Transmitter Impression

Receiver Impression

Space of Signal

Antenna Architecture

Discovering the Influence of 5G Signal on Built Environment

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1. Introduction

1.1 Research Summary

At the beginning of XX century, the signal discovery together with antenna invention caused a significant change in field of architecture as well as widely altered ordinary human lives by offering the society a promise of connectivity and technological advancement. The existing research that I encountered, focused mostly on the historical influence of signal on architecture – sudden appearance of television towers typology in cities or public perception of antenna-related architecture (La Belle, 2010). However, recent changes in architectural environment, caused by signal invention are still not investigated thoroughly. Currently, 5G technology is being implemented in cities without sufficient studies on how it will influence the field of architecture. Therefore, the question remains: how does wireless technology, together with 5G implementation, promote conceptual and formal change in the discipline of architecture? How will the new 5G signal processing method influence the aesthetics and functional aspects of transmitters and receivers?

1.2 Project Introduction

The project Space of Signal in a speculative design that explores the potential impact of 5G signal on built environment. As proved by the conducted research, the Presence of 5G Transmitter will encourage the act of gathering of e-businesses in the close proximity to signal source, as this will remain the guaranty of reliable and stable 5G connection. Therefore, the scope of the project may be defined as 5G implementation model consisting of signal transmitter and receiver design, where the primary spatial topic will be the relation between two buildings. Both facilities are considered with a particular focus towards the urban relation between facilities, efficient placement of antennas and spatial consequences within each building. The project will therefore embrace the different spatial qualities required by signal transmitter and receiver. By looking through the scientific lenses of signal streams and directions, the final outcome will depict, how the built environment that surround us continuous to be shaped by individual dimension of signal.

1.3 Design Brief Summary

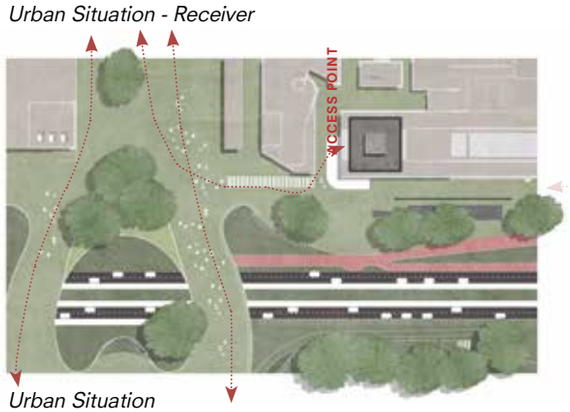
Three main topics defined by previously prepared design brief are: relation between facilities, placement of antennas and public perception of 5G implementation. The design brief includes as well separate guidelines for both facilities that have to respond to each other on urban and architectural scales. The ‘conversation’ between two buildings may only be achieved with direct signal transmission that cannot be interfered by any objects. This implies the specific height regulation for both facilities. At the same time, the placement of antennas is dictated by 5G Massive MIMO antennas implementation guidelines, according to which the devices have to be installed on specific heights in the cities, ultimately resulting in the notion of ‘striped city’ where, certain heights are dedicated solely to transmit and receive the signal streams.

1.4 Site Choice

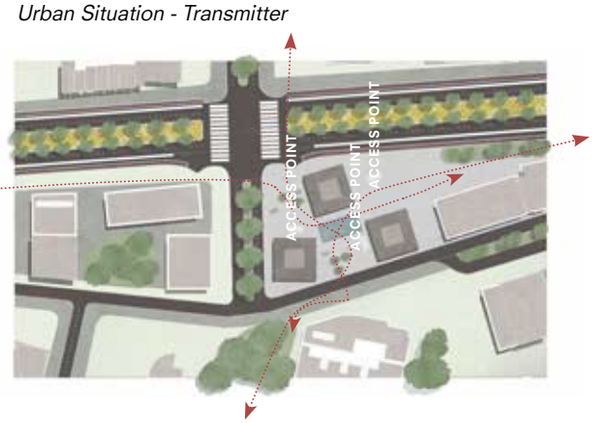
The two facilities are located along the same business strip, yet separated into two plots to underlay the public character of transmitter and private aspects of businesses that take advantages of its presence.

The transmitter is planned as the extension of Erasmus MC Hospital, which west part is planned to be developed as Smart Tech Campus related to e-healthcare advancing with 5G implementation. The transmission tower will use the rooftop of existing structure as public plaza and access zone for public. It will be accessible directly from pedestrian bridge by existing staircase leading to the rooftop.

On contrary, the receiving facility will be developed around a central plaza to invite flows of people towards the glass covering of 5G experience center. The plaza will be accessible from business boulevard and its presence will be reinforces by public restaurant and cafés surrounding it.

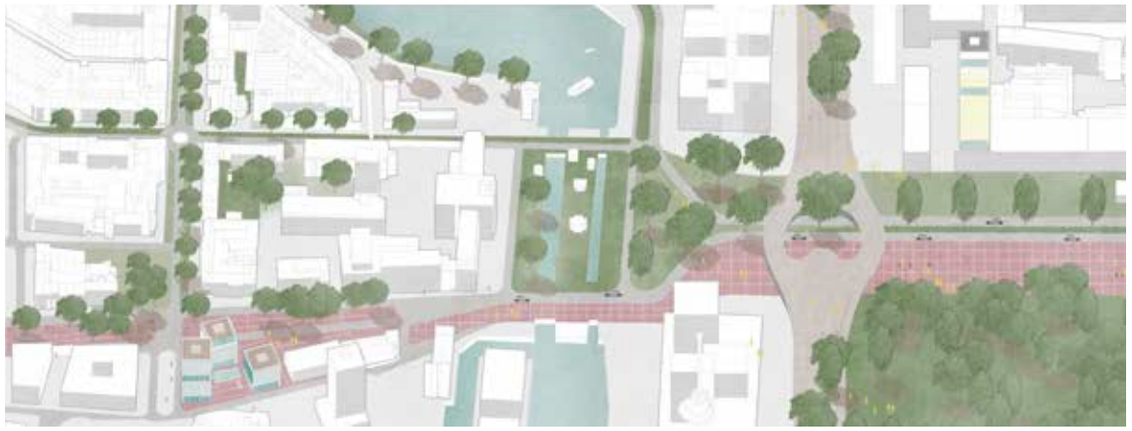


Urban Situation - Receiver



Urban Situation - Transmitter

Urban Situation



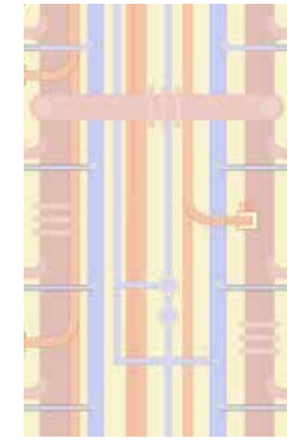
2. Project Description

2.1 Transmitter

Acknowledging that the 5G transmitter should embrace the XXI century approach to technology, the concept for the building is based on the contrast between exterior and interior of the building. Over time, the technology that humans use is everyday live becomes more complex, while the objects that we use tend to become simplified in their appearance. As analogy, the 'skin' of the building becomes rather enigmatic, while the technology used inside the building is exposed.

This creates a unique user's experience, where the visitors only by entering the interior of the building may experience and understand how complex and extensive the use of technology is nowadays. This experience is translated into a spatial concept where, the outside of the tower core becomes a technical space, where all technological products are exhibited for users.

Transmitter - Exploded Axonometry



Left: Exterior, Right: Interior - Contrast Concept

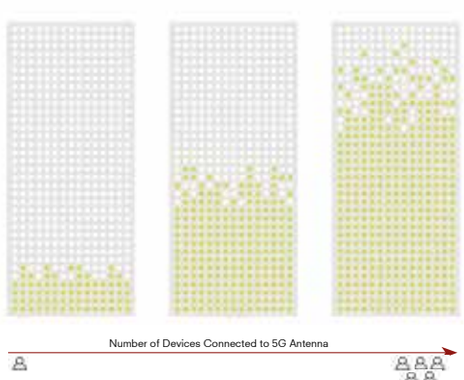
Entrance - Plaza on Rooftop

Interior - 'Sky' Restaurant

The programmatic concept for the transmitter focuses on the relation between visitors and antennas. By placing public restaurant, and observatory on the floors with direct view towards installed antenna devices, the main goal of the program distribution is to re-discover the relation between humans and technology by bringing both to one space.

Transmitter - Perspective Section Towards Public Floor

Ultimately, the building is also perceived from the outside - informing the users about the intensity of the use of 5G signal. The façade becomes here an informative tool – depicting the intensity of antenna use on each side of building. The skin will consist of panels that will shine accordingly to the number of devices used at the moment.



Facade Panels Concept

View From Pedestrian Bridge

Elements

1. Steel Bracing
2. Maintenance Path
3. Facade Support System Steel Profile
4. Maitenance Ladder
5. LED Reflectors
6. Supporting Steel Frame
7. Lignatur Panel
8. Steel Joint
9. Steel I-Beam 300mm
10. Service Distribution Area/Wooden I-Beams
11. Antenna Palelling Control Unit
12. 5G Massive MIMO Antenna
13. Double Glass Window
14. Mullion
15. Aluminium Roof Profile
16. Server Cooling System
17. Prefabricated Facade Panel
18. Anchor Bolt
19. Mineral Wood 150 mm
20. Reiforced Concrete Beam
21. Suspended Ceiling System
22. Air Handling Unit
23. Aluminium Roof Profile

W1 Facade Skin
Aluminium Frame 160 mm
Panels with LED Lights

W2 Attic Wall
Fiber Cement Panel 30 mm
Water Isulation th. 0,5mm
Gypsum Board th. 20 mm
Mineral Wool th. 150 mm
Gypsum Board th. 20 mm
Water Isulation th. 0,5mm

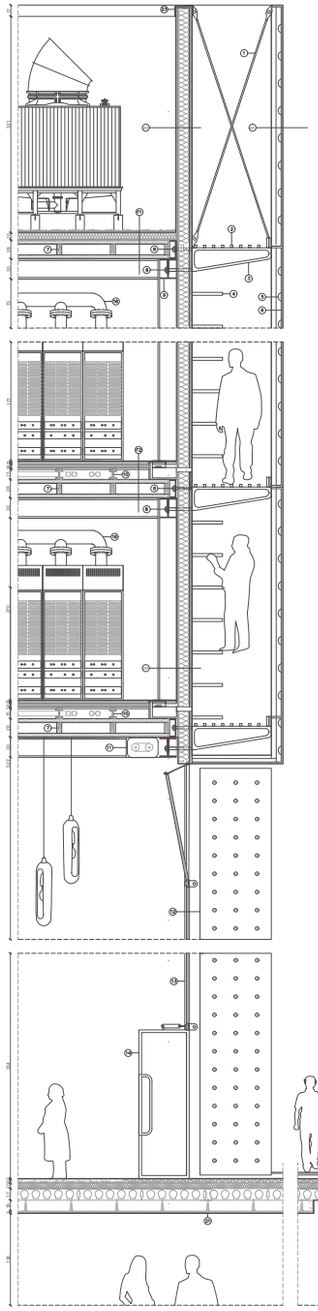
W3 External Wall
Fiber Cement Panel 30 mm
Water Isulation th. 0,5mm
Gypsum Board th. 20 mm
Mineral Wool th. 150 mm
Gypsum Board th. 20 mm

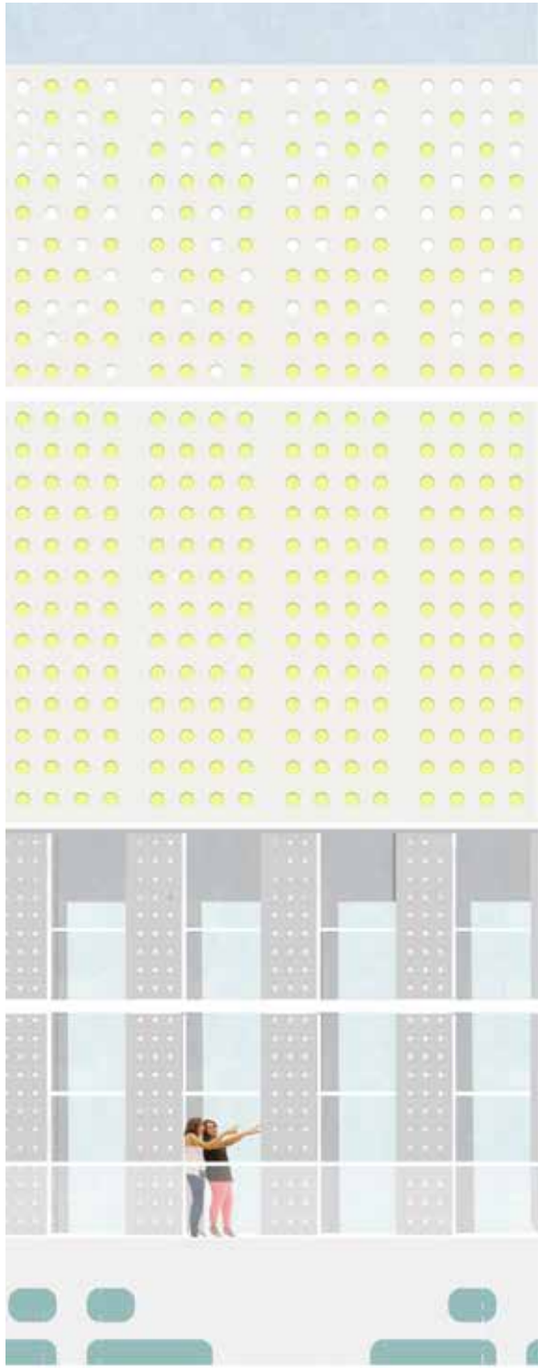
F1 Roof
Gravel th. 30mm
Water Isulation th. 0,5mm
Thermal Insulation - mineral wool th. 10 cm
Lignature Floor Panel th 280 mm

F2 Middle Floor
Floor FInish th. 20 mm
Gypsum Board th. 20 mm
Service Distribution Space th. 250 mm
Hard Fiber Insulation 100 mm
Lignature Floor Panel th 300 mm

F3 Existing Floor
Floor FInish th. 20 mm
Concrete th. 40 mm
Hydro Insulation th. 0,5 mm
Mineral Wool th. 150mm
Hydro Insulation th. 0,5 mm
Concrete Slabs Floor th. 250 mm

Transmitter Facade Section





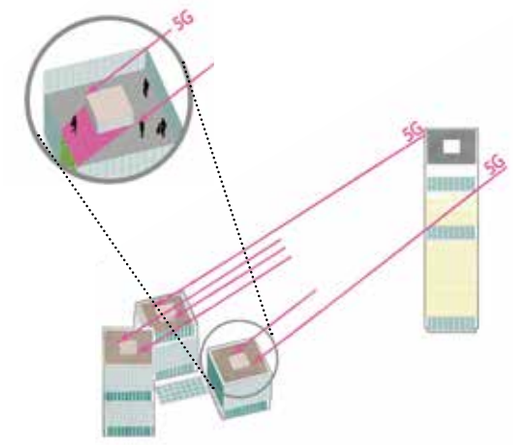
2.2 Receiver

The mass of signal receiver is separated into three separate volumes, to allow signal to reach each part of the building. Additionally the office spaces are separated into three towers to underline the contribution of three separate telecommunication operators. This results in creation of urban plaza that becomes a space to experience the potential of 5G use in cities by including the glazed view towards the underground experience center.

However, the signal beams have also influence on the interior spatial arrangement of the building. The first impact of signal to discuss is the direct impact of signal on architecture. The phenomenon of signal shadow results in creation of signal passive zones, where the signal received from main transmitter cannot be directly delivered.

As a result, the functional program of the building may be divided into spaces, where a reliable signal is needed (signal active) and analogue spaces (signal passive). This phenomenon changes the layout of offices by differentiating the space for work and leisure.

Receiver Axonometry

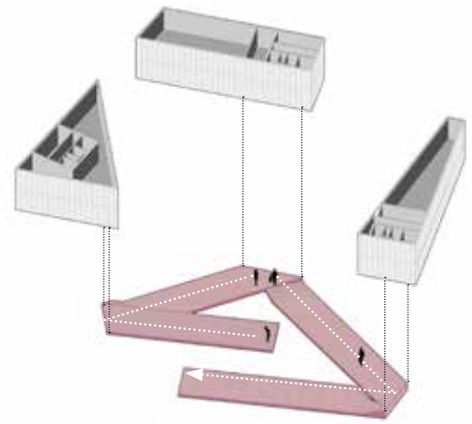


Signal Active and Passive Zones - Concept

Receiver Axonometry

At the same time, the signal beam from transmitter shapes the underground experience center, where users move along the signal path that turns when reflected by volumes with aluminum cladding in the interior.

Receiver Axonometry



Experience Center - Aluminium Volumes and Signal Path

Receiver Axonometry

The indirect impact of signal may be discovered, by looking closer at the current working practices. With the use of 5G, the use of small and portable wireless devices will increase. As a result, the presence of hybrid workers will be more common. By bringing their own devices, workers will need to connect to larger screens present in the office. With this in mind, the interior system for the 5G offices was designed, where large screens are used as separation between working spaces.

Interior - Signal Active Zone

Interior - Signal Passive Zone

Interior - Between Singal Passive and Active Zones

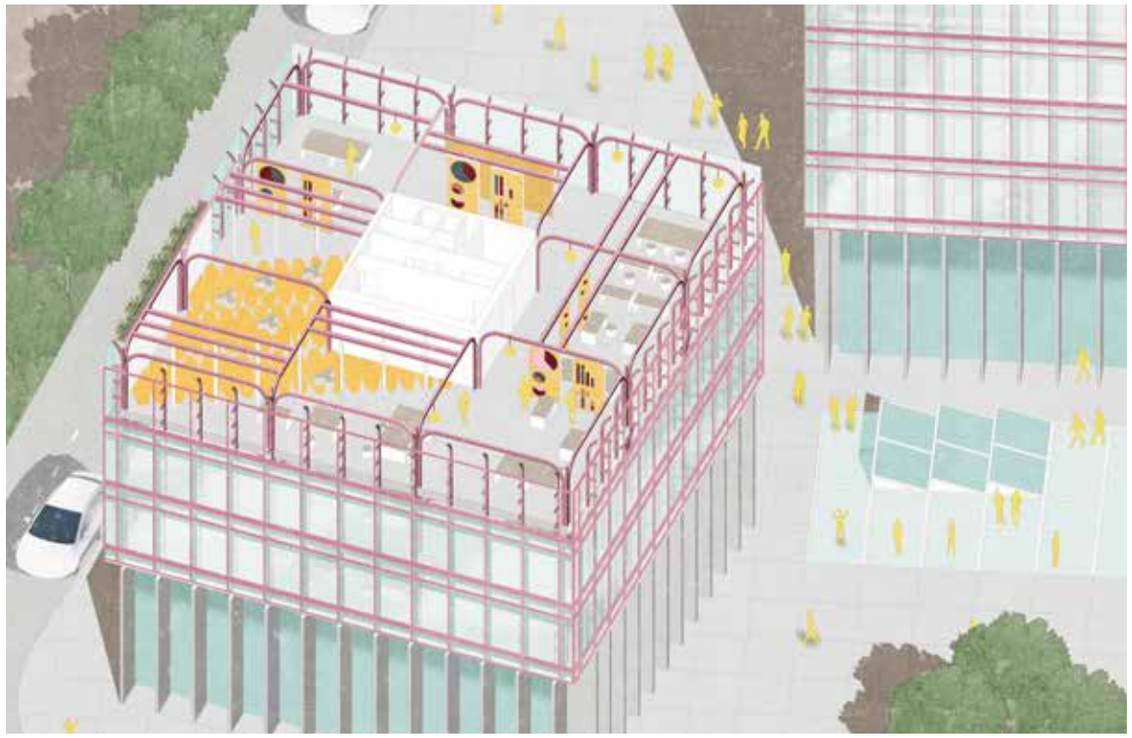
Large Screens & Portable Devices

Virtual Meetings

5G Controlled Facade

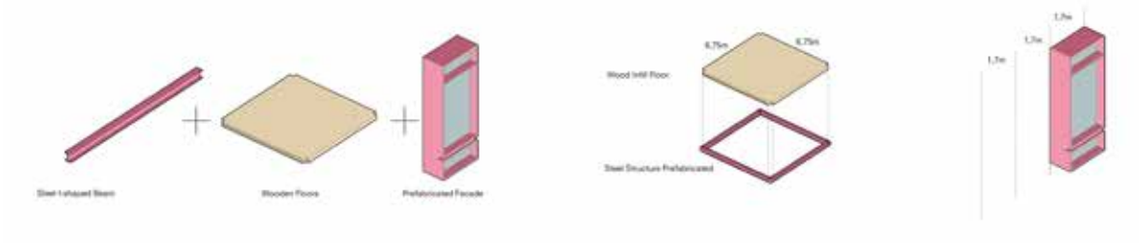
Demountable System

Receiver - Interior System



In order to provide minimal signal loss due to material, the building façade will be entirely glazed with spectrally reflective glass. This visual transparency will at the same time allow people outside of the building to understand the positive consequences and potential of 5G use in cities.

Demountable and Adaptable Building System



View Towards Plaza

Elements

1. Glass Fiber Isulation
2. Mullion
3. Spectrally Selective Double Glass
4. Air Inflow Floor System
5. Aluminium C Profile 100 mm
6. Steel I-Column 300mm
7. Aluminium Profile
8. Lignatur Panel
9. Steel Joint
10. Steel I-Beam 300mm
11. Roller Blinds System
12. Blinds
13. Air Handling Unit
14. Aluminium Facade System
15. 5G Sensors
16. Screens
18. Antenna Palelling Control Unit
19. 5G Massive MIMO Antenna
20. Double Glass Window
21. Automatic Doors 220x90
22. Water Drainage System
23. Reinforced Concrete Foundation
24. Drainage Water Pipe o 100mm
25. Ceiling Cooling Panels
26. Wood I-Beam 150 mm

W1 Glazed Facade
Double Glazed Curtain Wall th. 20 mm

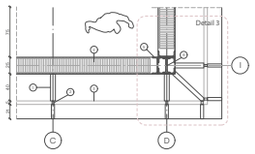
W2 Attic Wall
Gypsum Board th. 20 mm
Water Isulation th. 0,5mm
Fiber Glass th. 10 cm
Panel Cladding th. 10 mm

F1 Roof
Gravel th. 30mm
Water Isulation th. 0,5mm
Thermal Insulation - mineral wool th. 10 cm
Lignature Floor Panel th 280 mm

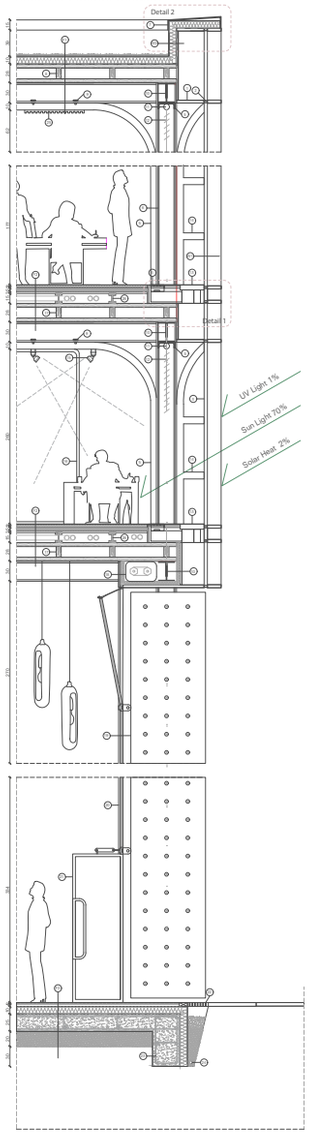
F2 Middle Floor
Floor FInish th. 20 mm
Gypsum Board th. 20 mm
Hard Fiber Insulation 50 mm
MDF Board 30 mm
Service Distribution Space th. 150 mm
Lignature Floor Panel th 280 mm

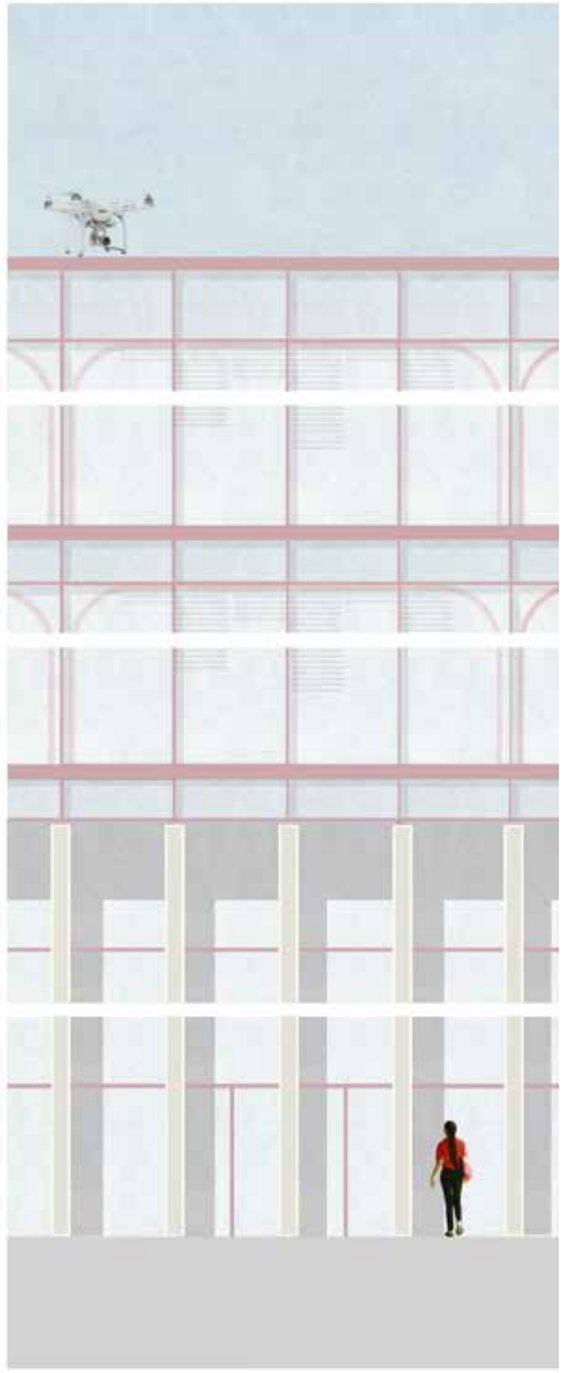
F3 Foundation Floor
Floor FInish th. 20 mm
Concrete th. 40 mm
Hydro Insulation th. 0,5 mm
Thermal Insulation - Mineral Wool th. 100mm
Hydro Insulation th. 0,5 mm
Reinforced Concrete Floor th. 250 mm
Sand 200 mm

Receiver Facade Plan



Receiver Facade Section





3. Reflection

3.1 Aspect 1 - The relationship between research and design.

Thinking back about my initial fascination in signal influence on architecture, I believe the consequence of these wireless revolution can be summarized on two levels. The fist aspect of signal influence is purely scientific. It recognizes the shape of antenna, height requirements, and urban blockades as primary design aspects. Signal determines minimal, formal and functional requirements for cities and buildings. In scientific sense, although invisible, signal still can be measured in lengths, amplitude or directions and applied in architecture.

On the other hand, the history of signal is purely subjective. It is about the relation between humans and technology or its public perception. It is without doubt that historically, the form and functionality of architecture was changing together new types of antennas that were invented. However, most of the design decisions were just brought to the extreme, as a result of human's fascination in the power of technology. To put it simply, as the matter of scientific logic, the architecture did not need to obtain such cosmic and elaborated forms but it started responding to the need of people. Architecture of signal became primarily the material promise and irrational symbol of new digital era.

Therefore, conducted research helped to develop design in several aspects including, in particular: determining the relations between two buildings, defining system for antenna placement on both facilities, planning a spatial distribution of signal active and passive functional zones as well as to respond to human perception of 5G implementation in cities. It is without doubt that the both historical research about how signal altered human lives as well as scientific understanding of 5G Implications on architecture, significantly influences all design decisions and led to multiple discoveries, on how this new era of signal processing can once again cause a revolution in architecture.

3.2 Aspect 2 - The relationship between your graduation topic and studio topic.

Graduation project tackles the topic of complex project studio by identifying signal as the medium of contemporary migration and an important factor constituting to rapid globalization. At the same time the defined problem of 5G implementation in cities aims to investigate the influence of wireless technologies on built environment, where the 'congestion' factor of cities will be from the beginning of 5G era, depending on the proximity to signal source. Therefore, signal can be seen as a fourth, invisible dimension that continues to shape places as well as human lives.

By looking at the regions, cities and buildings through lenses of signal strength and directions, the graduation project has impact on all scales of architectural thinking, what is directly linked to methodology and philosophy of the Complex Project Studio. In addition, 5G may be seen as an opportunity for renewing the cities on large scale, together with technological advancement that is arriving. By by developing the consistent narrative, starting with urban consequences of 5G implementation, through investigation of appropriate signal-responsive building massing and programmatic distribution of functions within a building, the graduation project reveals the range of complexity on all scales of architectural intervention.

3.3 Aspect 3 - Research method and approach chosen by the student in relation to the graduation studio.

In the initial stage, as an element of the graduation studio methodology, the research was based on collaborative studies among students, regarding Delfshaven region in Rotterdam during which hard data was gathered and interpreted in order to formulate group strategy and site vision. At the same time, the empirical research consisted of site visit that allowed to observe and critically verify previously collected data.

With this in mind, the individual fascination was developed, based on one of the findings on site. My initial interest in signal started from the presence of Euromast on site of group intervention. Therefore, the next stage of research was focused on historical analysis of signal influence on architecture. The conducted overview of literature enabled to find the gap in existing research and allowed to clarify problem statement, what was defined as insufficient research on 5G Implementation in the city of Rotterdam and its influence on built environment.

Consequently, in the next stage of the research I focused on translation of scientific papers into architectural and urban implications that allowed to create own contribution towards existing research about 5G throughout a speculative analysis. This analytical speculation, reinforced by former historical background, allowed to formulate rules and guidelines for efficient and conscious 5G implementation in cities. At the same time, one of the graduation studio requirements was to prepare an extensive design brief, where these findings were included together with the analysis of chosen case studies.

Ultimately, in the last stage of research, the analysis and mapping of urban context were conducted, that allowed to formulate urban rules and guidelines for planned design intervention as well as determine plot characteristics and design requirements related to that.

3.4 Aspect 4 - Relationship between the graduation project and the wider social, professional and scientific relevance.

By tracing the origins of signal discovery and related antenna invention as well as through the analytical speculation on future impact of wireless technologies on architecture, the graduation project aims to create a background for the further, effective and sustainable implementation of wireless technologies in cities. In the era of extensive development in digital sphere, the understanding of signal influence on architecture and humans maybe a key to progress towards understanding of the feasible future for our cities.

Therefore, by identifying the key changes in the architectural environment, caused by signal progression from 1G to 4G technology and throughout a critical analysis of scientific papers regarding the anticipated implementation of 5G technology, the conducted research may be highly relevant for the design decisions regarding the implementation of this new method of signal distribution in cities.

The purpose of graduation project was to discover the architectural, urban and social consequences of 5G implementation, define rules and ideas for 5G antenna devices implementation in cities and focus both on expected physical requirements for the built environment as well as on embracing architectural necessities related to 5G implementation in cities. Therefore, the understanding of how wireless technologies will continue to shape cities and buildings, provided by the graduation project, may be a crucial knowledge and solid base for design decisions in contemporary architecture.

3.5 Aspect 5 - Ethical issues and dilemmas you may have encountered during graduation.

The ethical dilemmas that I encountered during research and design process were related to public perception of infrastructure-related object in cities. On one hand, with every signal technology improvements, humans were given more possibilities. The evolution from 1G to 4G enabled among others live transmissions, geolocation system or constant connection through social media. Undoubtedly, each of the signal inventions meant a life-quality improvement and allowed human species to advance.

Yet, on the other hand, the implementation of 5G technology raises strong human concerns about security or consequences on health. Protesters are burning antenna masts across the cities in Netherlands and spreading conspiracy theories among residents. Fear of 5G technology arises from ignorance, as the infrastructures of signal that still exist in urban areas, started being carefully camouflaged in the skyline of cities (Parks, 2019). Broadly speaking, the infrastructural aspects of architecture started being recognized as one of 'poor esthetics' and as a result, relocated to suburbs or carefully hidden in cities.

Therefore, the ethical dilemma that I encountered was mostly related to the question, how much should the technology and antennas be exposed in the cities. Acknowledging, that as a result of new 5G implication, the number of antennas in cities will increase ten times (Shaw, 2019), the question remains to be answered on global scale – how to incorporate them into the build environment? Is the politics of infrastructural invisibility and related lack of knowledge about the infrastructure that surrounds us, leading to fear of technology and 5G Implementation?

4. Conclusions

This graduation project is on one hand purely about science of signal, while on the other it tackles primarily the relation between humans and technology. The overall design concept, by developing both facilities, transparent placement of antennas and educational aspects of built architecture aim to inform the citizens about the influence of signal on architecture and everyday lives. By allowing people to directly see the impact of signal and throughout the merging of the environment of machines with public zones of entertainment, the project aims to reduce the fear and negative perception of 5G implementation in cities. Ultimately, the graduation project re-discovers the power of architecture in altering human perception of new technologies in city.

5. Bibliography

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