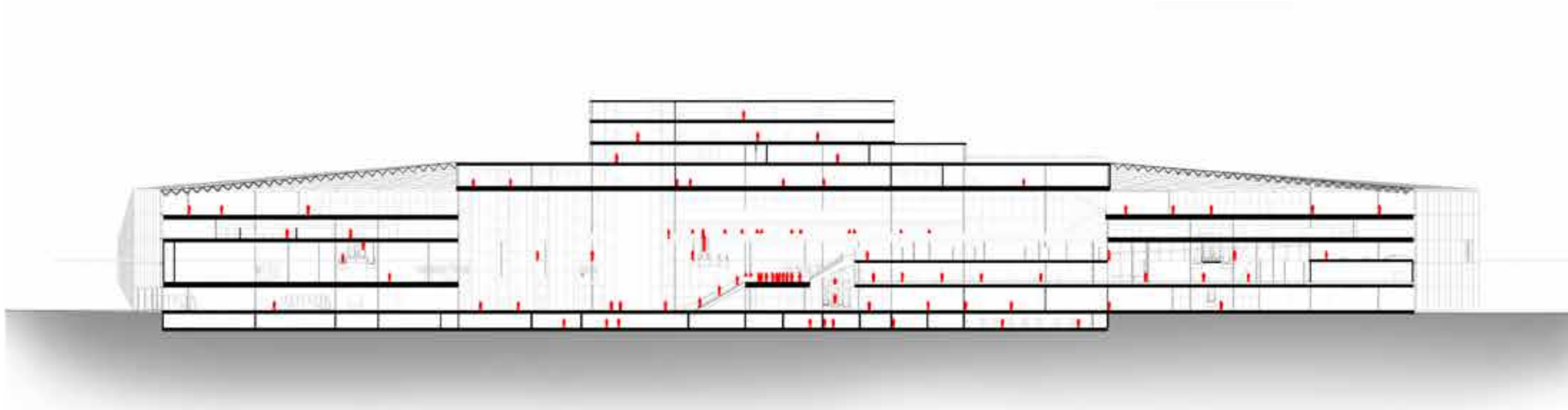
Scale 1:500

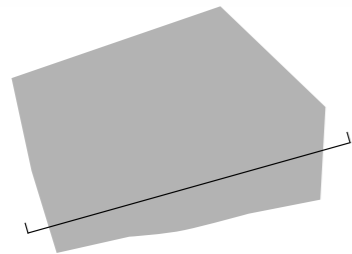
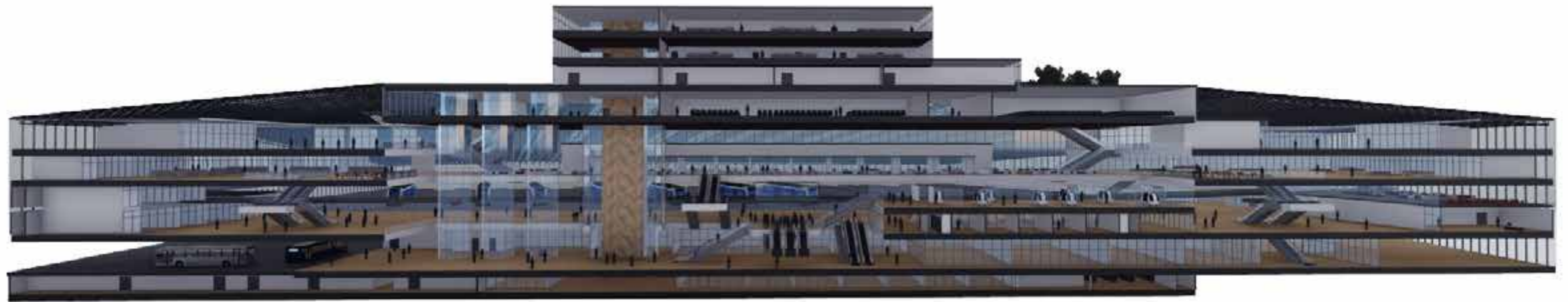




Scale 1:500







ELEVATIONS

SOUTH ELEVATION



Scale 1:750

EAST ELEVATION



Scale 1:500

EAST ELEVATION



Scale 1:500



DISCUSSION

CONCLUSION

The graduation studio began with the concept of 'building for the masses'. For me, this translated into a station, because it involves the movement of masses. Because of the interesting transport opportunities, this idea changed into a transport hub for 2030. My research question was: *What design of a transport hub for 2030 deals with the complexity of diverse types of transport and different kinds of users?*

The answer to this question has several parts. A transport hub of 2030 will have a diverse set of transport types, with the addition of drone taxis, personal rapid transit, autonomous busses and maglev trains. The organisation of the hub is based on the domain concept, which separates and organises different uses and experiences in the building. The users of the transport hub have different needs. These needs relate to facilities and transport, but also to experiences.

The location research showed that the station was mainly used by commuters and that the station lies in a business district. This provided an opportunity to add workspaces and a conference centre to the transport hub. The area also has large differences that are used in the arrangement of the transport within the hub.

The research question and the location research raised four goals for the project: All the transport should be under one roof, the inside of the building should be flexible, the new building should fit within the lines of the existing building and there should be a cathedral-like central hall.

The transport hub was designed from inside to outside with a separate interior and exterior of the building. The transport types within the building are arranged on different levels. This gives the building its complexity. The transport types are arranged around the central hall. The central hall reaches over all the levels, which connects the various transport systems. The exterior roof fits like an umbrella over the transport. The roof of the public functions, like the transport and work areas, is separated from the private offices. This separation makes the roof simpler and creates a clear division between public and private areas.

The new design keeps the front facade of the existing building. The massive and closed facade forms a contrast between the modern materials and building techniques of the new building. The added functions to the building (the workspaces and conference hall), add something to the area and plays into the shift of the modern workplace. The visible connection to the transport gives these functions the experience of the transport. The design of the transport hub reaches the set goals while adding new functions to the transport hub that have added value to the area. The design has become a complex 'anthill' of traveller routes.

REFLECTION

One of the most difficult aspects of the design process of the graduation studio has been predicting the future. Many aspects of the hub depend on the assumptions I made about the future. I didn't have examples or rules for some elements, which required me to make educated guesses.

I've also become a little lost in my own ambition for the project. I wanted to put so many elements in one building that I sometimes lost track of some. The size of the building and all the complex elements I worked with made it hard to go into the level of detail I wanted to achieve.

During the studio, I learned things about myself that I didn't realise before. One of my realisations this year has been that if I really struggle with something, I tend to leave it and focus on the easier parts, instead of facing the struggles head-on and asking for help. I already knew this to some degree, but

during the graduation studio I was really confronted by this. For example, I struggled with the location research and writing this book. Writing has never been my strong suit and writing a book has challenged me. I am happy that I was able to finish the book with the help of the tutors.

My ultimate ambition for my project was that when I'm walking in a station in 2030, I will recognise elements of my project in it. I don't expect my prediction of the future to be perfect, but I would like to see elements I thought of being implemented in the future. I'm looking forward to 2030 to see if my predictions were correct.

ACKNOWLEDGEMENTS

I would like to thank my tutors, David, Maarten and Tom, for their support and dedication during the graduation process.

I want to thank David for always pushing me with harsh but necessary commentary. But at the same time, he always ended with a comment that I could build from.

I want to thank Maarten for asking questions—not because he wanted to know the answers, but to make sure I knew them. This helped me to keep thinking about what I was doing.

I want to thank Tom for pushing me on the location analysis and guiding me in the process of writing the book. I also valued our conversations about the transport of the future.

I would like to thank everyone in the graduation group. In the past year we have become a tight group that had fun together but also worked hard. This made all the long working days (and nights) a lot easier. I could always use someone as a sounding board for an idea or just to ask for advice.

I would like to thank my family for supporting me and helping wherever they could. Sometimes simply listening to all my ideas would help me figure out what I needed. I especially want to thank my mom for accompanying me to Paris and my sister for helping with the book.

I would like to thank Eva Goedhart from the NS for taking the time to show me how a station worked from behind the screens and literally opening any door if I wanted to see what was behind it.

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