

# HEALTHCARE IN TRANSITION

*Architecture(s) and processes at the  
convergence of healthcare and technology*

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P5

Transitional Territories Studio





# RESEARCH

## *Research Question(s)*

**What kind of public health intervention (infrastructural and systemic) can contribute to innovation in the management of the Dutch healthcare system and alleviating its territorial footprint?**

### **Territorial/Urban**

What infrastructural/typological reconfigurations should be carried out to increase the resiliency of medical facilities and alleviate the territorial footprint of healthcare?

How can the calculated displacement and reconfiguration of the decentralized model of healthcare facilities contribute to an alleviation of urban-related illnesses and medical disorders?

To what extent can the urban shore be reconfigured as a territory of healthcare?

### **Architectural**

To what extent can digitisation (logistic and process optimization, human-centric robotization, automation and patient data collection via wearable technology) alter the scale and programme of medical facilities and processes of cure & care?

How do natural and digitised healing processes result in coexisting healing spaces and practices?

## *Theoretical Background*

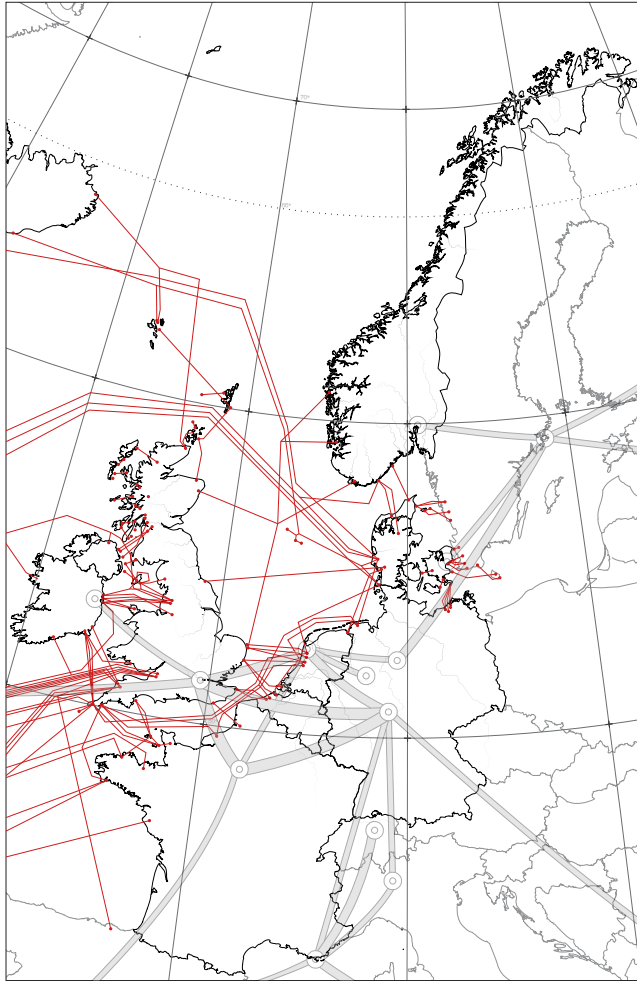
### *Williams: Retooling*

*“A humanistic account of the changing role of technology in society”*

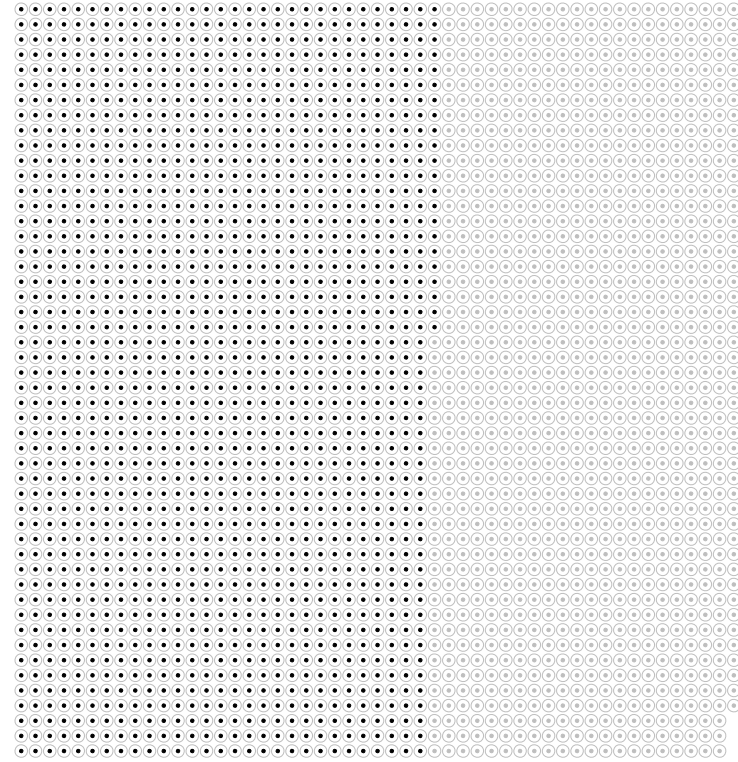
*Drawing insights from society’s obsession with technology and advocating for a reconciliation between technological change and community (and nature). This will come from connecting social innovation to technology.*



## North Sea data infrastructure



## Physical footprint of data



### Data Centres in Europe

United Kingdom	(415)	Ireland	(44)	Georgia	(2)
Germany	(417)	Denmark	(43)	Iceland	(4)
Spain	(98)	Portugal	(16)	Serbia	(6)
Netherlands	(247)	Ukraine	(46)	Belarus	(2)
France	(249)	Slovakia	(14)	Gibraltar	(1)
Austria	(59)	Hungary	(12)	Malta	(4)
Sweden	(93)	Croatia	(6)	Cyprus	(5)
Poland	(116)	Norway	(36)	Slovenia	(10)
Belgium	(65)	Luxembourg	(23)	Bosnia & Herzeg.	(1)
Bulgaria	(21)	Turkey	(28)	Monaco	(1)
Italy	(115)	Greece	(11)	Moldova	(3)
Romania	(21)	Finland	(34)	Liechtenstein	(1)
Russia	(117)	Latvia	(14)	Azerbaijan	(1)
Switzerland	(68)	Lithuania	(13)	Guernsey	(1)
Czech Republic	(37)	Macedonia	(2)		

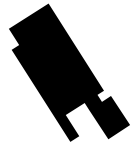
### Data Centres with the most data traffic and number of service providers

**Equinix FRS**  
Frankfurt, GER  
Service Providers: 244

**TeleHouse London Docklands North**  
London, UK  
Service Providers: 374

**Equinix AM7**  
Amsterdam, NL  
Service Providers: 234

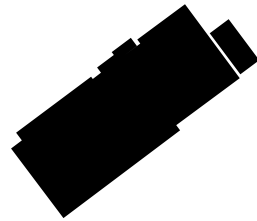
# Typological Study



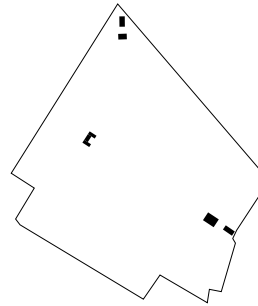
**Rotterdam-The Hague Airport**  
Airport, Rotterdam, NL



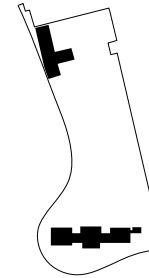
**National Bank of Denmark**  
Bank, Copenhagen, DK



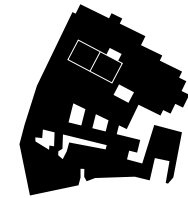
**Glasshouse**  
Glasshouse, Massdijk, NL



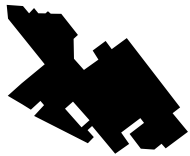
**Assisstens Cemetery**  
Cemetery, Copenhagen, DK



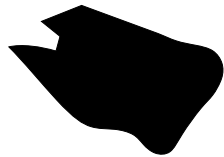
**Hortus Botanicus**  
Botnaical Garden, Leiden, NL



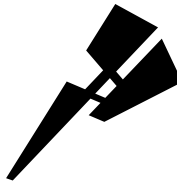
**Guy's Hospital**  
Hospital, London, UK



**Royal Library of the Netherlands**  
Library, The Hague, NL



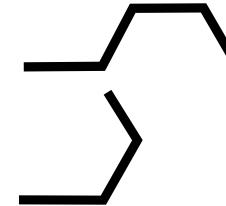
**Selfridges**  
Department Store, Birmingham, UK



**Astrup Fearnley Museet**  
Museum, Oslo, NO



**Scottish Parliament Building**  
Parliament, Edinburgh, UK



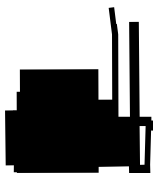
**Bijlmermeer**  
Residential, Amsterdam, NL



**Noma**  
Restaurant, Copenhagen, DK



**City Hall**  
Governmental Building, London, UK



**Gare du Nord**  
Railway Station, Paris, FR



**Amazon Fulfillement Centre**  
Factory, Tilbury, UK



**Royal Courts of Justice**  
Judicial, London, UK



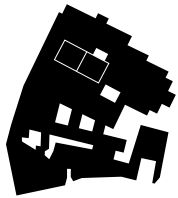
**Royal Academy of Fine Arts**  
Educational, Antwerp, BE



**Hotel New York**  
Hotel, Rotterdam, NL



# Digitisation of Healthcare - Disruptions



**Guy's Hospital**  
Hospital, London, UK

SYSTEM THEMATIC

Healthcare

Data

BioTechnology + Data



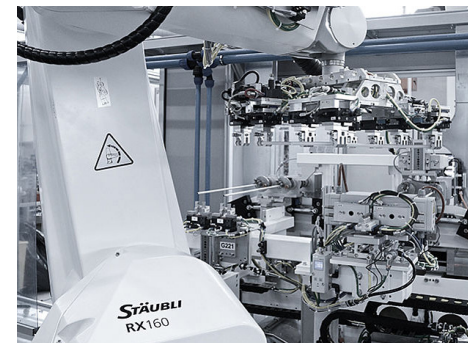
INFRASTRUCTURE - Food & Medicine  
Medicine Plant



INFRASTRUCTURE & AI SYSTEMS  
Research Laboratory



INFRASTRUCTURE - Treatment  
Operation Theatre

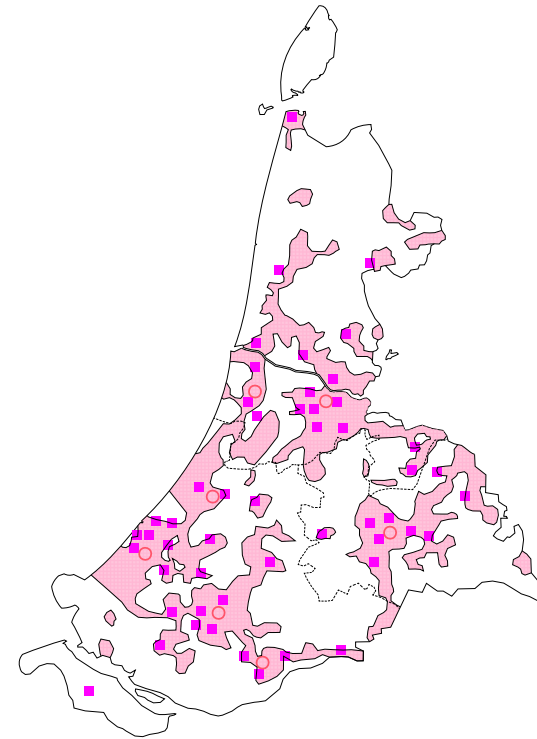


INFRASTRUCTURE  
Medical Tools and Machinery

*Footprint: Netherlands*

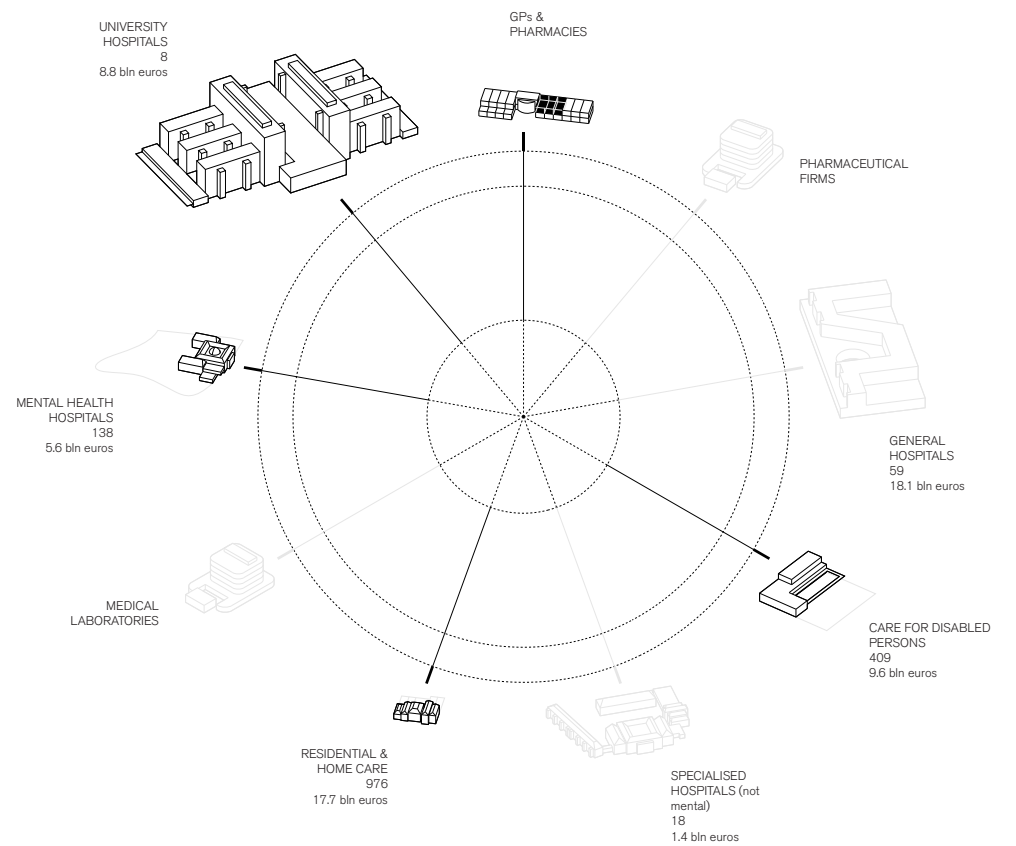
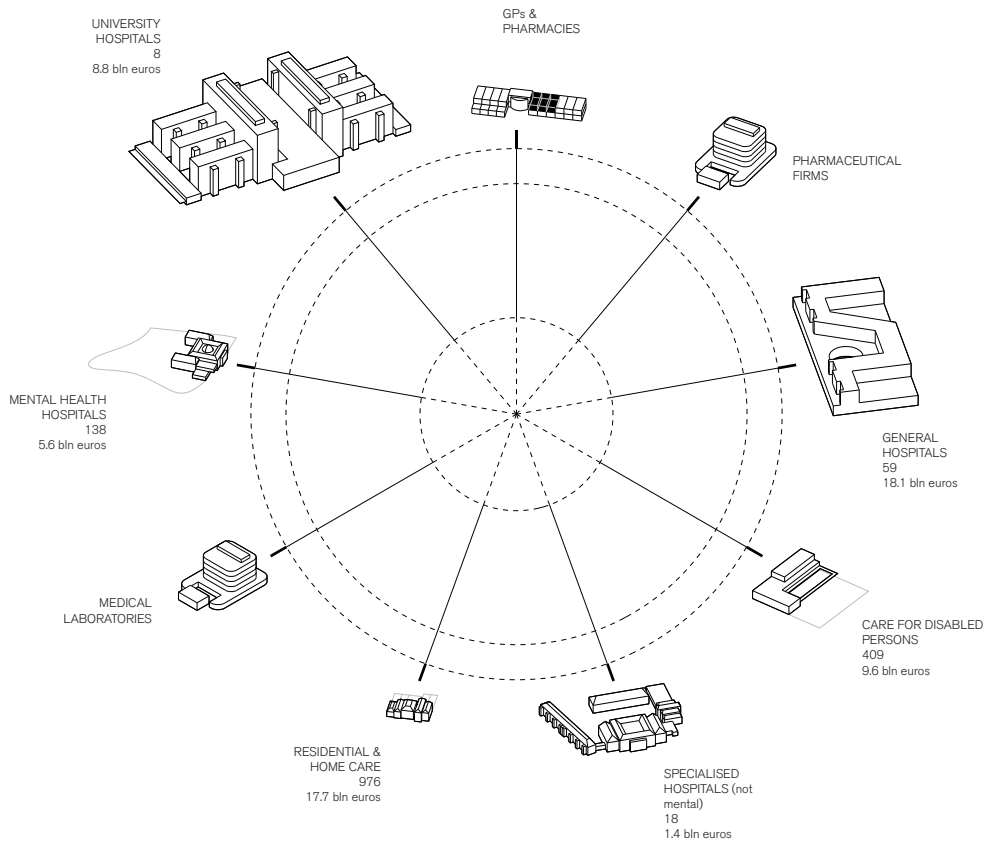


*Footprint: Randstadt*

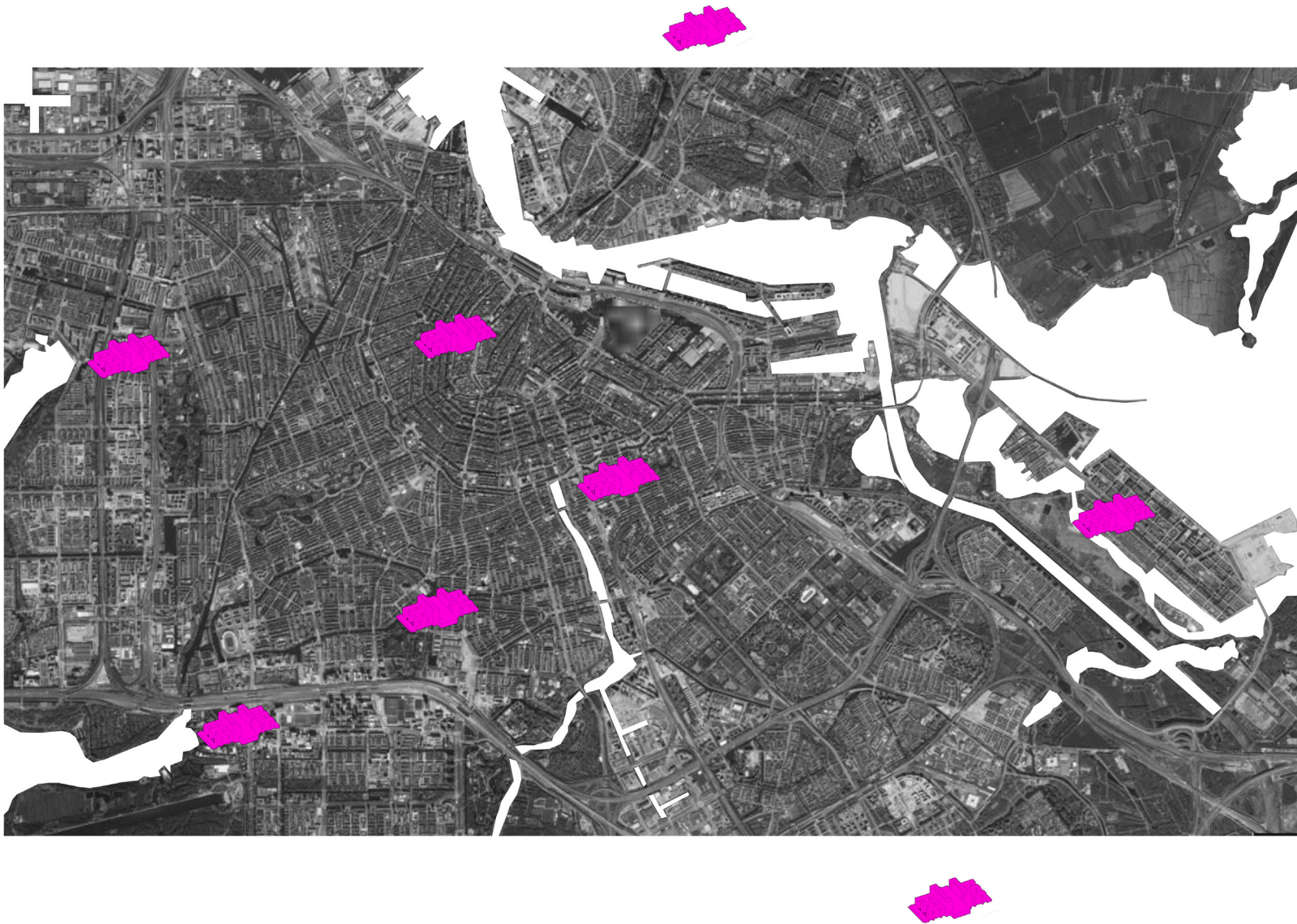


- Main Cities/Towns
- Hospitals  
University & General



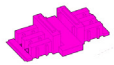


**Future of Medical Typologies**  
Redundancies

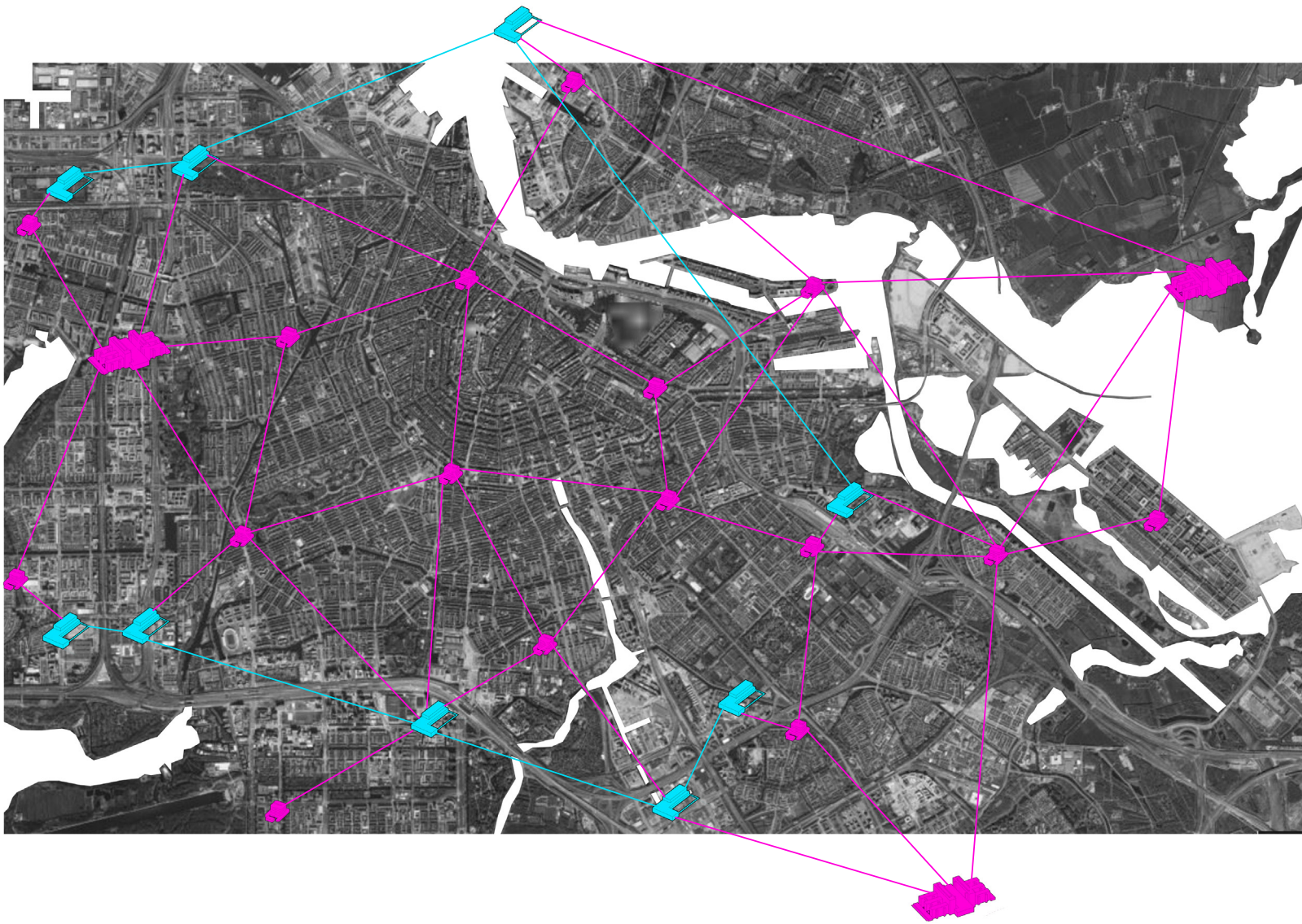


Hospital Sprawl





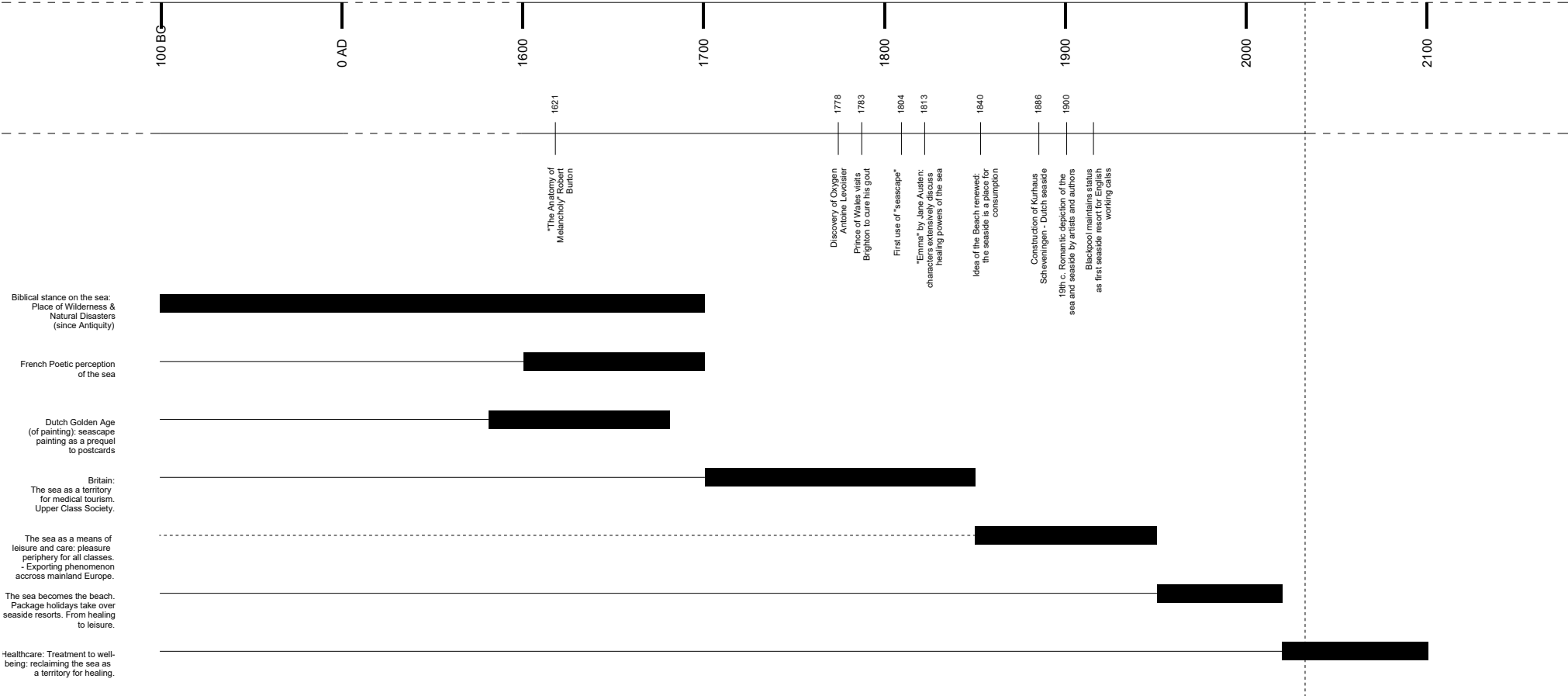
Medical Facility  
Decentralisation







# Seaside History



Historical Timeline

*Seascape*



\*The Maas at Dordrecht"  
c. 1650  
Aelbert Cuyp



*The Sea as a healing territory*

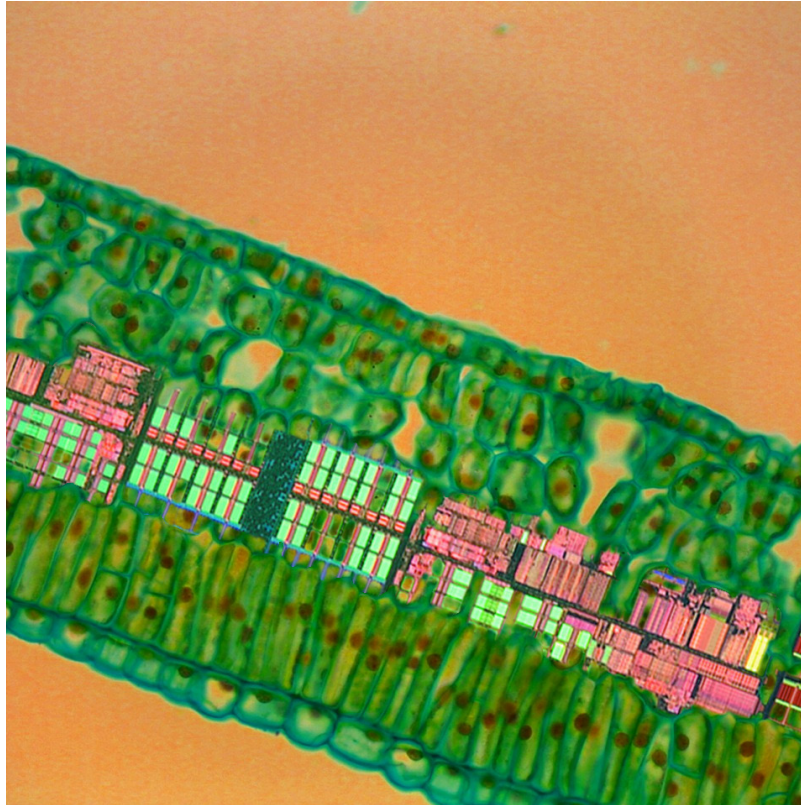


Kurhaus Scheveningen: Grand Hotel & Solarium  
circa 1900



"On the beach at Trouville"  
1871  
Claude Monet

## *Engineered Ecology*



Source: Own collage adapted from microscopic section through plant leaf.

## *Objectives*

1. Increasing efficiency of health architectures and systems via technology (digitisation, automation & robotisation)
3. Equalising digital and natural infrastructure as treatment means via interdisciplinary programme
4. Reclaiming the sea side as a territory for health and treatment

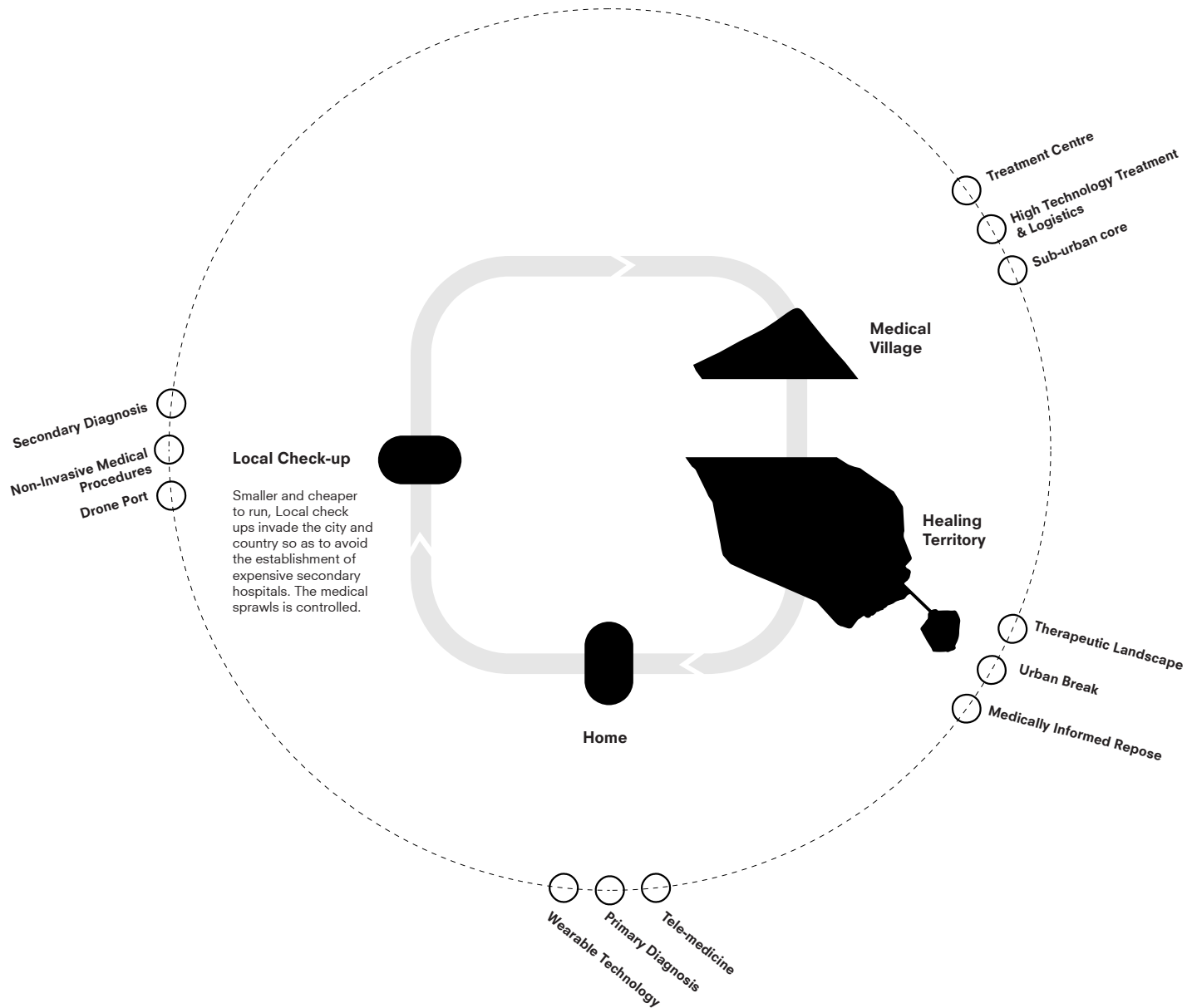
## *Project Proposal*

The architectural and territorial challenge aims to rearrange the healthcare space as a stage for radical natural-techno-human intervention. The project is committed to challenging the ramifications (cure and care) of health through the creation of a masterplan and architectural project.

“Healthcare in Transformation” enquires into the entangled processes and territorial occupation of the medical field in order to imagine alternative biotechnological, medical and ecological futures as means to alleviate sprawling facilities and urban strain.

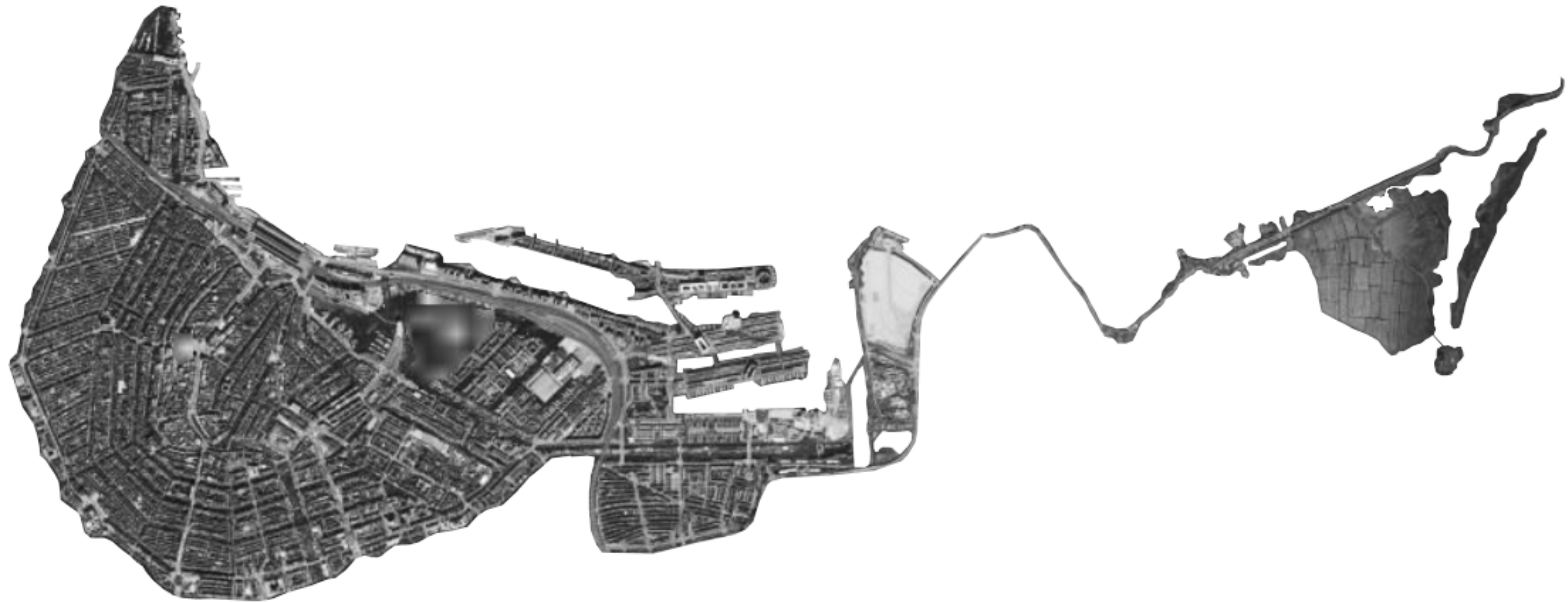
Thus, the project uses a multi-dimensional approach to solve problematics in local and territorial scales and to increase efficiency in management of public health, via data, automation and the natural environment. The project proposes an acute treatment facility (medical village) nestled within a coastal territory for healing to harness its therapeutic conditions.

# System





*Region*



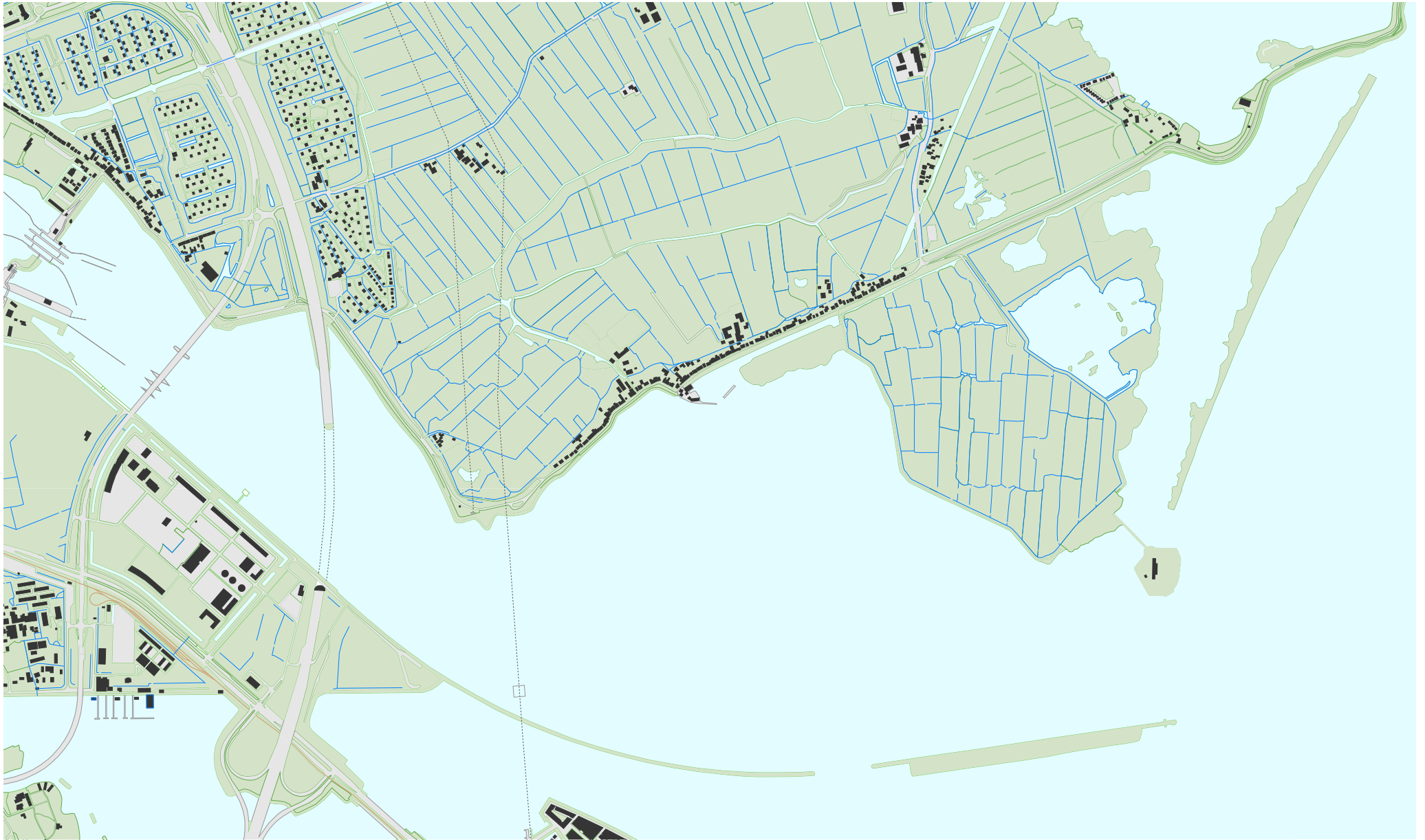
**Connection to Amsterdam's Fabric**  
City to Local context



*Site*



**IJdoorn Polder Aerial Photography**  
Siebe Swart, 2017



Ijdoorn Polder  
Intervention Location



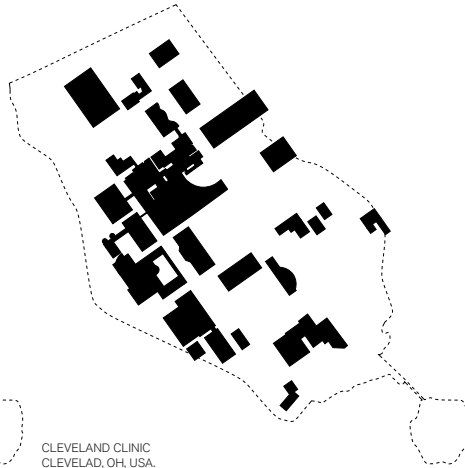
Site Analysis



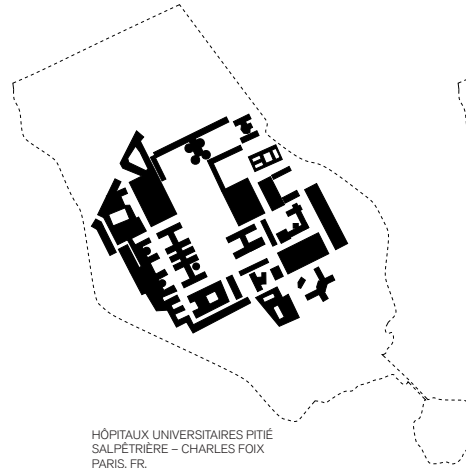
Description of the site and it's multi-layered systems



CHARITÉ – UNIVERSITÄTSMEDIZIN  
BERLIN, DE.



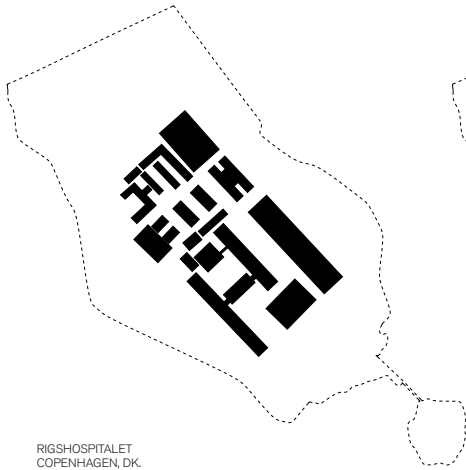
CLEVELAND CLINIC  
CLEVELAND, OH, USA.



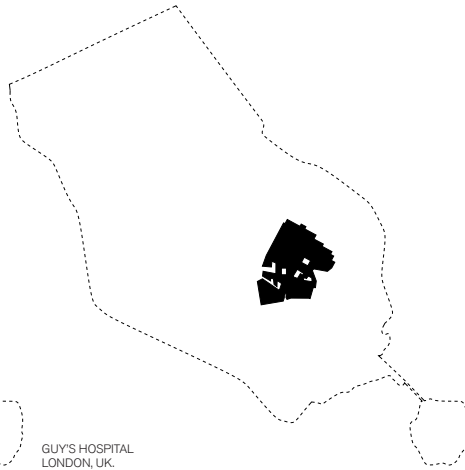
HÔPITAUX UNIVERSITAIRES PITIÉ  
SALPÊTRIÈRE – CHARLES FOIX  
PARIS, FR.



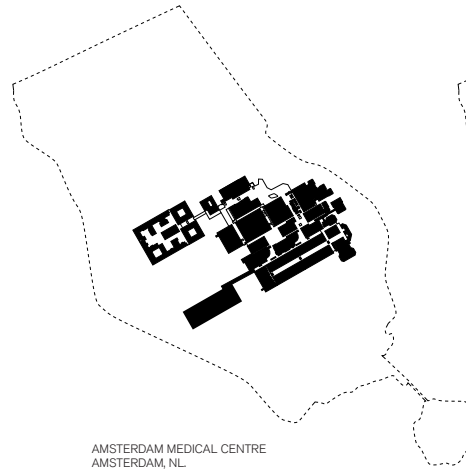
SUNSHINE COAST UNIVERSITY  
HOSPITAL  
SUNSHINE COAST, AUS.



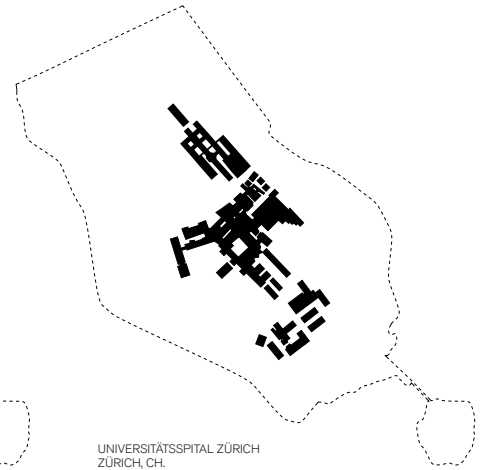
RIGSHOSPITALET  
COPENHAGEN, DK.



GUY'S HOSPITAL  
LONDON, UK.



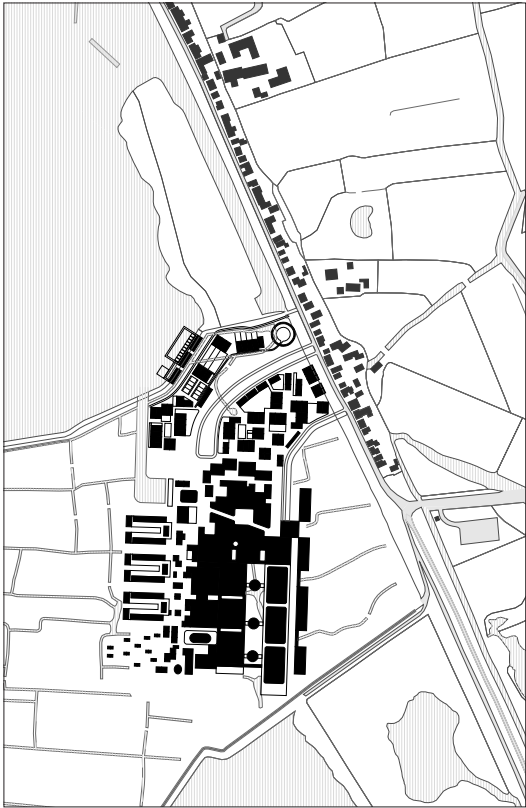
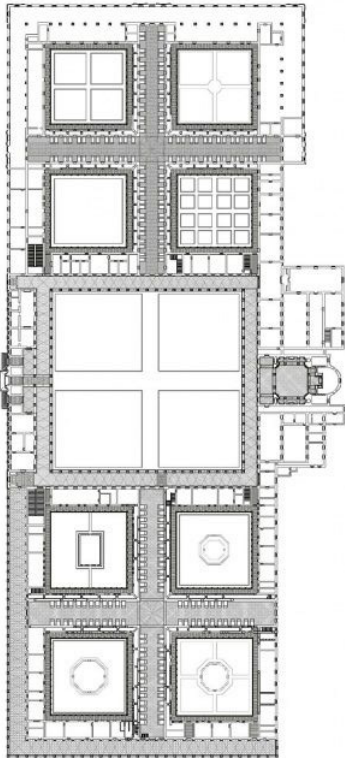
AMSTERDAM MEDICAL CENTRE  
AMSTERDAM, NL.



UNIVERSITÄTSSPITAL ZÜRICH  
ZÜRICH, CH.

Typological Study

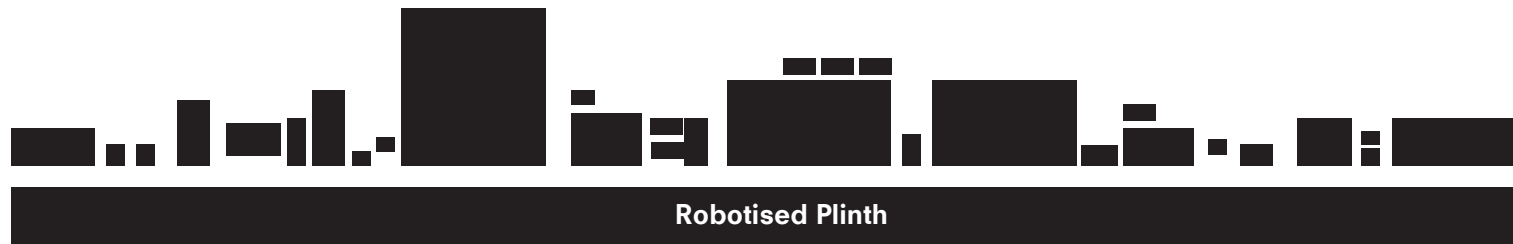
*Guiding Spatial Idea*



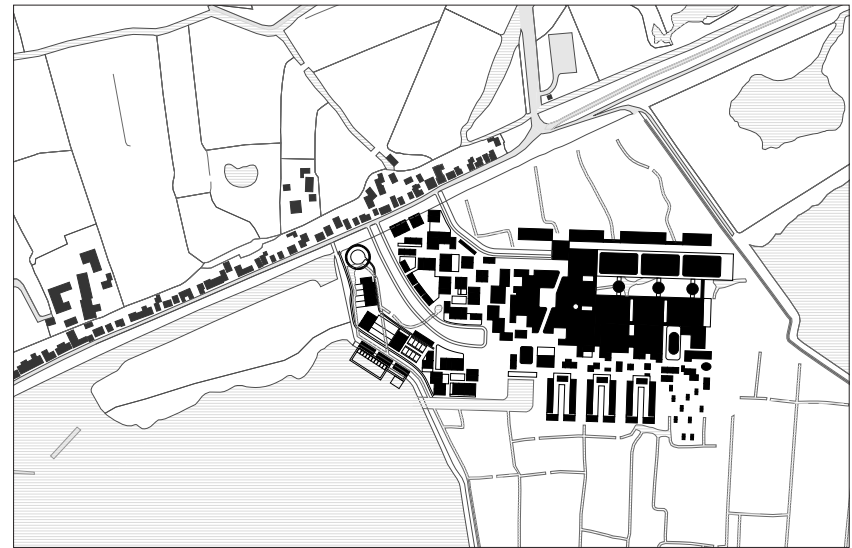
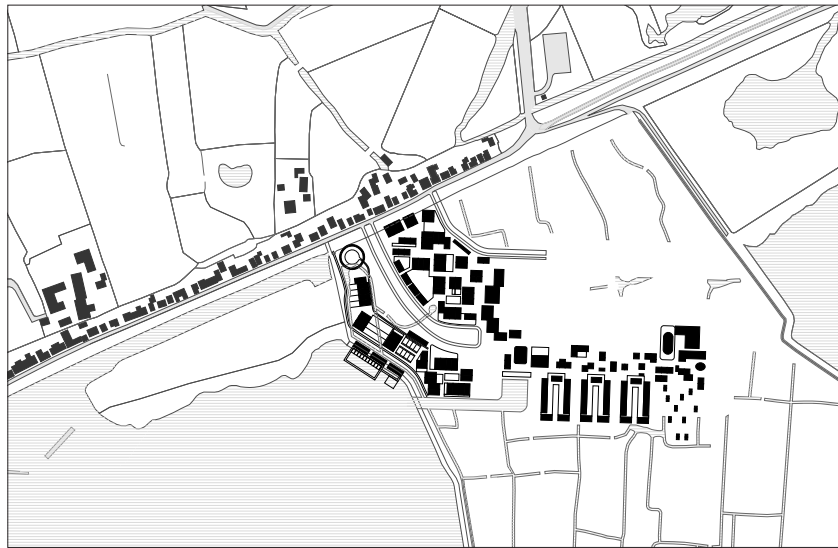
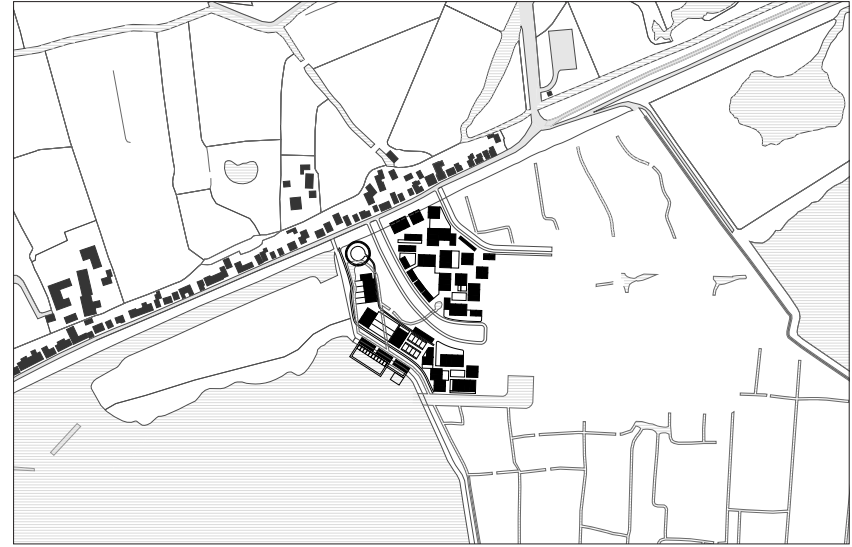
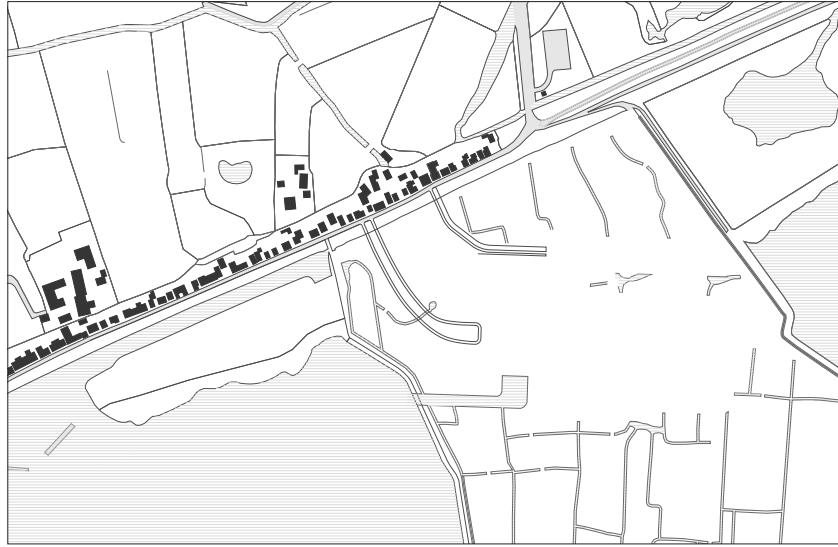
Courtyards - Tower - Village



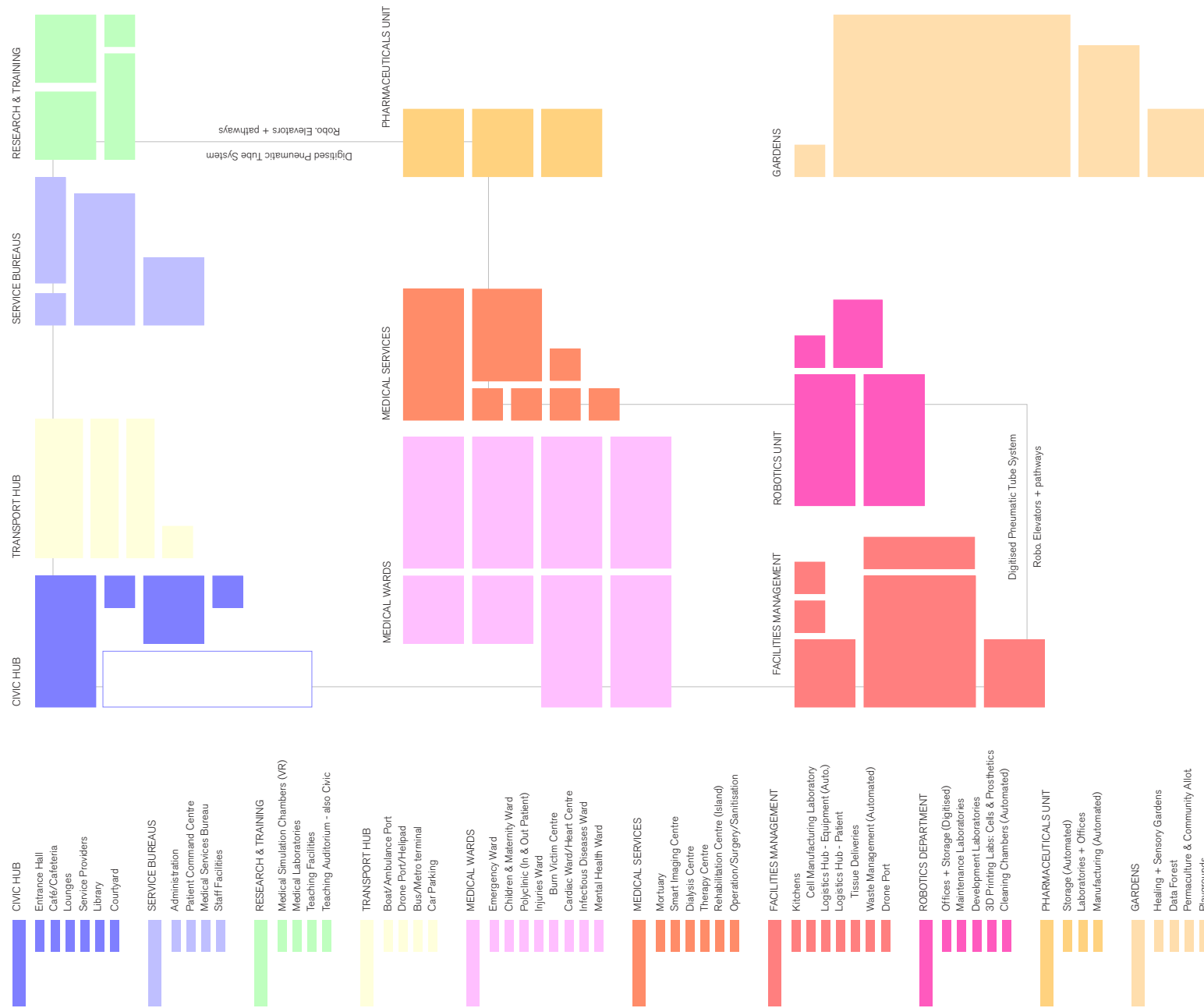
Village



Robotised Plinth

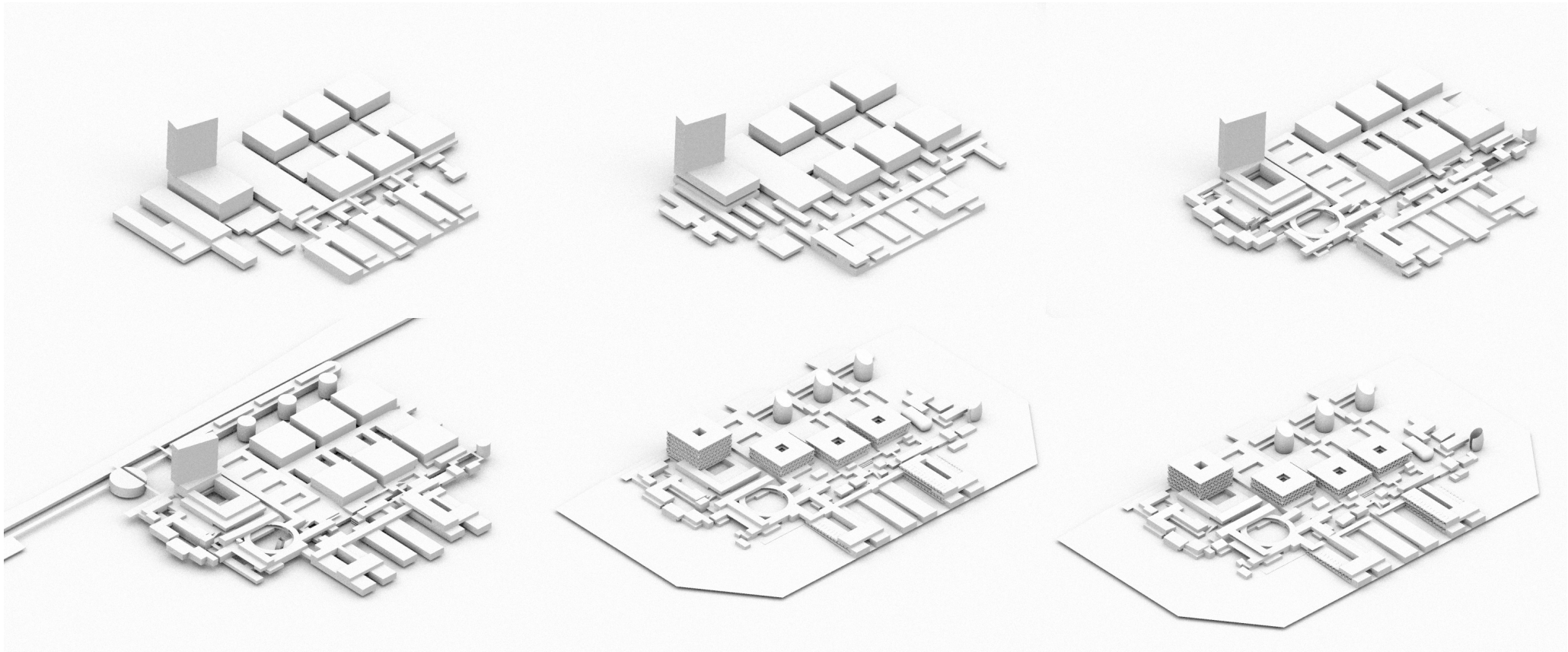




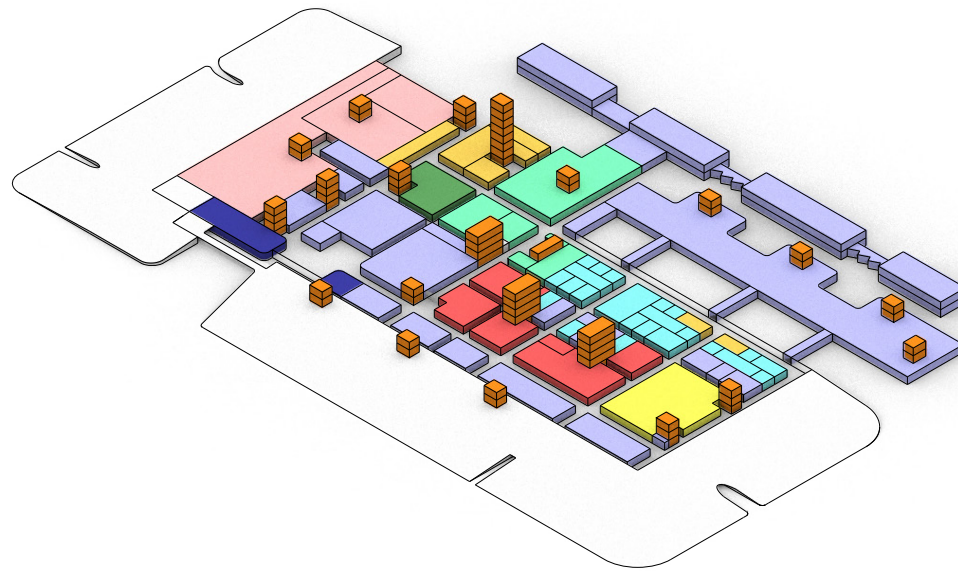


Medical Village  
 Programme Spatialisation

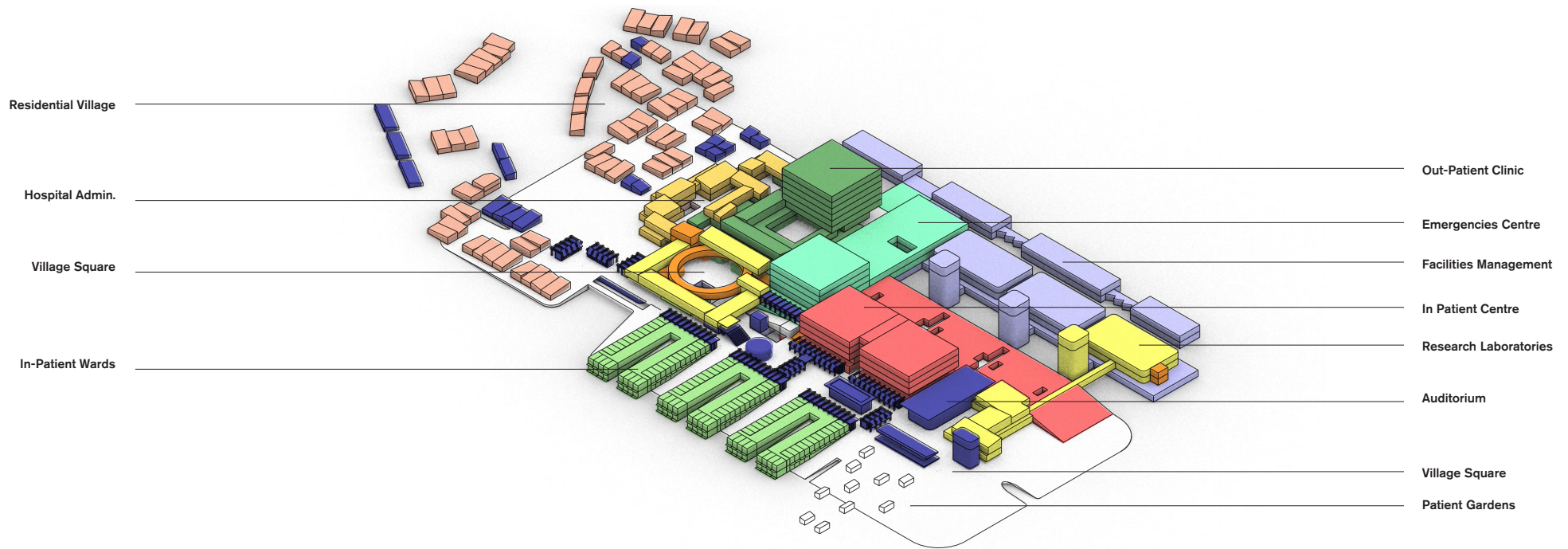








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|--|--|
| <span style="color: #90EE90;">■</span> In-Patient Wards      | <span style="color: #FFB6C1;">■</span> Parking               |
| <span style="color: #228B22;">■</span> Out-Patient Clinic    | <span style="color: #FFDAB9;">■</span> Housing               |
| <span style="color: #32CD32;">■</span> Emergency Centre      | <span style="color: #FF0000;">■</span> Medical Units/Machine |
| <span style="color: #40E0D0;">■</span> Automated Units       | <span style="color: #FF8C00;">■</span> Circulation/Cores     |
| <span style="color: #B0C4DE;">■</span> Facilities Management | <span style="color: #FFD700;">■</span> Offices/Staff         |
| <span style="color: #00008B;">■</span> Public Programme      | <span style="color: #FFFF00;">■</span> Research Centre/Labs  |

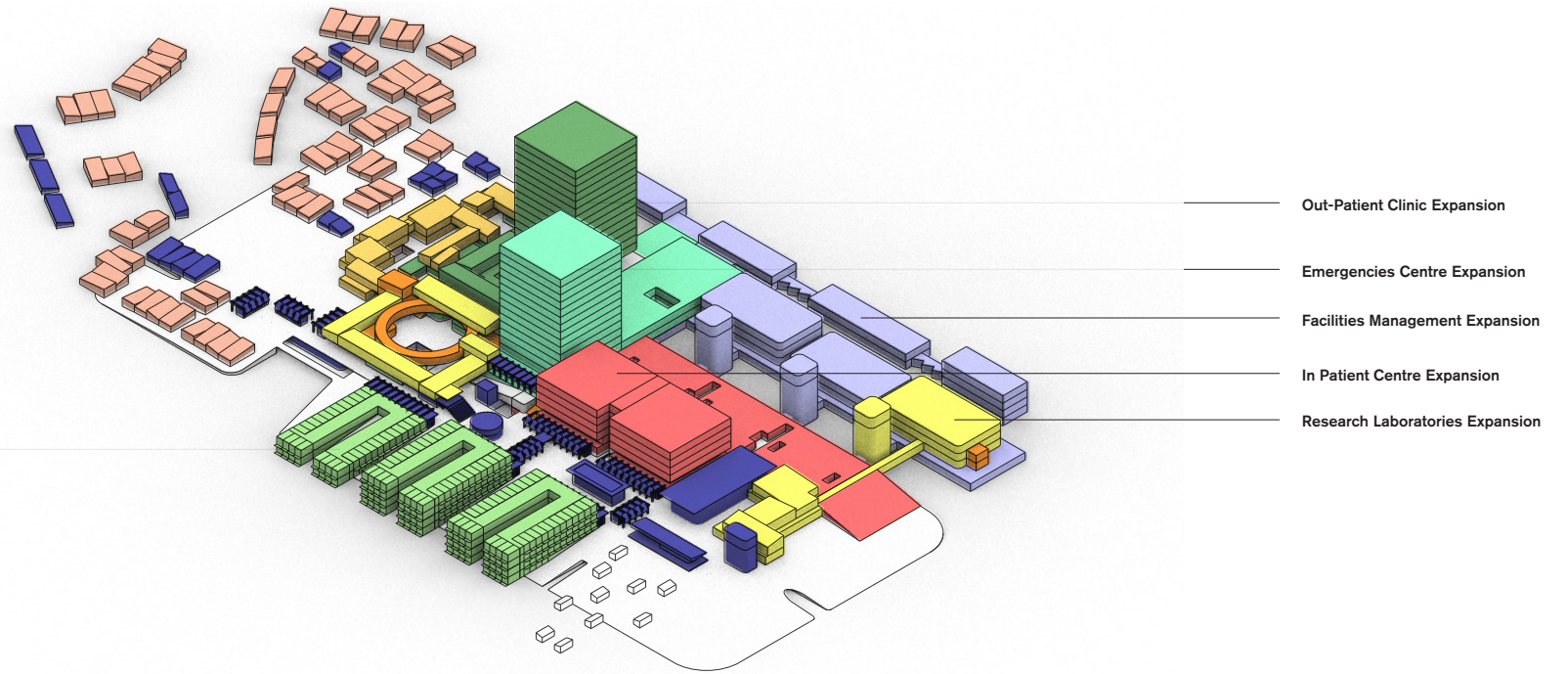


**Scenario**

Continuous Healthcare

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| <span style="color: #90EE90;">■</span> In-Patient Wards      | <span style="color: #FFB6C1;">■</span> Parking               |
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| <span style="color: #00CED1;">■</span> Automated Units       | <span style="color: #FF8C00;">■</span> Circulation/Cores     |
| <span style="color: #DDA0DD;">■</span> Facilities Management | <span style="color: #FFD700;">■</span> Offices/Staff         |
| <span style="color: #00008B;">■</span> Public Programme      | <span style="color: #FFFF00;">■</span> Research Centre/Labs  |



In-Patient Wards  
Expansion

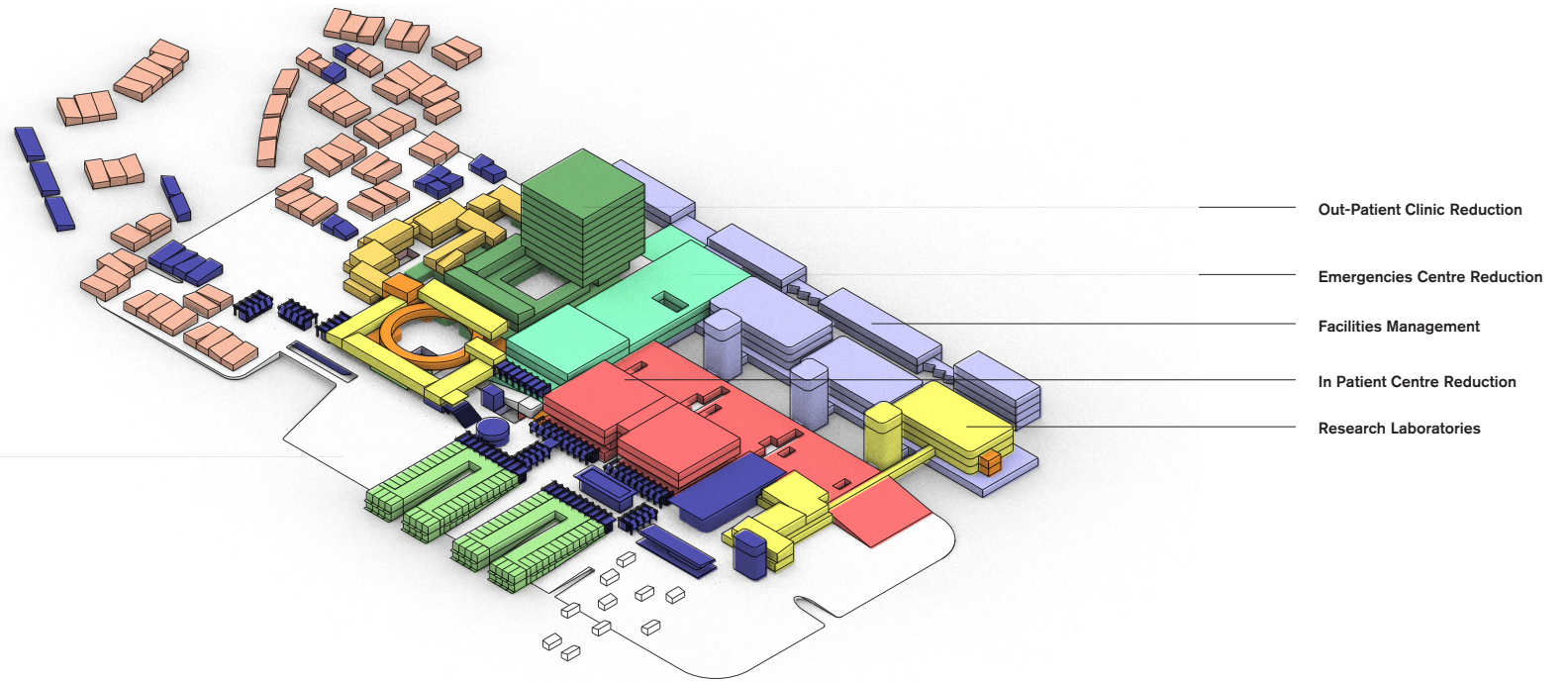
Out-Patient Clinic Expansion  
 Emergencies Centre Expansion  
 Facilities Management Expansion  
 In Patient Centre Expansion  
 Research Laboratories Expansion

**Scenario**

Pandemic/Mega Hospital/Popn. Growth

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| <span style="color: green;">■</span> In-Patient Wards          | <span style="color: pink;">■</span> Parking                |
| <span style="color: darkgreen;">■</span> Out-Patient Clinic    | <span style="color: orange;">■</span> Housing              |
| <span style="color: lightgreen;">■</span> Emergency Centre     | <span style="color: red;">■</span> Medical Units/Machine   |
| <span style="color: cyan;">■</span> Automated Units            | <span style="color: orange;">■</span> Circulation/Cores    |
| <span style="color: lightblue;">■</span> Facilities Management | <span style="color: yellow;">■</span> Offices/Staff        |
| <span style="color: darkblue;">■</span> Public Programme       | <span style="color: yellow;">■</span> Research Centre/Labs |

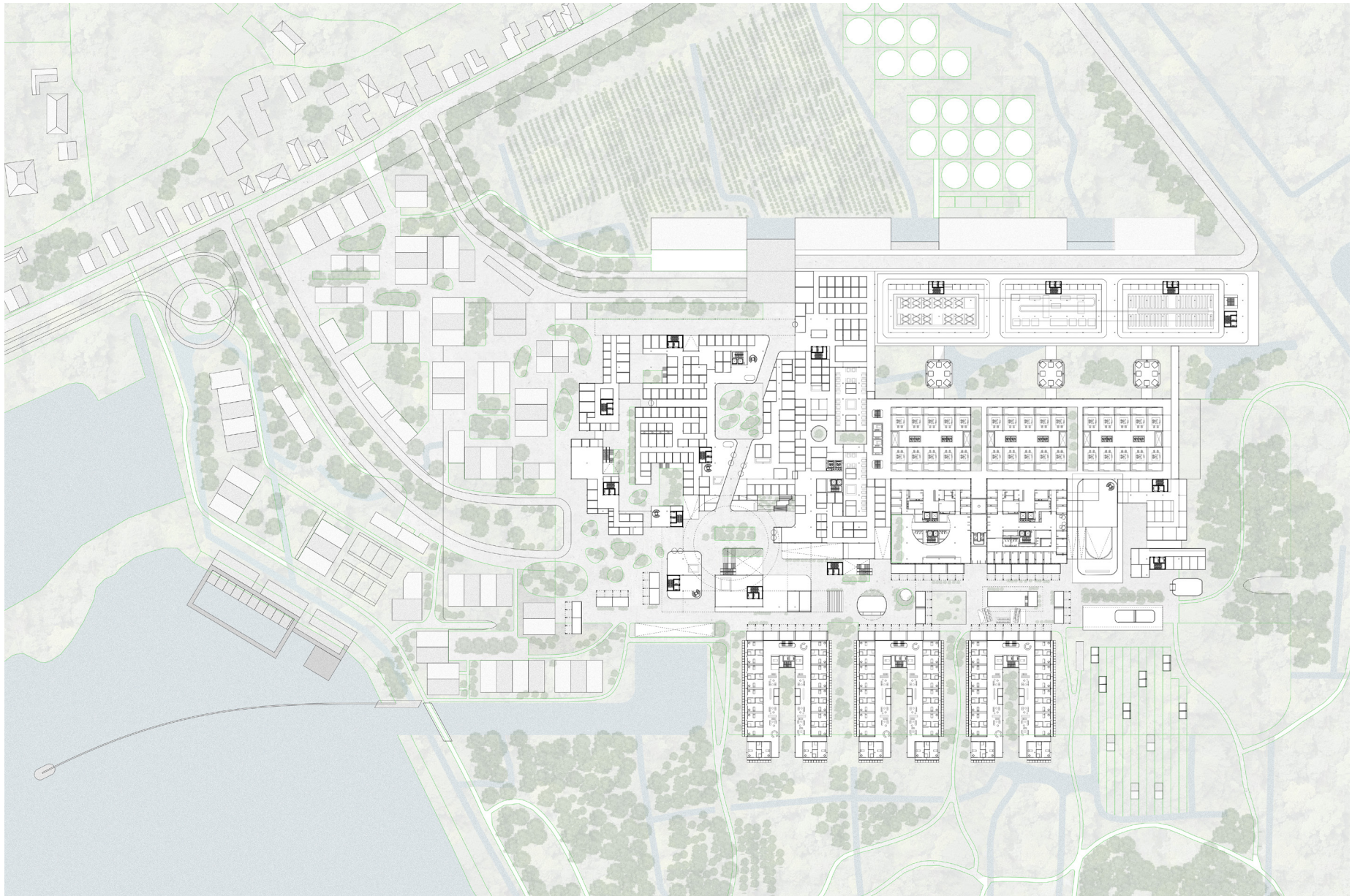


**Scenario**  
Telemedicine

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| <span style="color: #90EE90;">■</span> In-Patient Wards      | <span style="color: #FFB6C1;">■</span> Parking               |
| <span style="color: #3CB371;">■</span> Out-Patient Clinic    | <span style="color: #FFDAB9;">■</span> Housing               |
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| <span style="color: #40E0D0;">■</span> Automated Units       | <span style="color: #FF8C00;">■</span> Circulation/Cores     |
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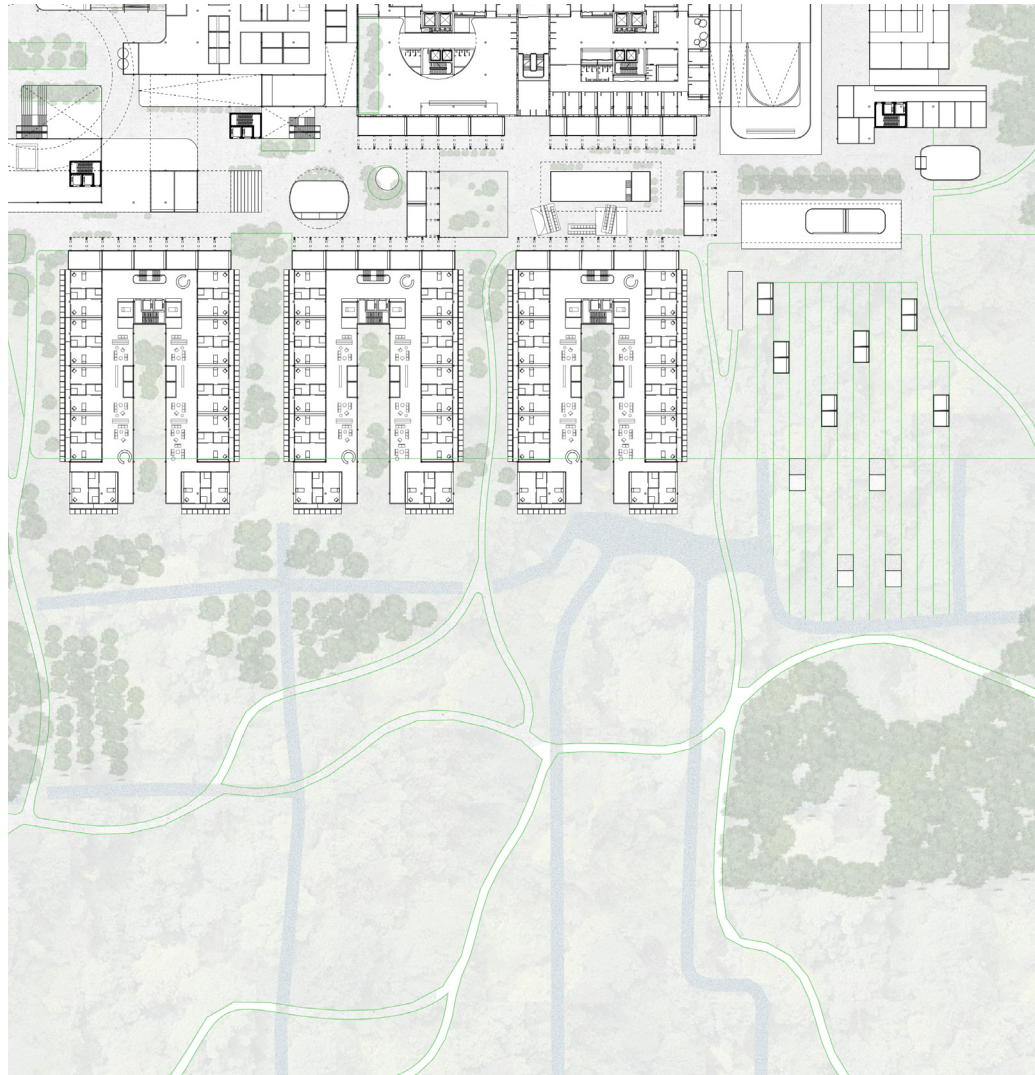






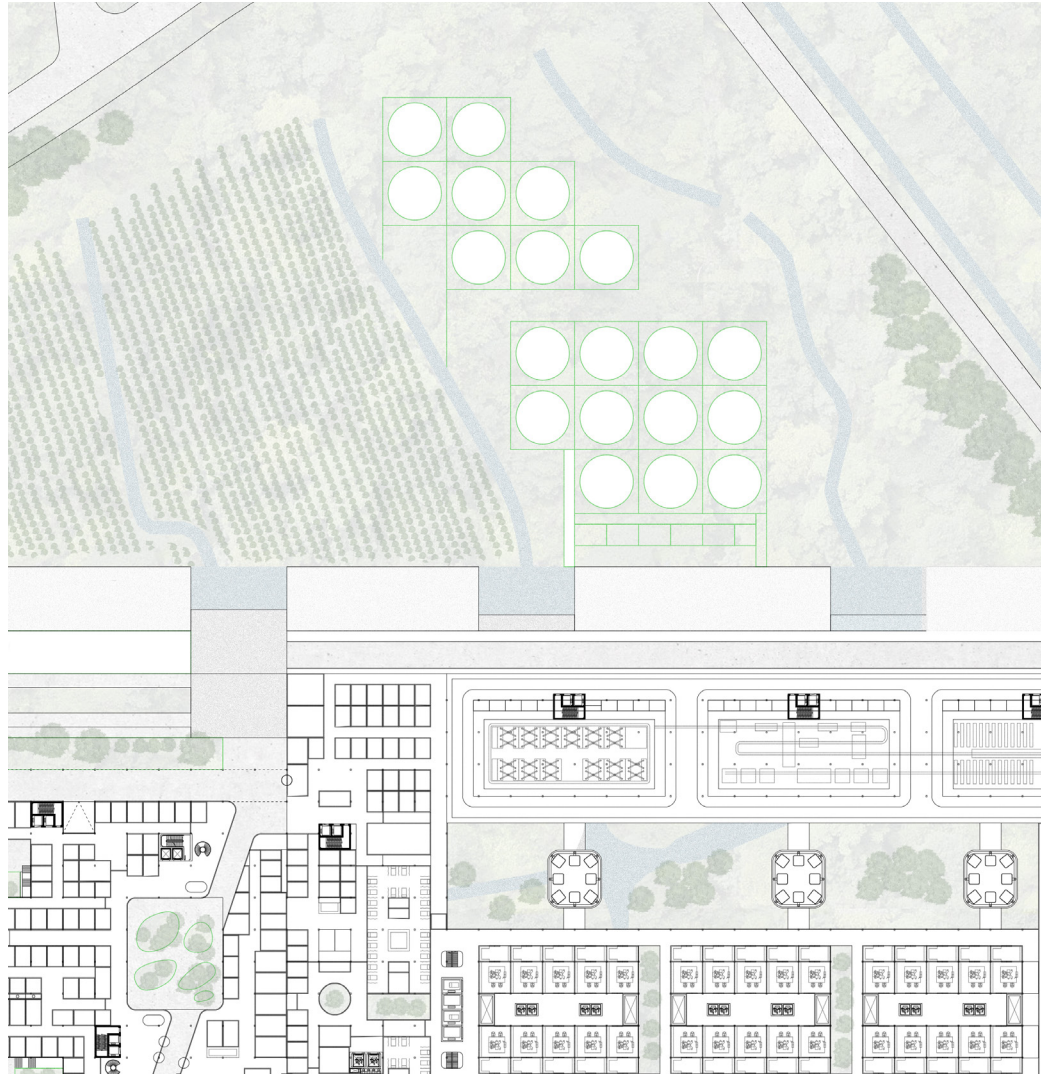


**Residential Village**  
Site Plan



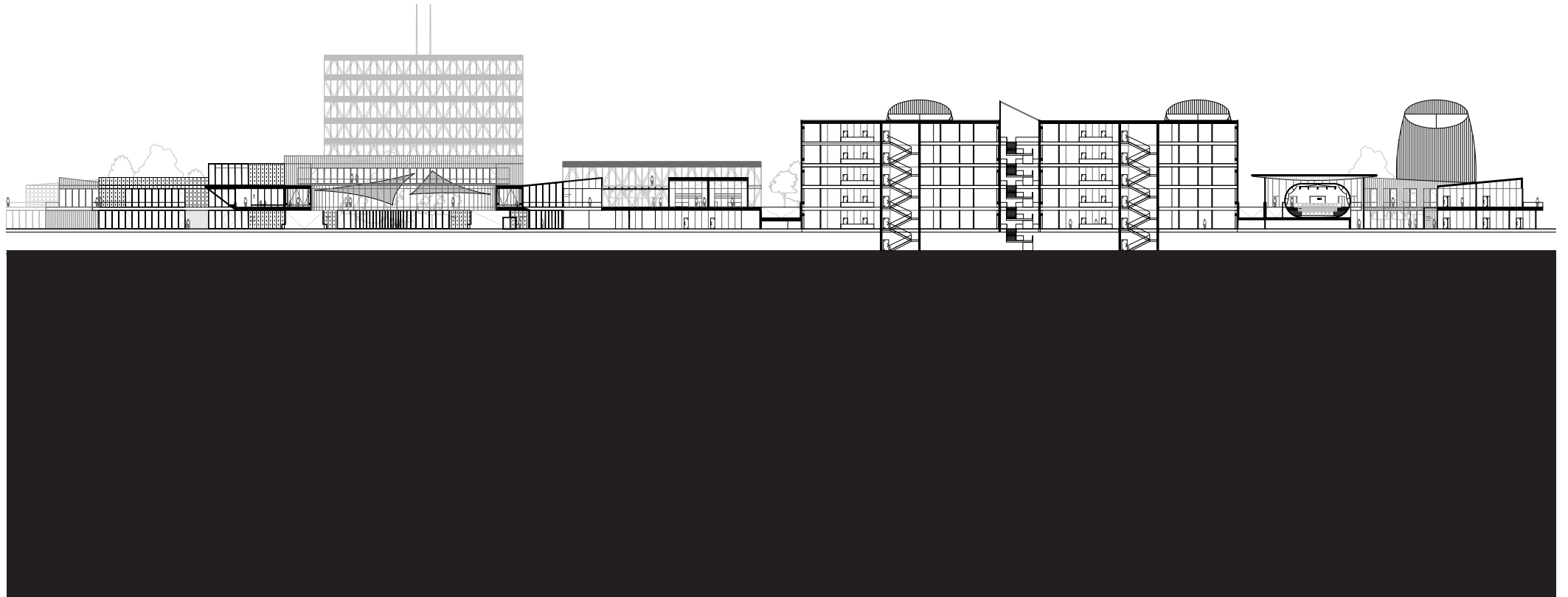
**Public Programme**  
Site Plan

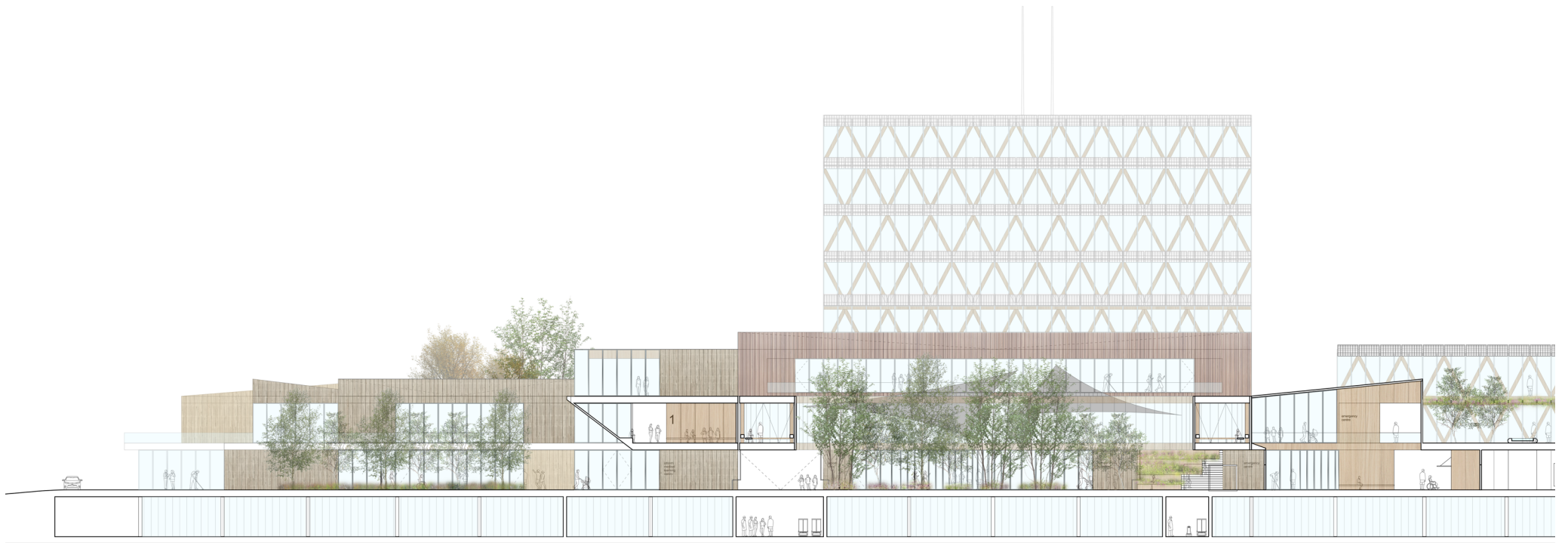




**Medical Machine**  
Site Plan



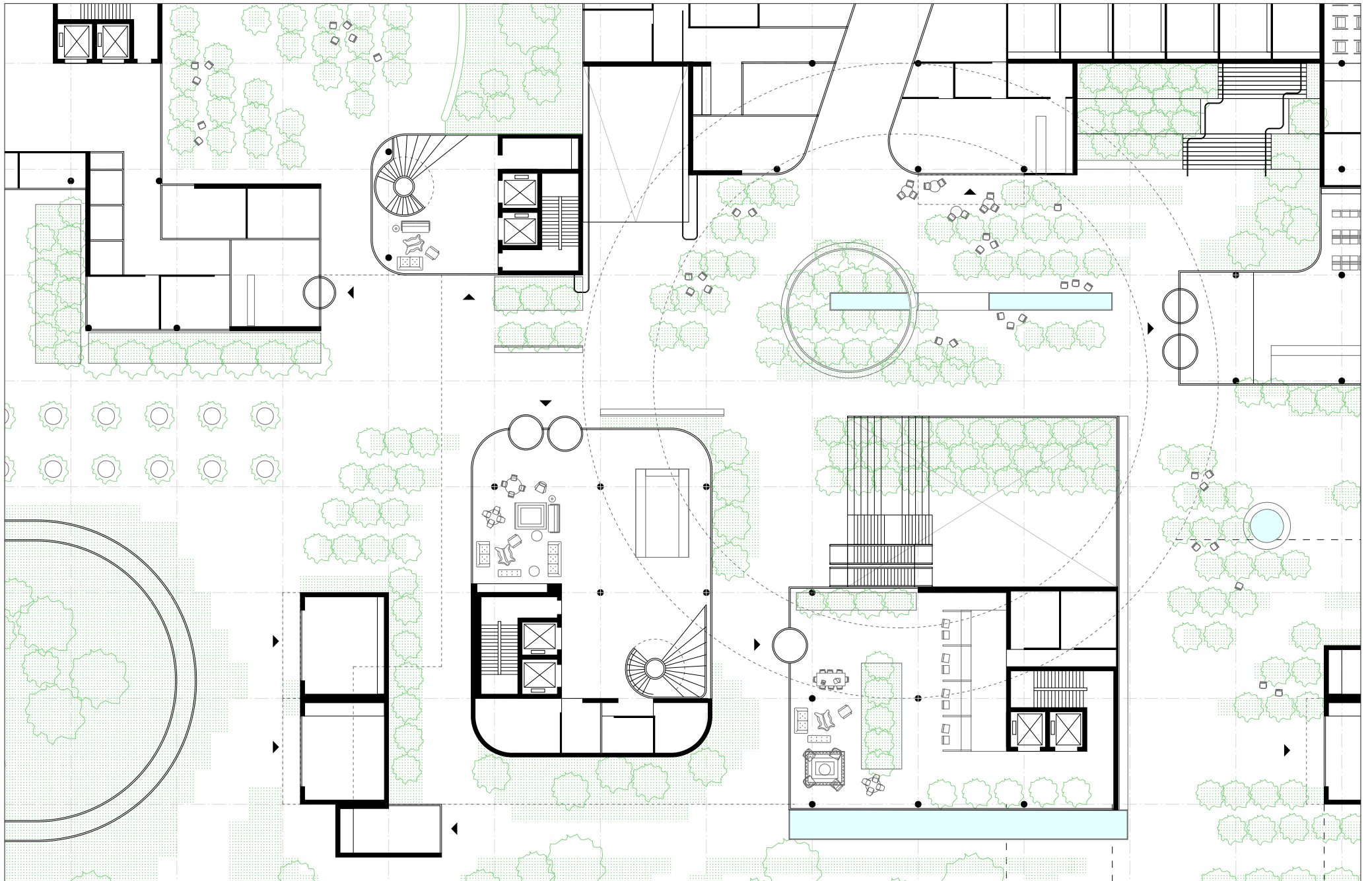




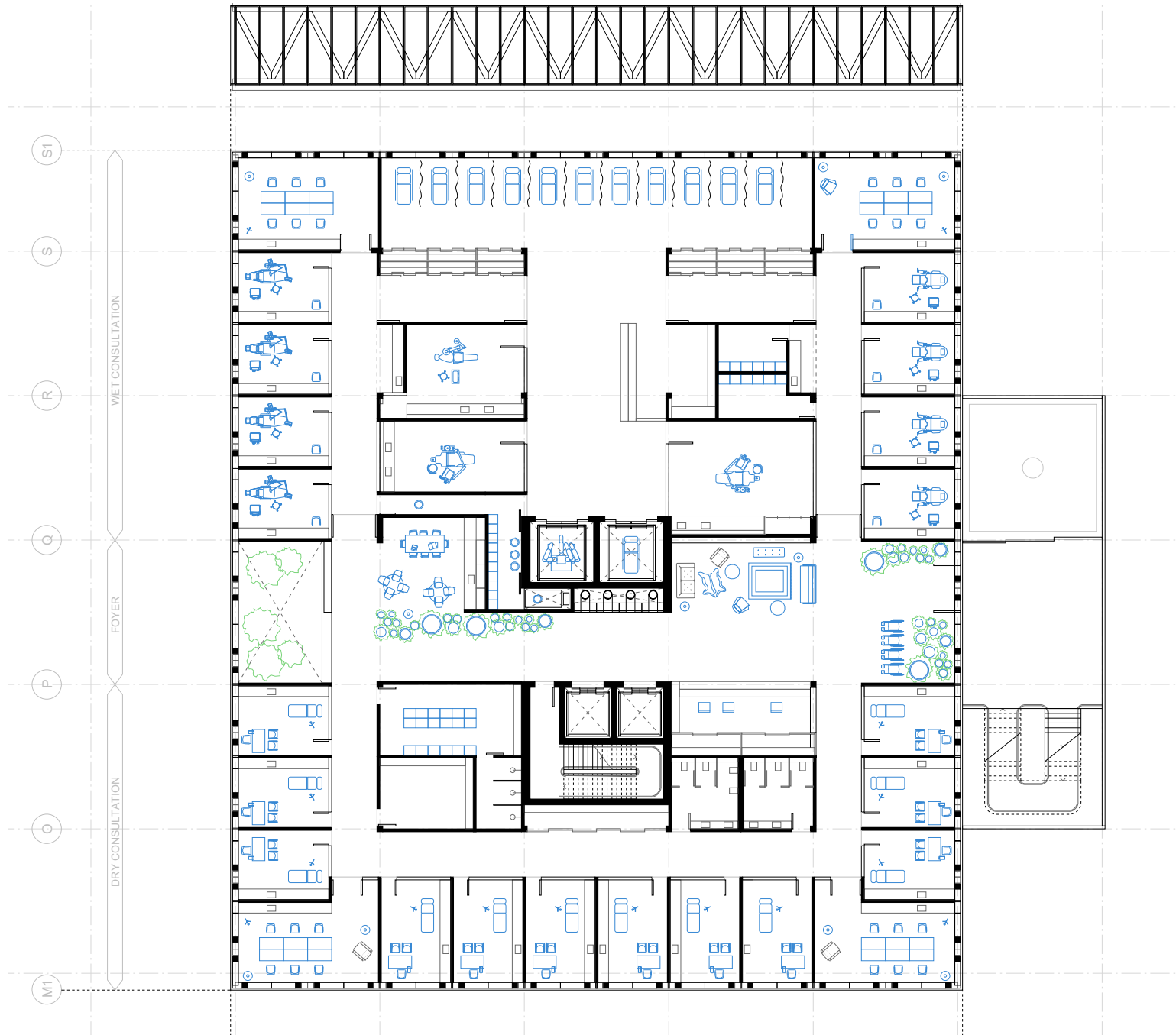


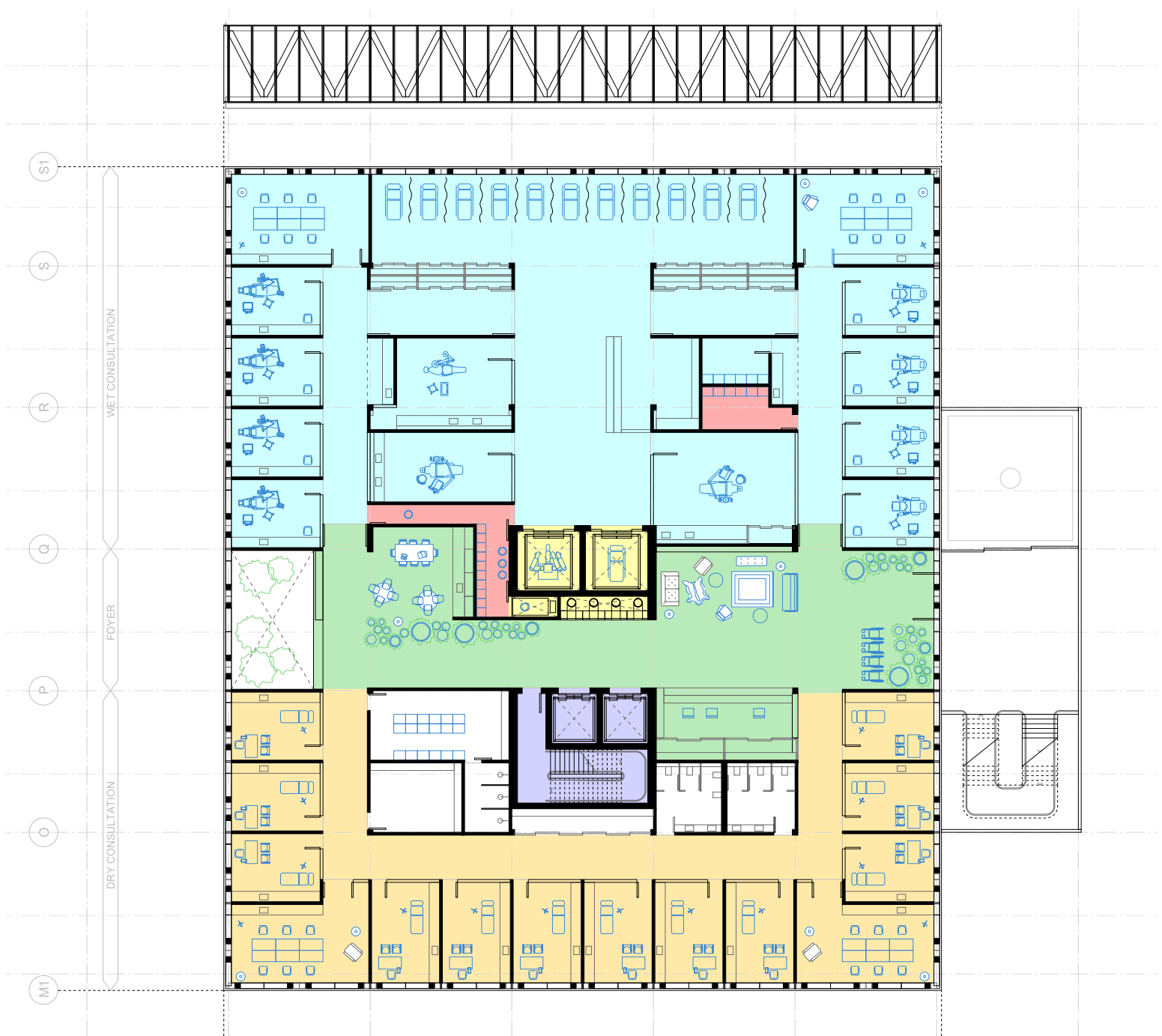
Residential Village

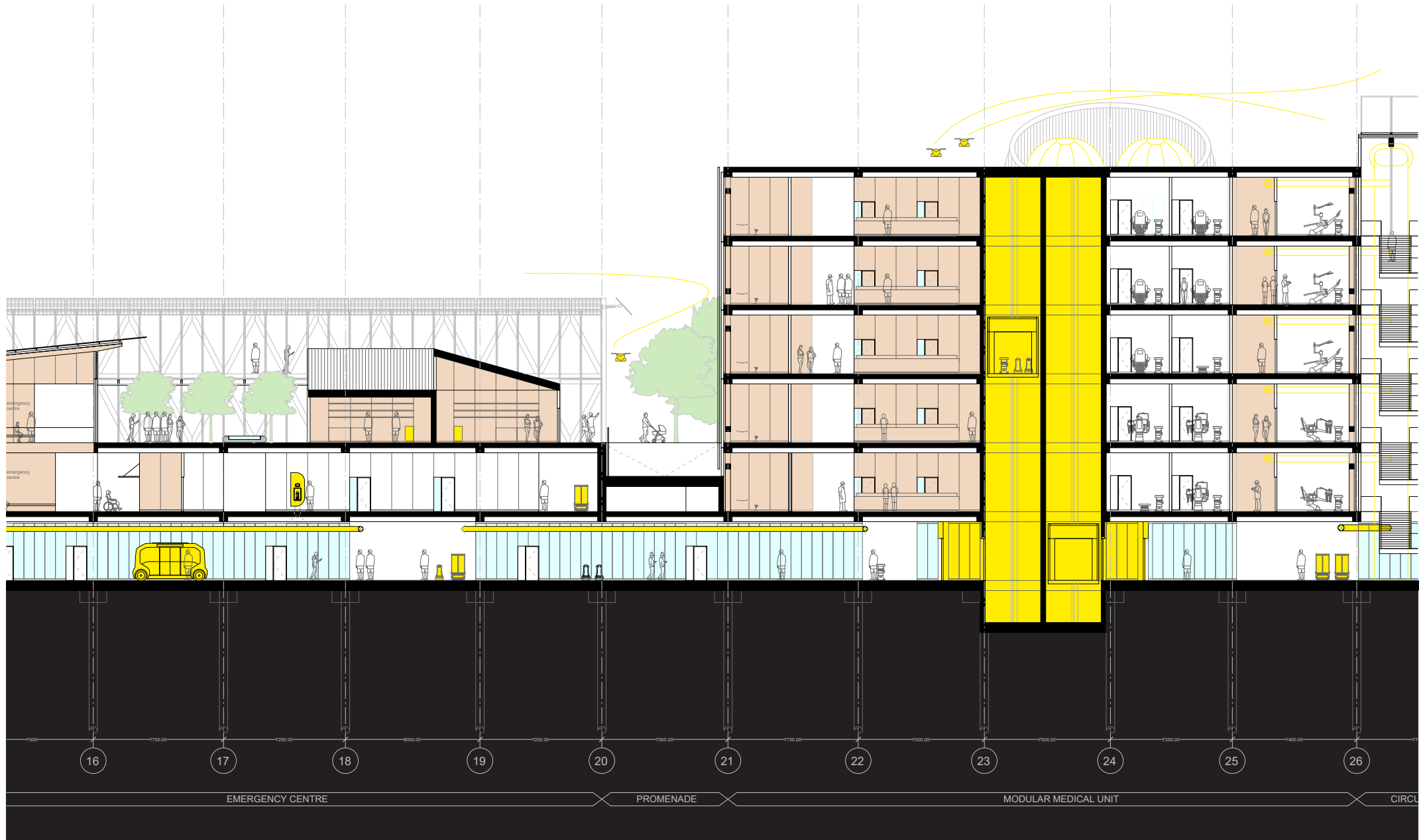


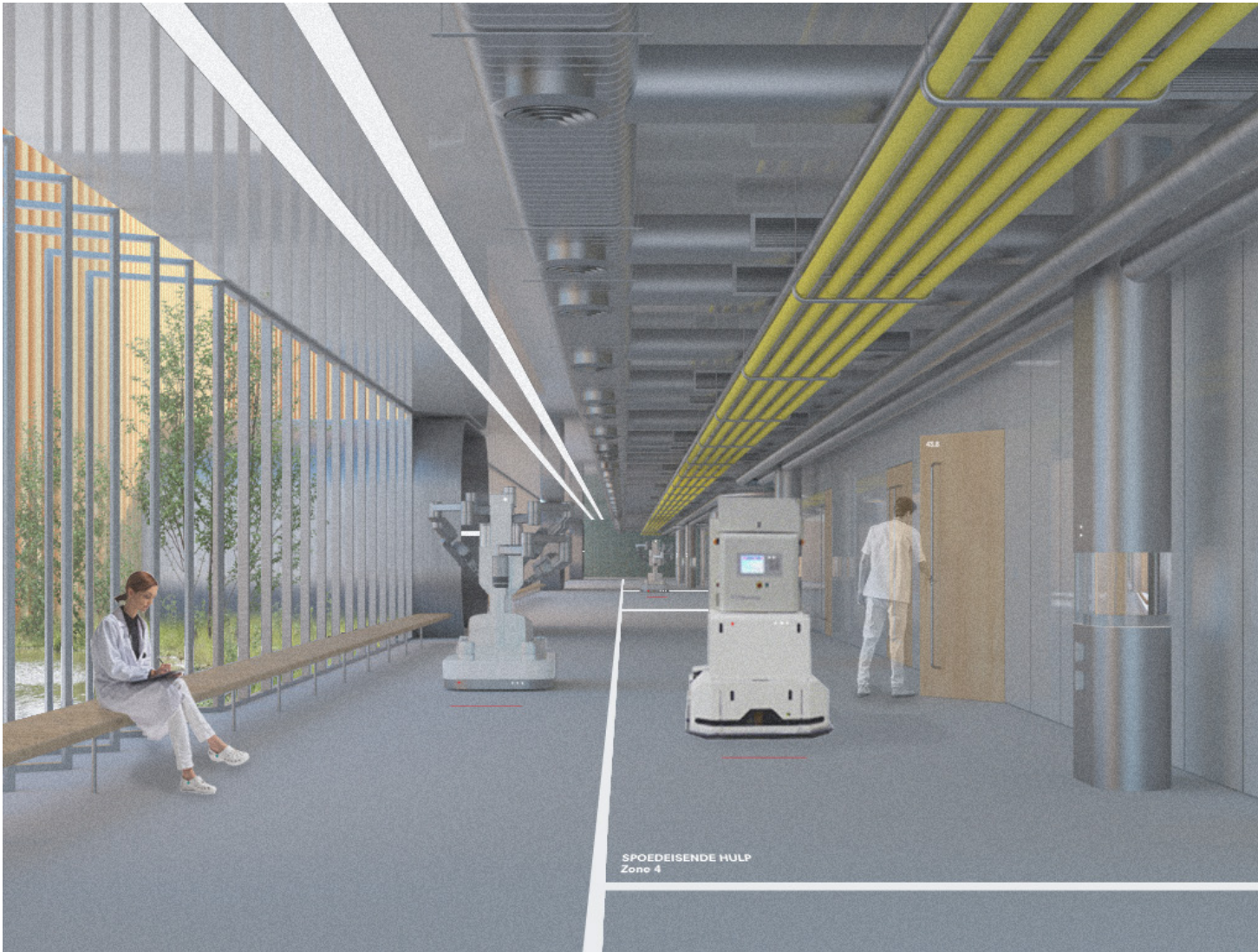






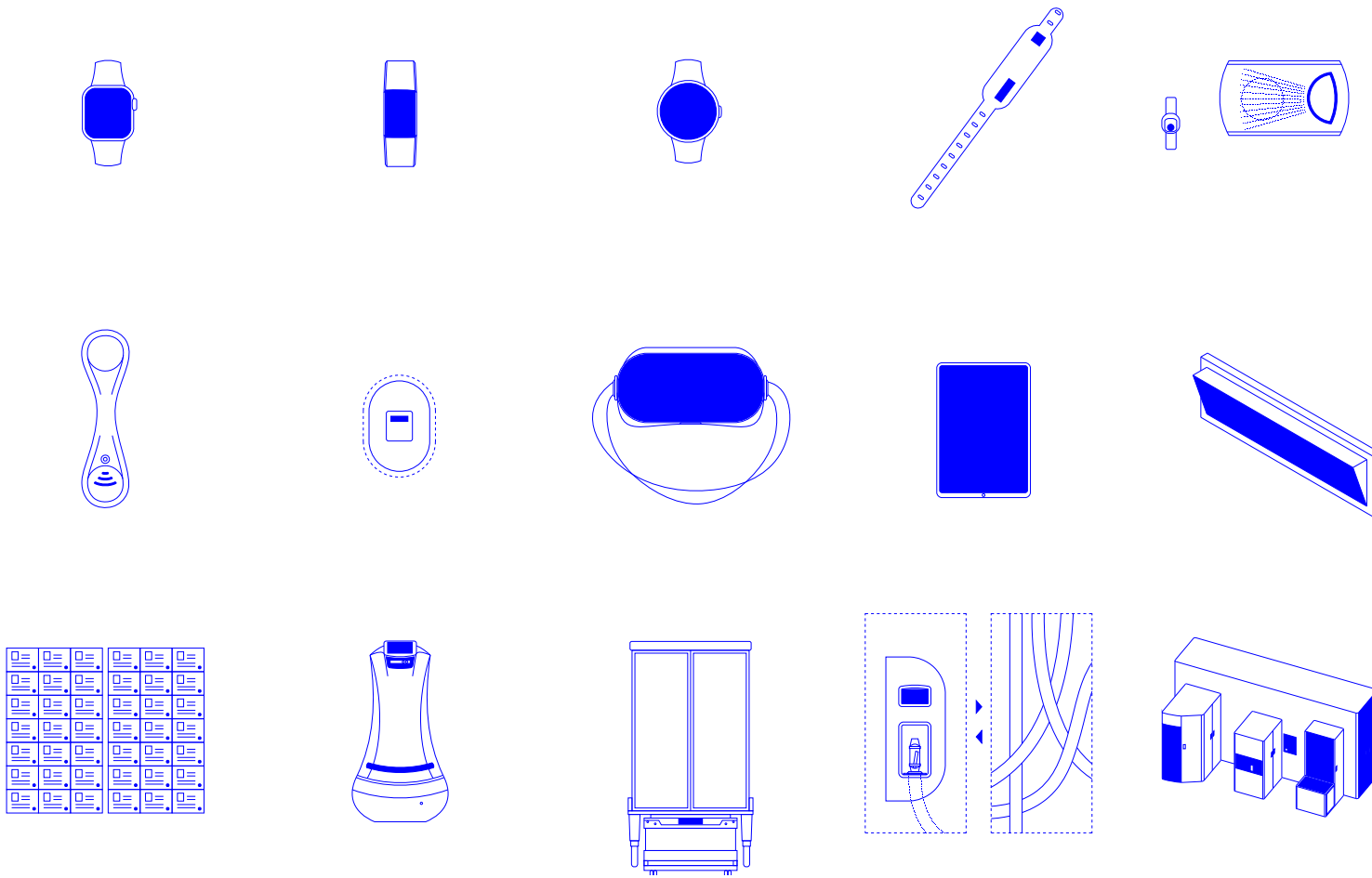




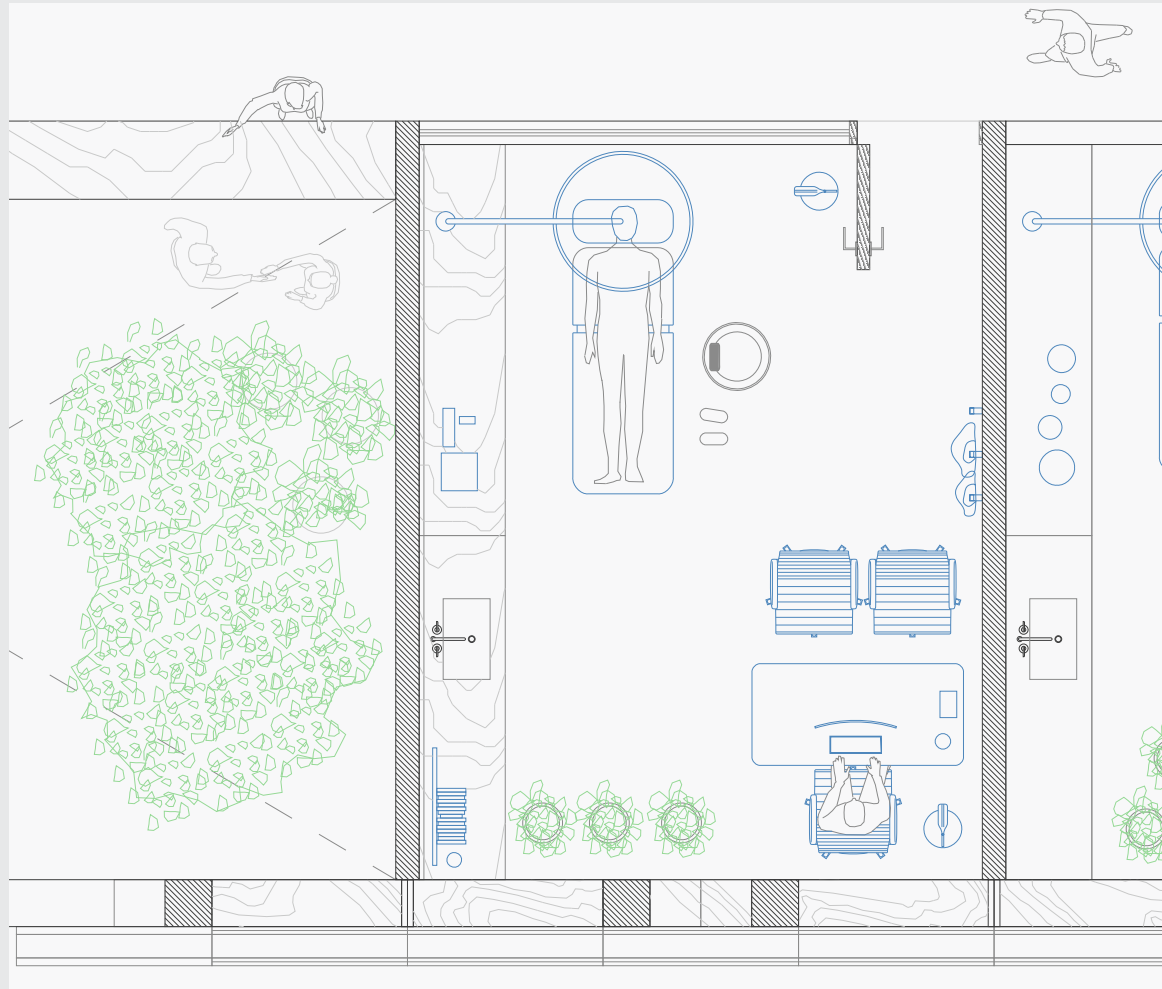


Robotic Slab



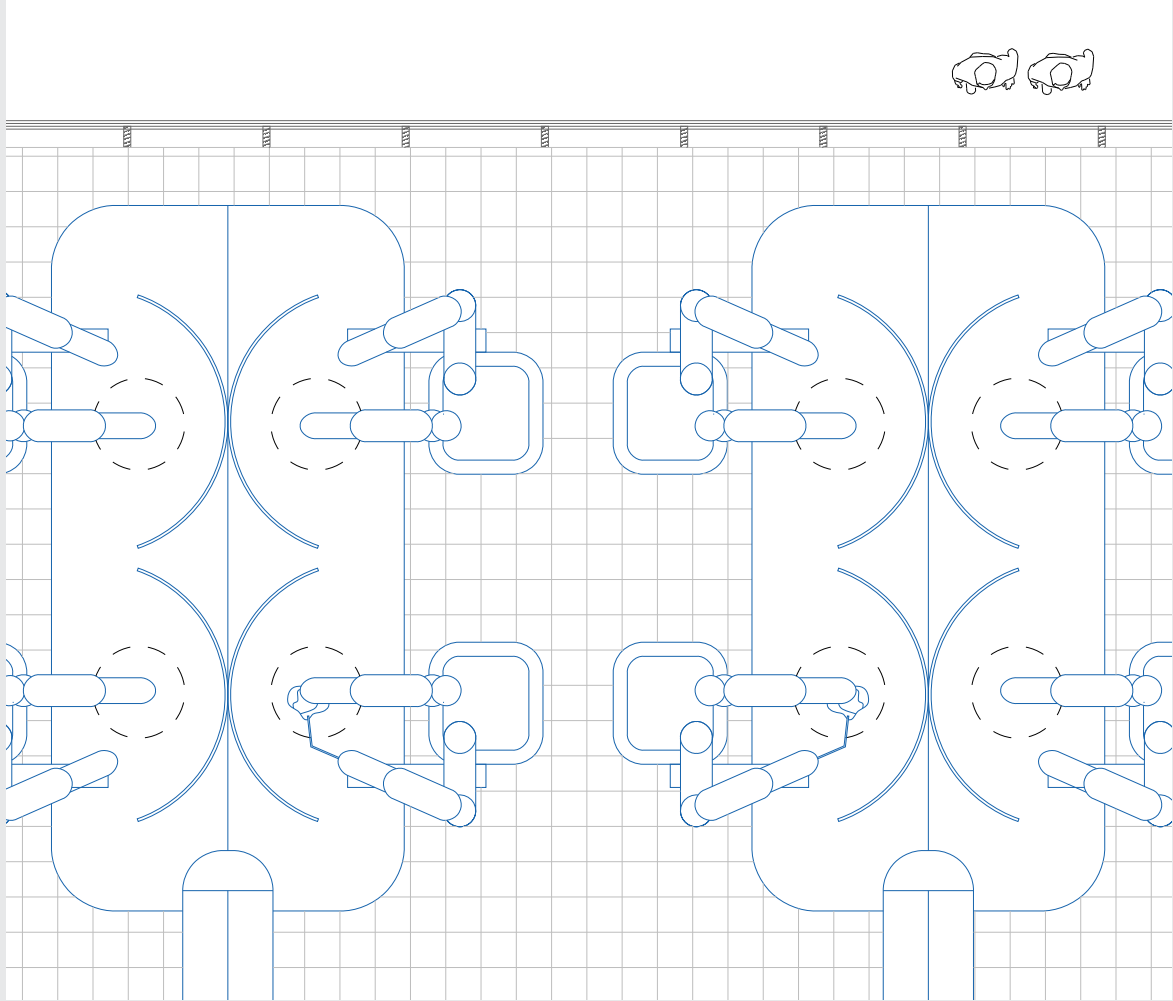


**Robotised Elements**  
Appliances & Systems



**Consultation & AR Visualisation of Procedure**  
Out-Patient Clinic

**Out-Patient Journey**  
1 : 50 Drawings

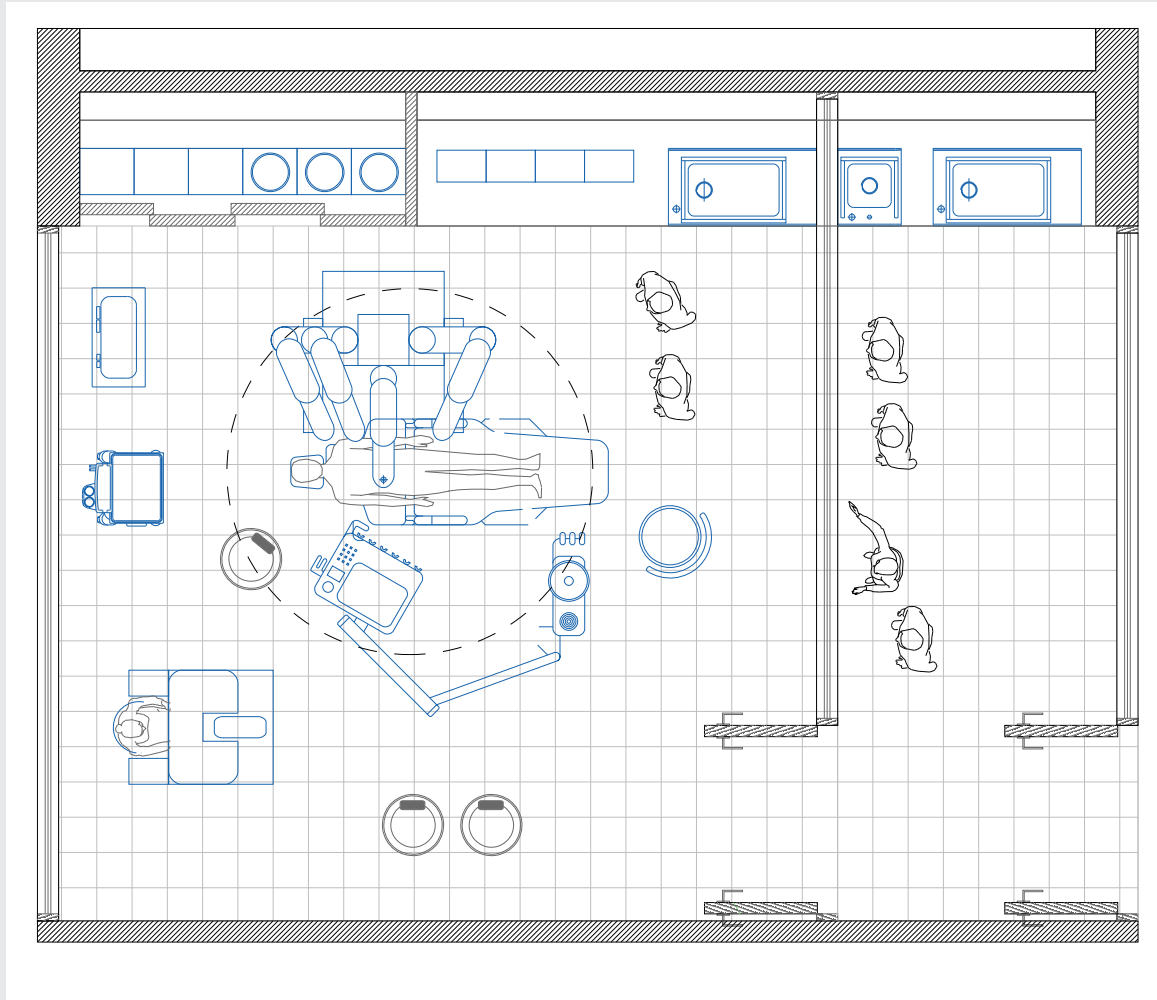


**Electronic Medical  
Records Data Centre**

**Precision Medicine  
Manufacturing Lab**

**3D Bio-printing of Required Tissue**  
3D Printing Centre - Facilities Management

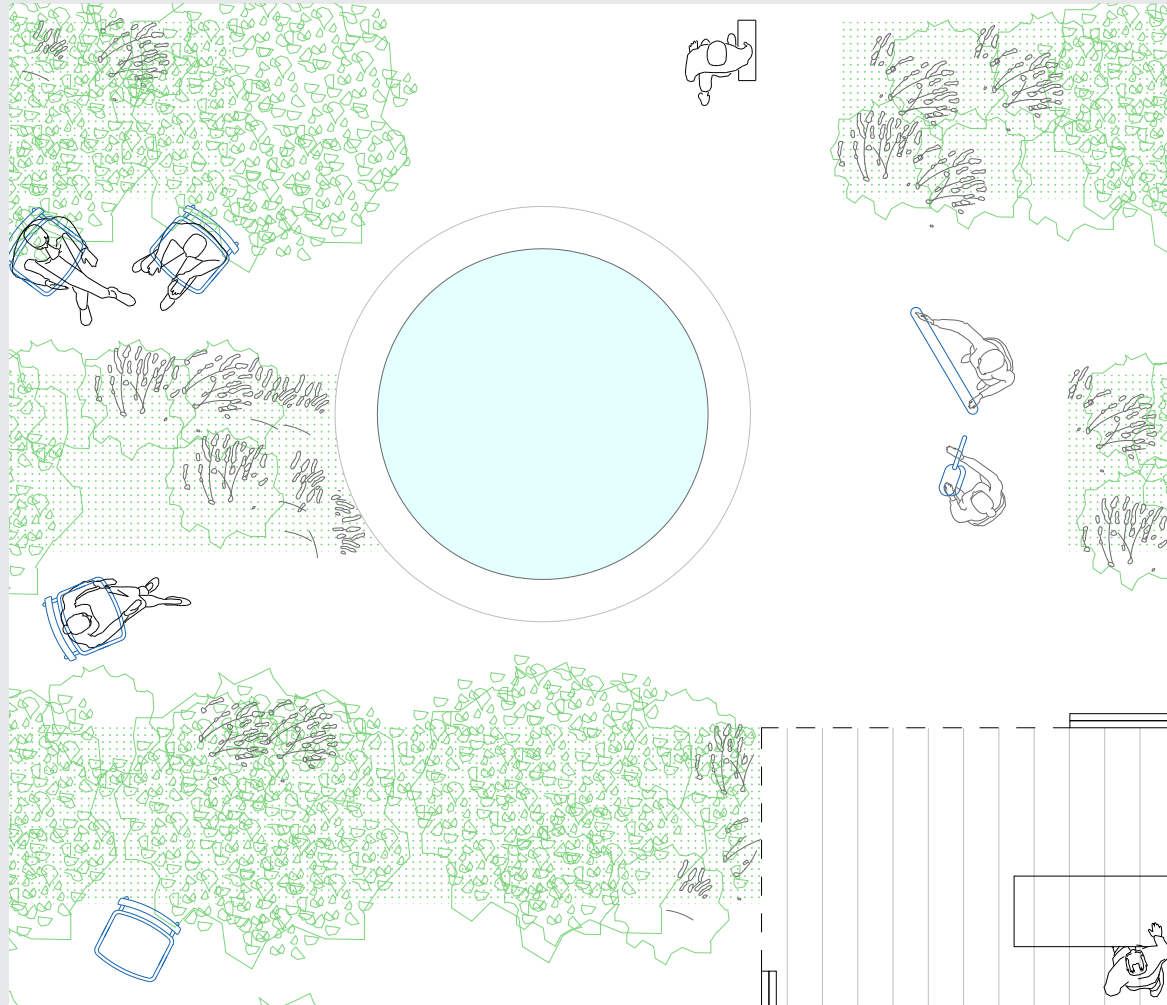
**Out-Patient Journey**  
1 : 50 Drawings



**Robotised Minimally Invasive Medical Procedure**  
Out-Patient Clinic

**Out-Patient Journey**  
1 : 50 Drawings





**Patient Recovery**  
Piazza in Medical Village

**Out-Patient Journey**  
1 : 50 Drawings



Civic Square





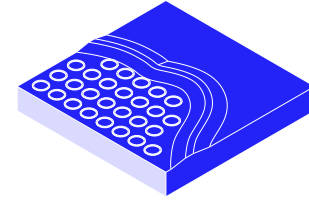
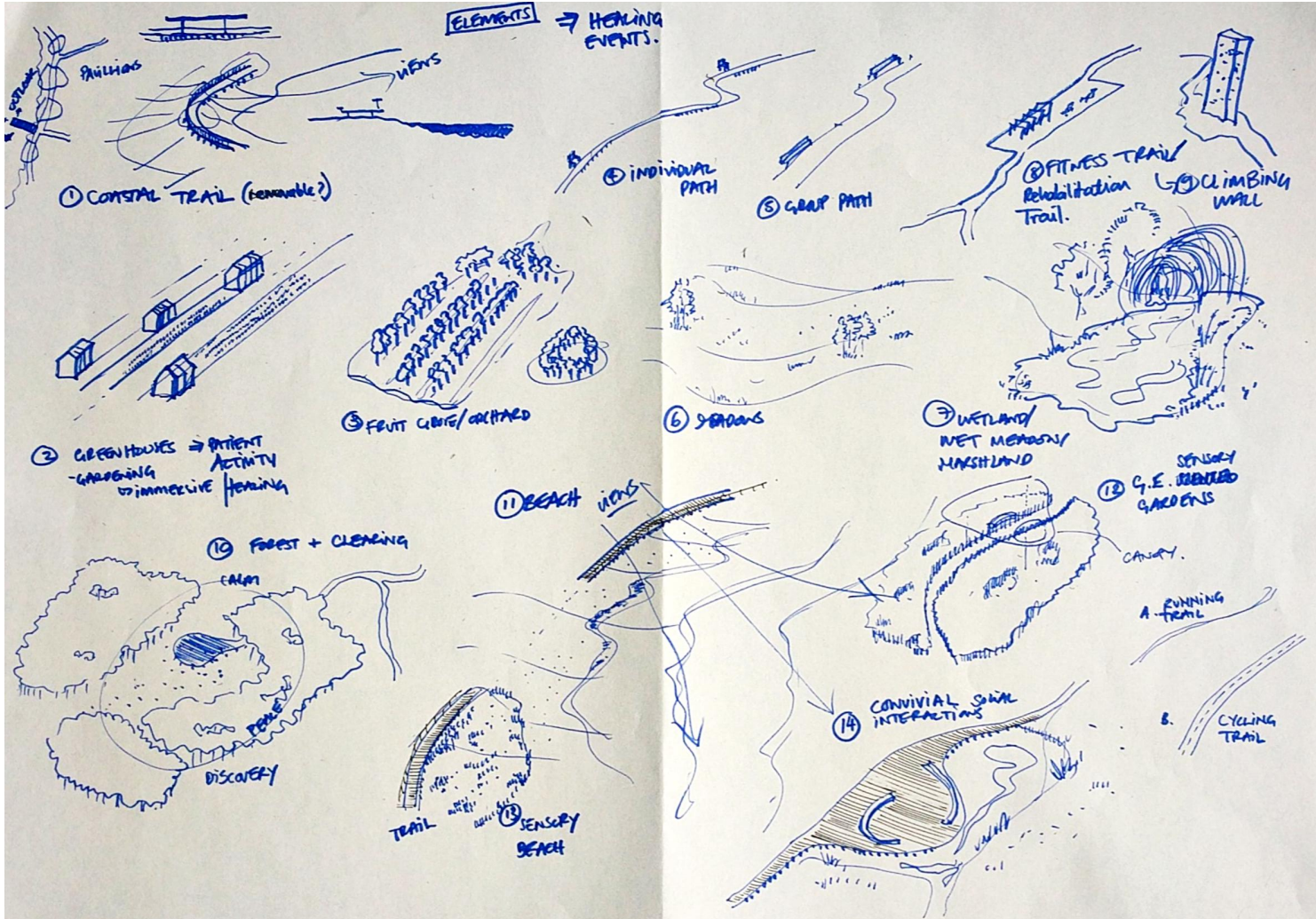
Arabic Bimaristan



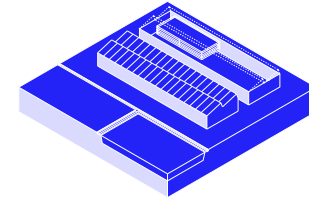
*Territory for Healing*



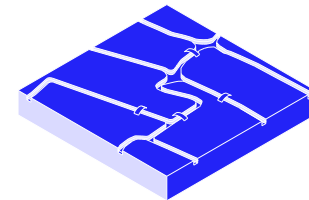




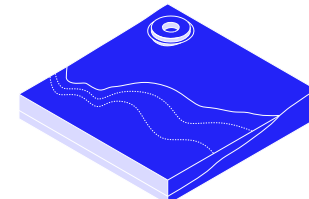
WASTE MANAGEMENT:  
AEROBIC TREATMENT CENTRE



FOOD PRODUCTION:  
ON-SITE FARMING



PATIENT REHABILITATION  
HEALING GARDENS



SOLARIUM  
SEASIDE AS A HEALING  
TERRITORY

Territorial Healing Events  
Illustrations

## Multi-Landscape

Supportive and challenging infrastructure which cater to long-term achievements and immediate gratification.

- **long term**
- rehabilitation
- personal goals
- sporting
- 
- **immediate**
- exercise trail
- sporting trails

Relaxing spaces for individual or calm restorative purposes. Here contemplation as an activity is encouraged and engineered.



Cultural/Personal places of meaning. The sense of place is gathered through belonging, identity and attachment to the landscape. The romantic idea of the coast as a healing medium is the narrative.

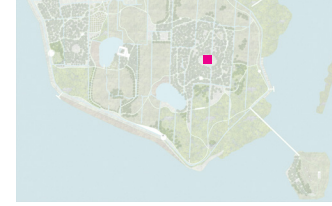
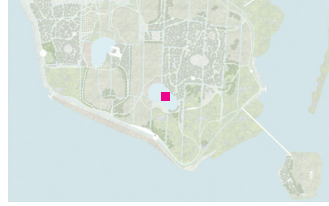
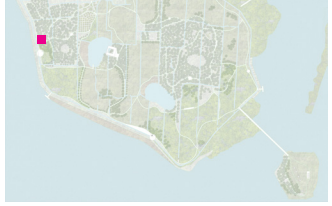
Immersive inspiring experiences are created through opportunities to explore the landscape.

**Captivating and multi-sensory spaces like coastal paths or sensory gardens** activate the sense of discovery.

- microclimates
- views
- sensory gardens

In creating places for encounters, convivial and social interaction can be engaged in. Leisure, conversation and a shared sense of well-being contribute to communal healing. **These spaces can be beaches, promenades, plazas and sporting facilities.**

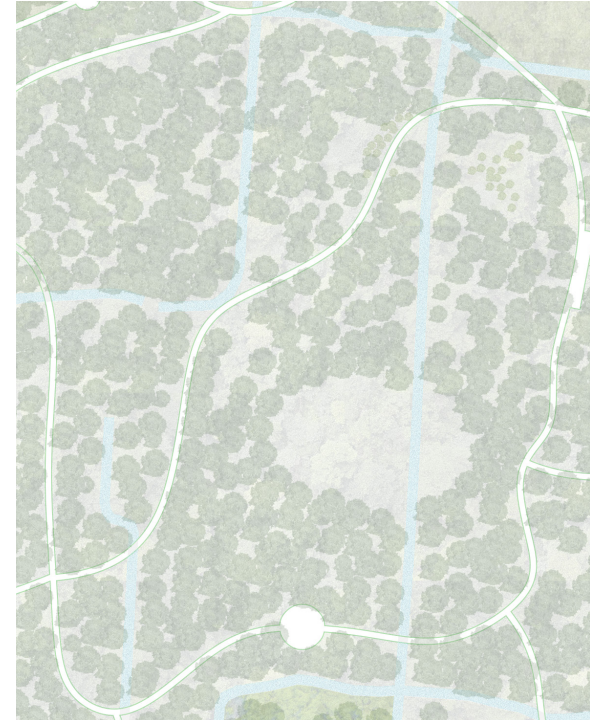




Coastal Trail  
Sensory Forest  
Sporting Trails



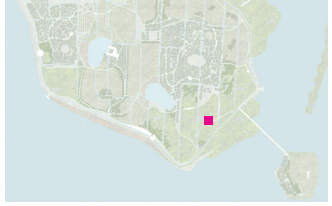
Fruit Orchard  
Garden Café  
Dry Meadows  
Water-Retention Ponds



Immersive Buffer Forest  
Solitary Paths  
Contemplative Events

**Healing Events**  
Territory for Healing





Wetland  
Minimally Invasive Paths



Social Paths  
Beach  
Sporting Trails  
Sea Pavilion



Island  
Sea Views  
Therapeutic Coast

**Healing Events**  
Territory for Healing





Forest



**Organic function of healing & technocratic system**  
Engineered Nature



# *Building Technology*

## **Research Questions**

### **Natural Infrastructure**

How can the flora/fauna contribute to the patients' healing?

### **Technical Infrastructure/Systems**

How can we climatise/create different zones in the hospital according to varying medical, technical, environmental and personal conditions?

### **Structure**

In the context of the project's modular approach, which structural tools can contribute to/enable the structure's flexibility & adaptability?

### **Sustainability**

How does the logistical network promote sustainability in energy, waste flows, materiality & mobility?

### **Territory**

What are the territorial management tools which allow for its resiliency?

## Energy Management Scheme



On-site energy demands are fulfilled using wind power, solar power and the general mains to ensure sustainability and resiliency in the event of an input shortage.

### Energy Centre

- Storage Batteries
- Substation & Distributor
- Wind Farm Link
- Solar Roofs Link

### Wind Farm on isolated island

- 2x on-shore wind turbines
- 2MW of electricity generation

- Hospital Size: 80,000 m<sup>2</sup>
- MWh Usage Per m<sup>2</sup>, Per year: 0.27
- Hospital MWh Usage per year: 21,600

### Wind Power Calculations

Wind Turbine Capacity of average on shore turbine: 2-3 MW

Energy output: 6000 Mwh/ year

### Solar Power Calculations

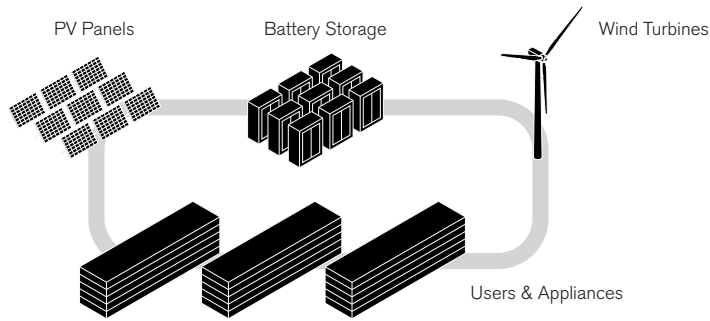
Solar panels capacity KWh/m<sup>2</sup>/year: 170

Roof surface for solar panels: 20,000 m<sup>2</sup> (or 10,500 panels of 1.7m<sup>2</sup>)

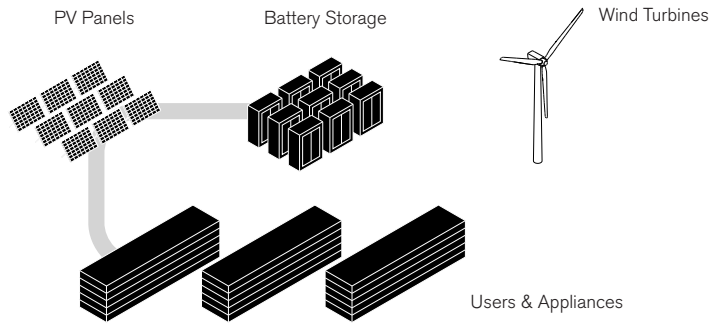
Energy output MWh/year: 2000

**2 Wind turbines theoretically produce 12,000 MWh/year. 10,500 solar panels produce 2000 MWh/year. These provide 2/3 of the hospital's energy needs With only 7,600 MWh required from the grid.**

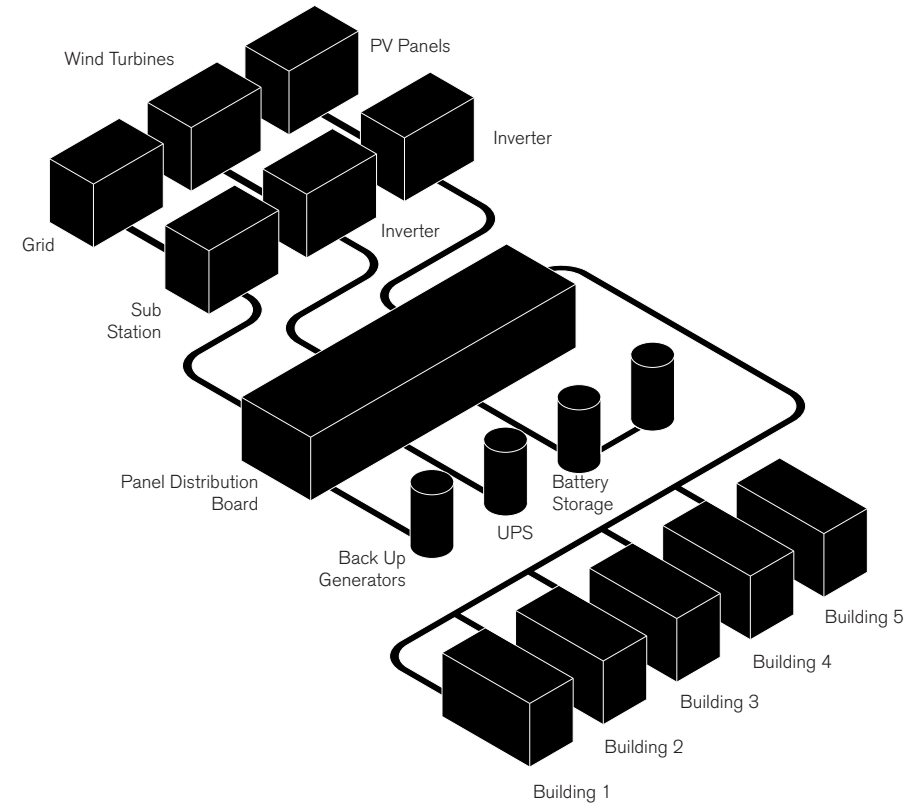
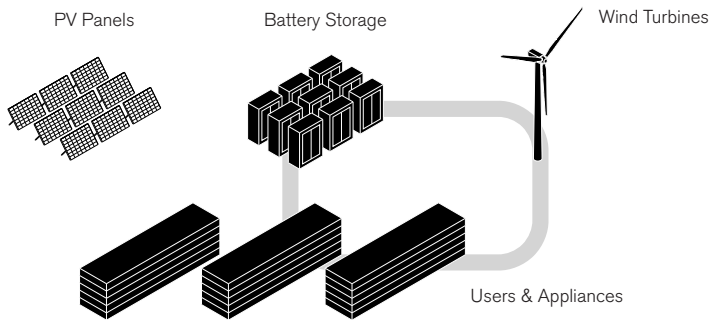
Windy & Sunny DAY



Windless DAY



Cloudy DAY/NIGHT



**Wind**

- minimal audible sound
- no physiological effects on human health
- placed away from protected area to avoid bird interaction

**Solar**

- PV panels across all semi-permanent roofs
- PV cells within glazed canopies
- PV panel shading facade on S & W facade of out-patient tower

**Storage Batteries**

- integrated DC storage device
- connected to WKO for cooling
- micro grid supplementing main grid
- emergency backup
- scalable infrastructure

**Wind and Solar are intermittent energy sources and can't be used as base-load energy sources but as supplements.**



## Waste Management Scheme



Waste management is primordial within a treatment centre's typology due to the different streams of waste created.

Additionally, as the centre is situated in a rural area, special attention is to be given to avoid the contamination of the surroundings.

- Small Scale Aerobic Digester**
- Tiered filtering of biological wastes
  - Bio-Oil and Fertiliser resulting from chemical process can be used on the agricultural plots and for building.
  - Waste heat from the chemical process sent to central heating facility

- Medical Gas Tower - Logistics Hub**
- Arrival & Docking Infrastructure
  - Medical Air Compressor
  - O2 Evaporator Tanks

**Process**

- Created Waste
- -
- Filtering of waste flow in robotic slab
- -
- Medical waste sent to external treatment plant for incineration.
- -
- Biological non-medical waste sent to Aerobic Digester
- -
- Recycled non-toxic water is filtered and used in building white bio-oil and fertiliser are used on site.

## Rain & Grey Water Management Scheme

Considering the site's geographic location as a peninsula, water management is of primary importance.

Water has to be managed at multiple scales, from the risks of storm surges and flooding to grey water and filtering facilities.

### Surges & Flooding

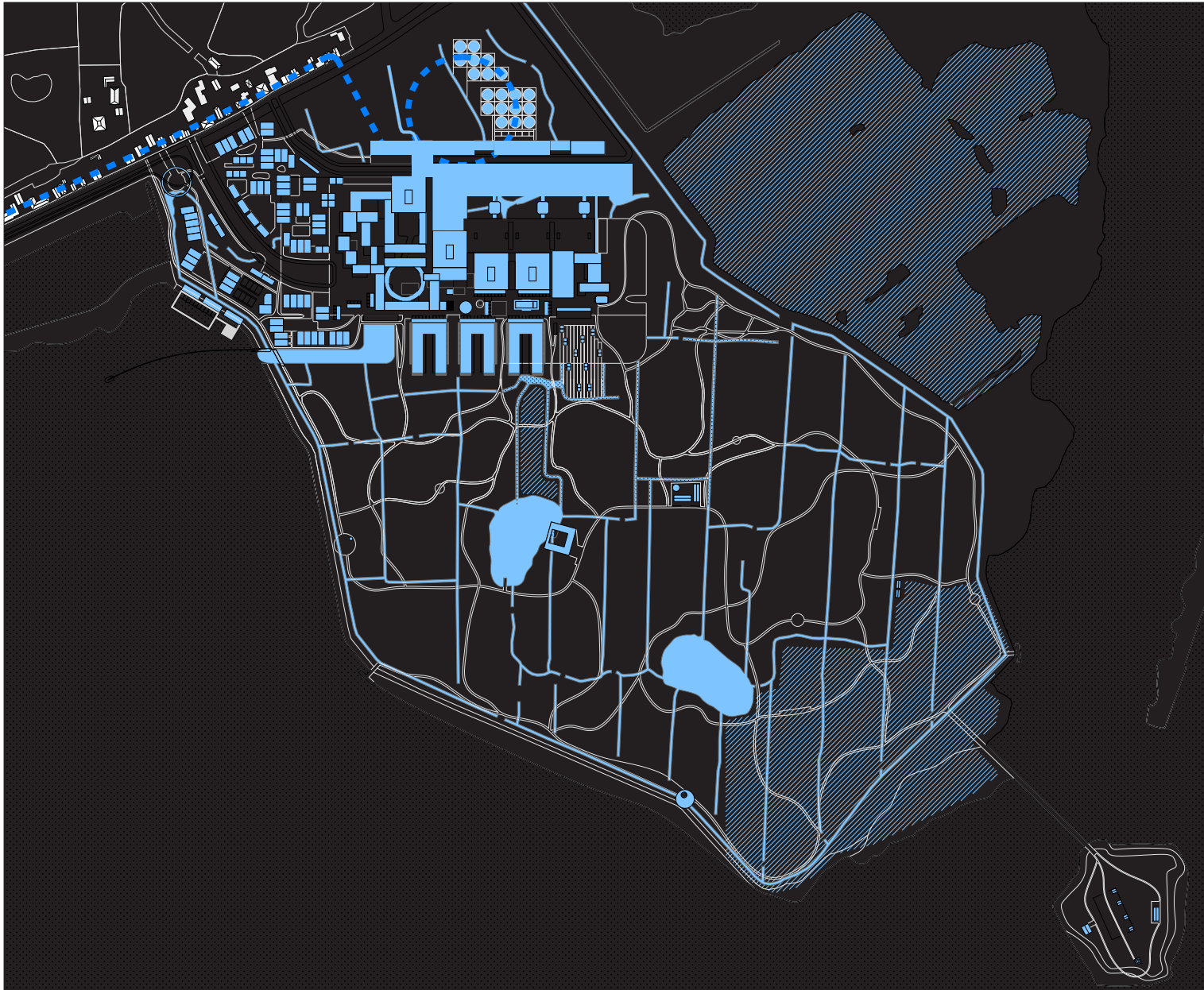
- Water Retention Ponds - fitted within the territory, they act as basins during surges.
- Drainage Basins and
- Wetland Flooding Plains act as overflow management in the event of floods

### Rainwater Collection

- Rainwater is collected on all of the village's buildings' roofs. This amounts to approx. 60,000 m<sup>2</sup> of available collection surface.
- This is used for irrigation and cleaning necessities
- The collected excess rainwater is filtered and sent to the surrounding homes via shared infrastructure.

### Waste Water

- The Aerobic Digester is used to filter grey water which is re-purposed for non-sterilised uses.
- Black water is sent to external treatment plant



## Heating & Cooling Scheme

On-site energy demands relative to heating and cooling are fulfilled using both an electric PV system supporting an open soil energy system.

In an effort to integrate the building in its surrounding and build resiliency, all local buildings are linked to a shared WKO system in a neighbourhood ring connected to a central heating hub.

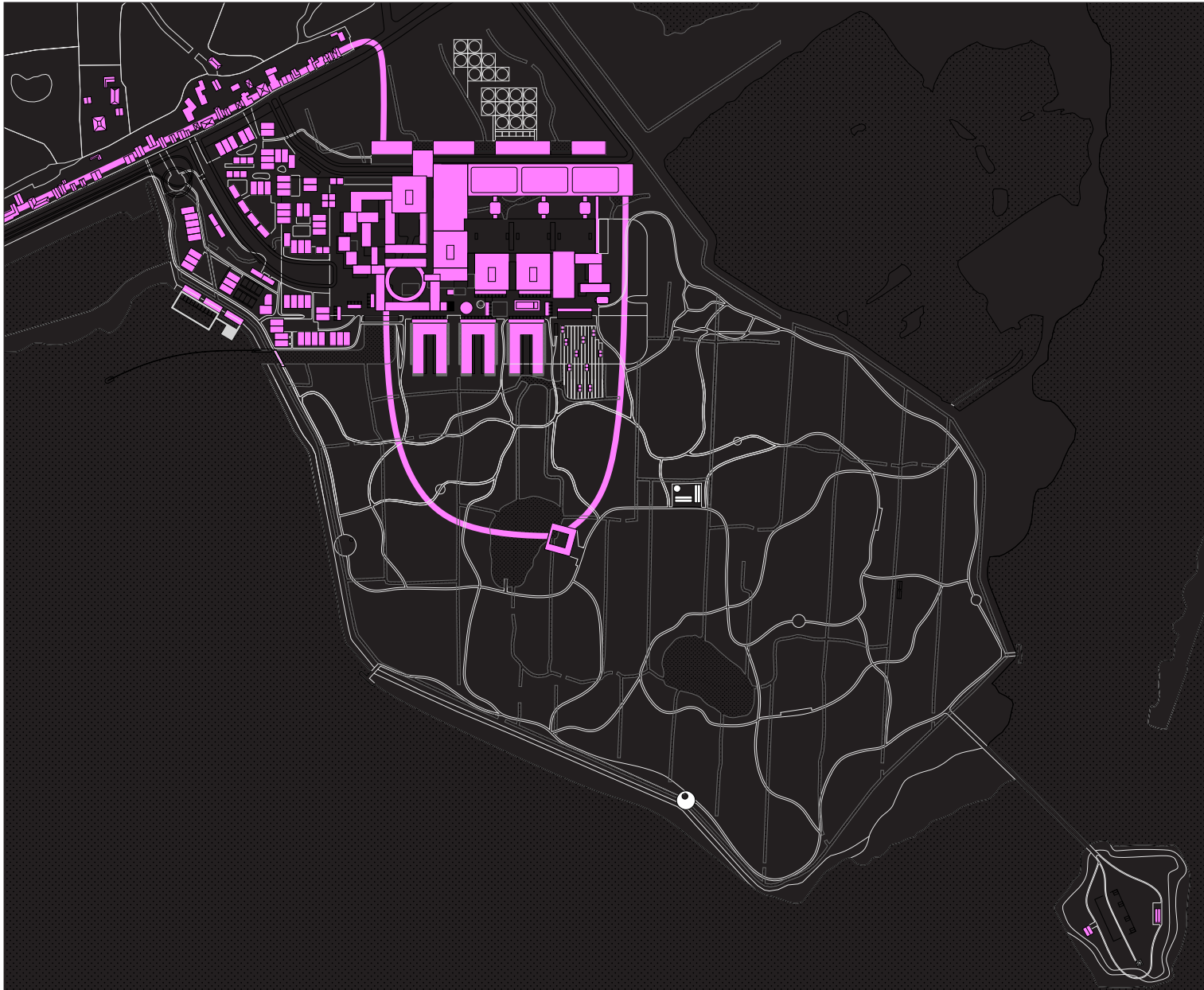
### WKO System

- Open soil energy system using two different sources: a hot and cold.
- Using ground water's constant temperature at 10-15°C as an energy buffer throughout the seasons by pumping water in and out of the sources.
- The system requires good process control and consistent management - energy management station at hospital to provide performance analyses.
- By using the heat pumps and passive cooling, we can save up to 60% in heating energy and 80% in cooling energy with a thermal storage system.

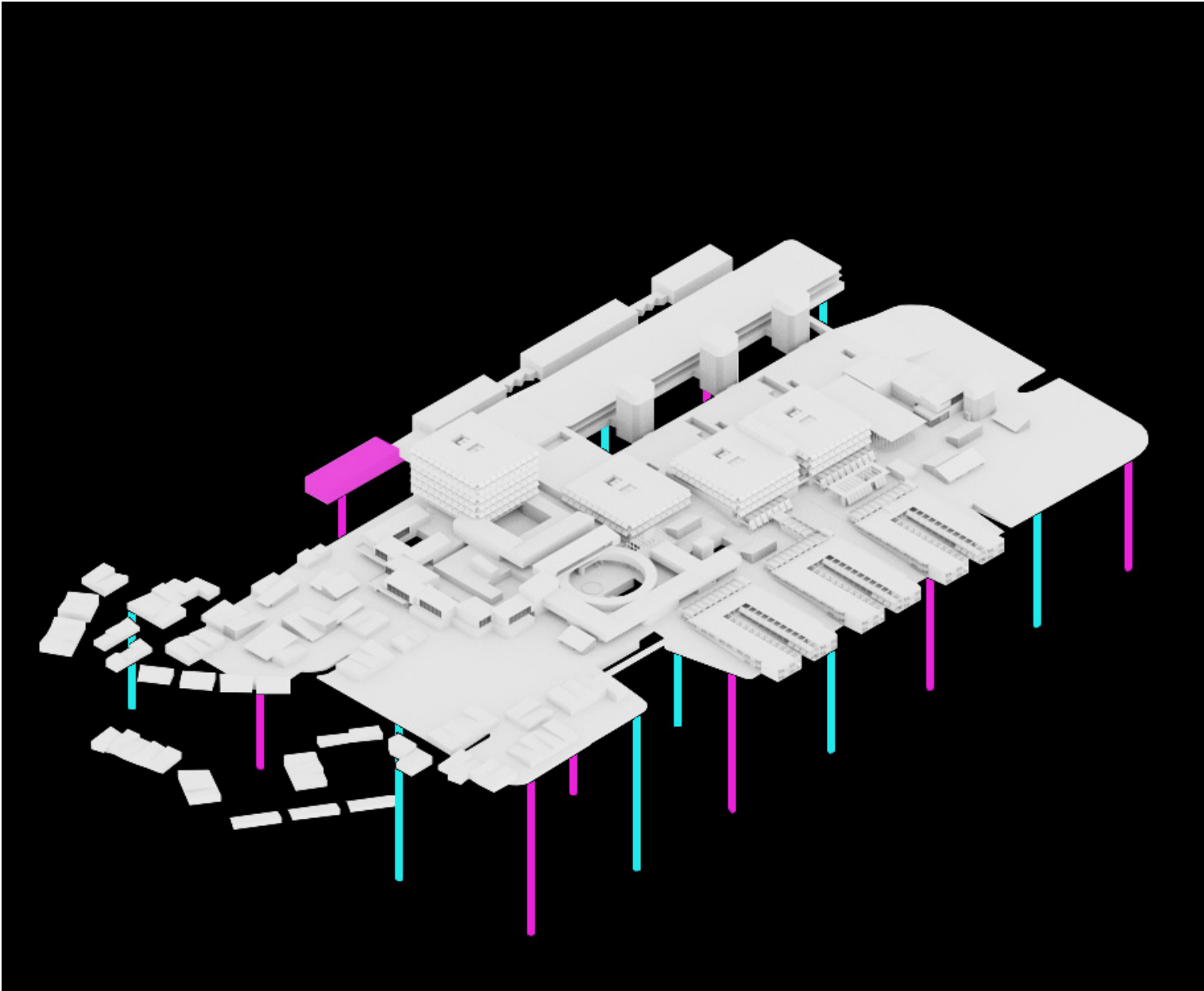
### Amenities

#### Central Heating Hub Management Station

- Electrode boilers
- Heat recovery from servers
- Heat recovery from Aerobic Digester
- Heat recovery from wind turbines







### Heating and Cooling Capacity

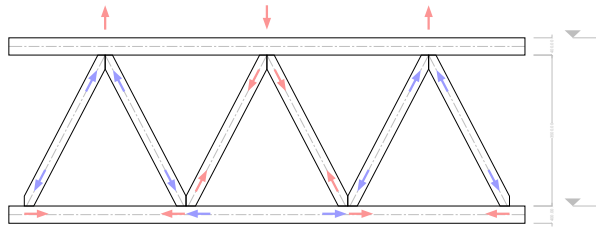
- 1 set of dual bore holes is required/9000 m<sup>2</sup> of a building.
  - The medical village's size is 80,000 m<sup>2</sup> meaning that 9 doublets are to be envisioned.
  - 9 doublets of 18 bore holes will be bored accompanied with a series of heat pumps.
  - There is a requirement for about 100 m<sup>3</sup>/hour of volume flow per source.
  - There needs to be between 50 - 100 m between the infiltration and extraction tubes - the large territory can cater to this.
- **Benefits**
    - Lower energy costs over time
    - High degree of controllability
    - Reduction in maintenance
    - The system can cater to variations in the energy demands (heating and cooling).

# Climate Scheme

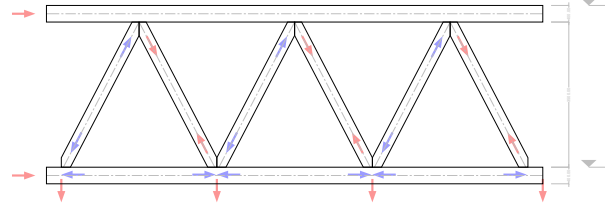


**Medical Unit Dry**  
**Construction Process**  
Diagrid Structural Assembly

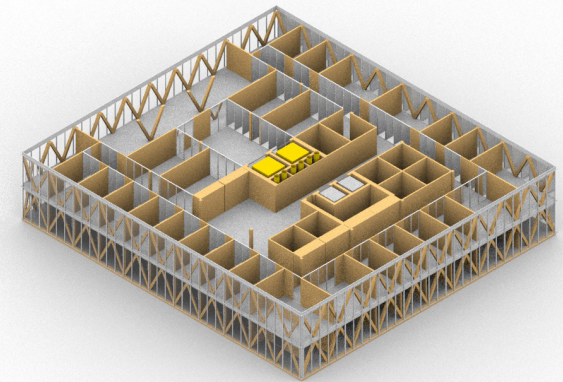
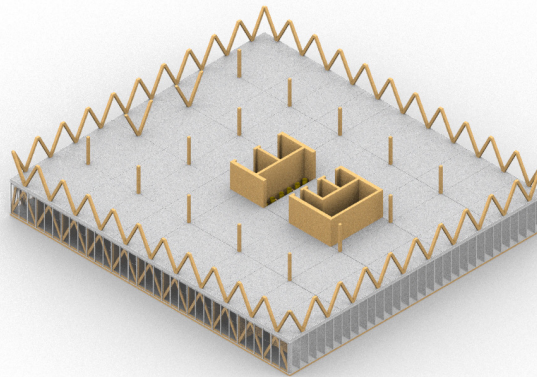
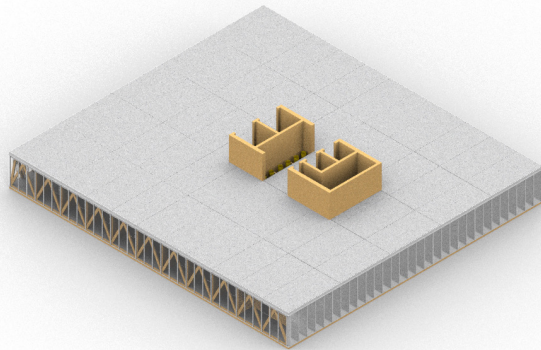
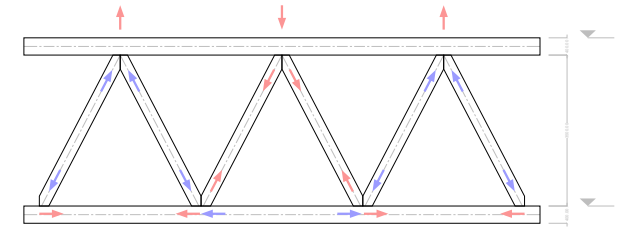
GRAVITY LOAD



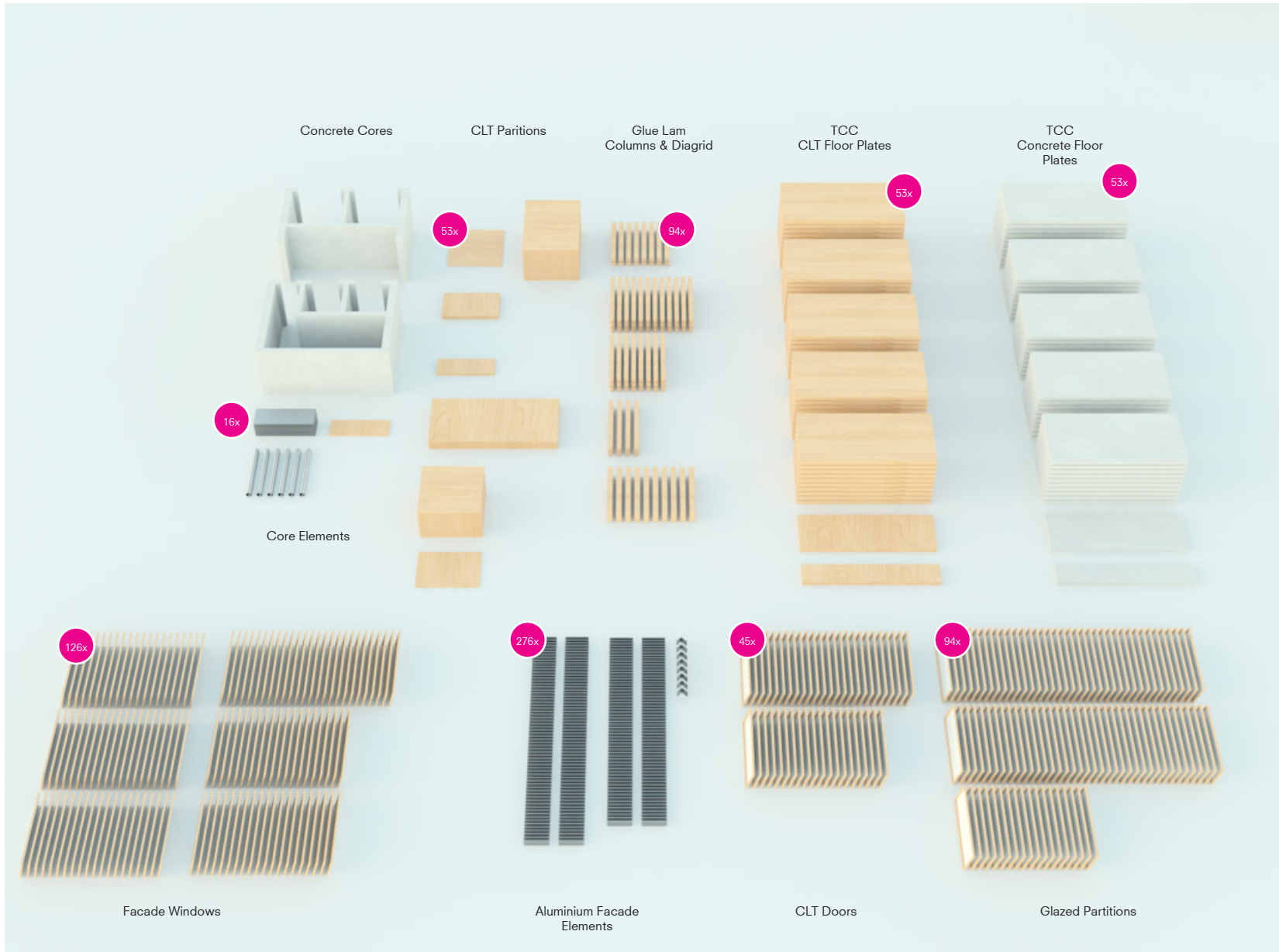
LATERAL/SHEER LOAD



OVERTURNING MOMENT

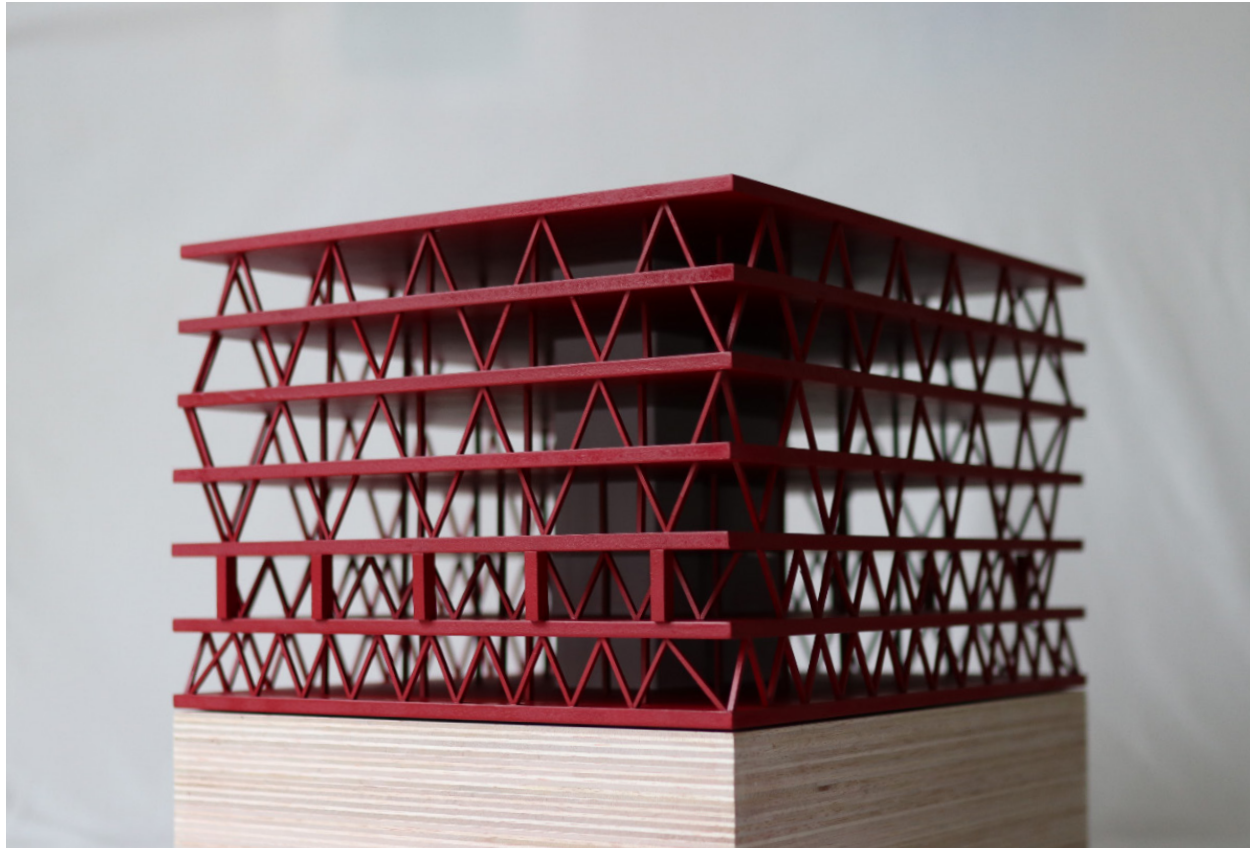




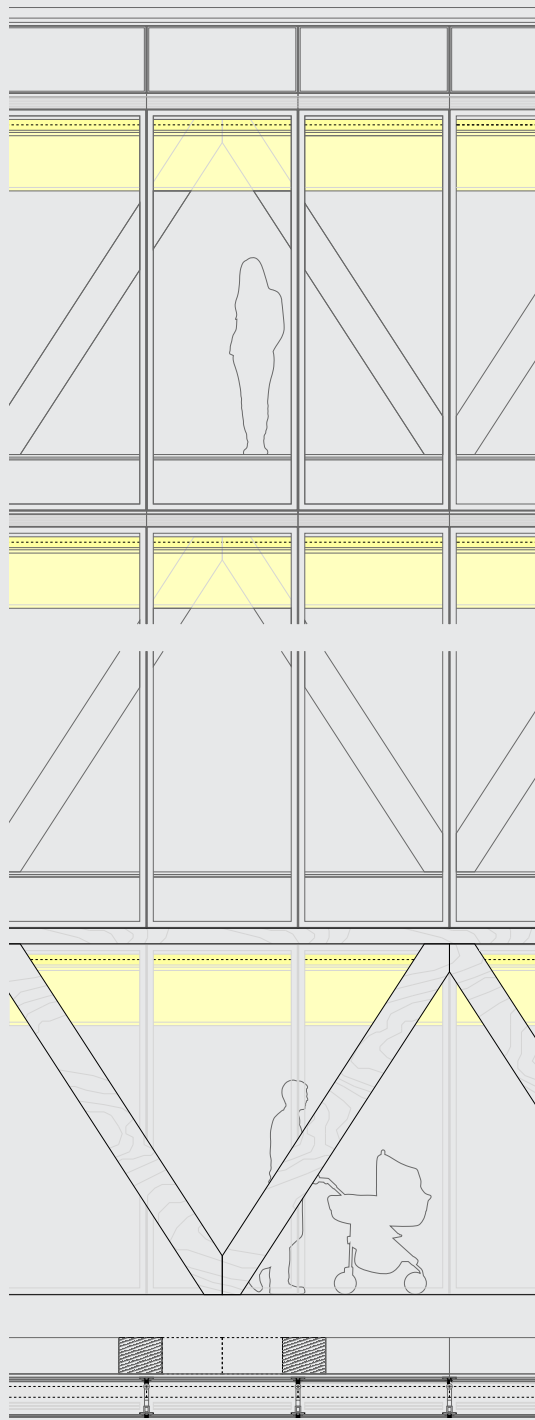


Tower Floor Catalogue of Elements

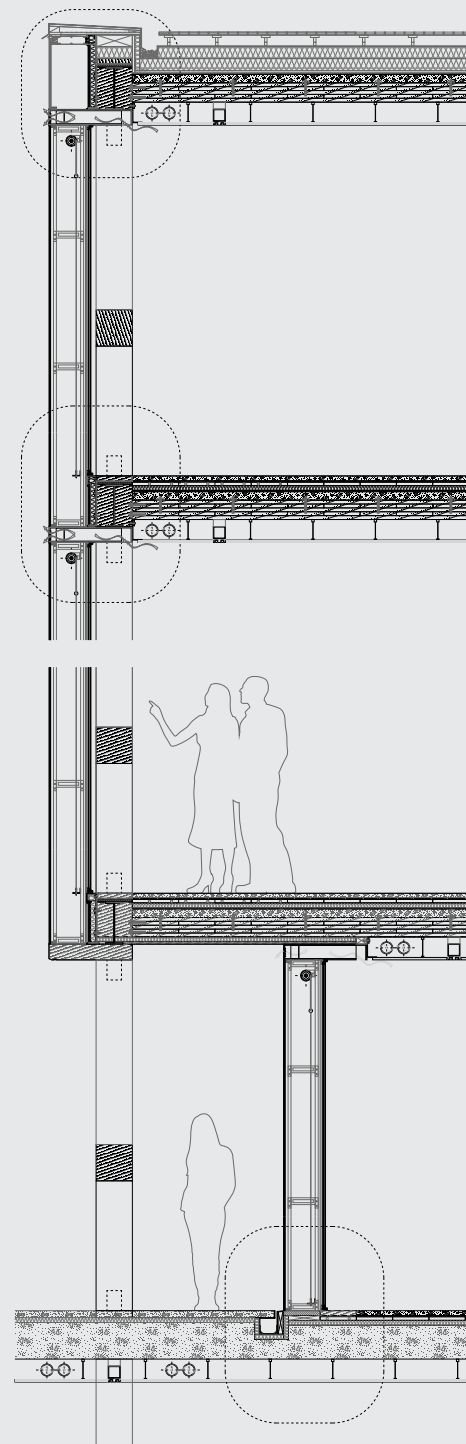




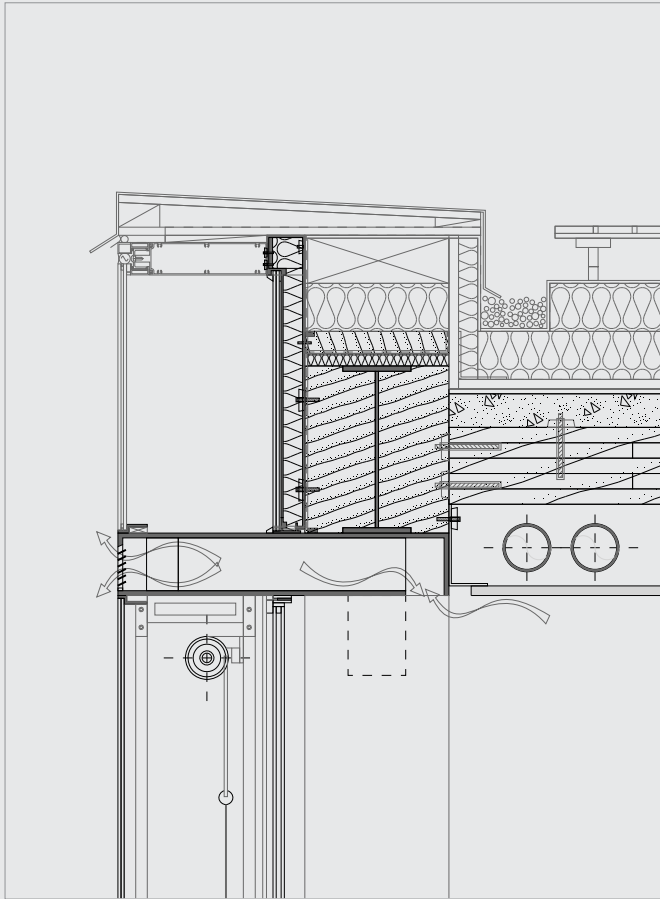




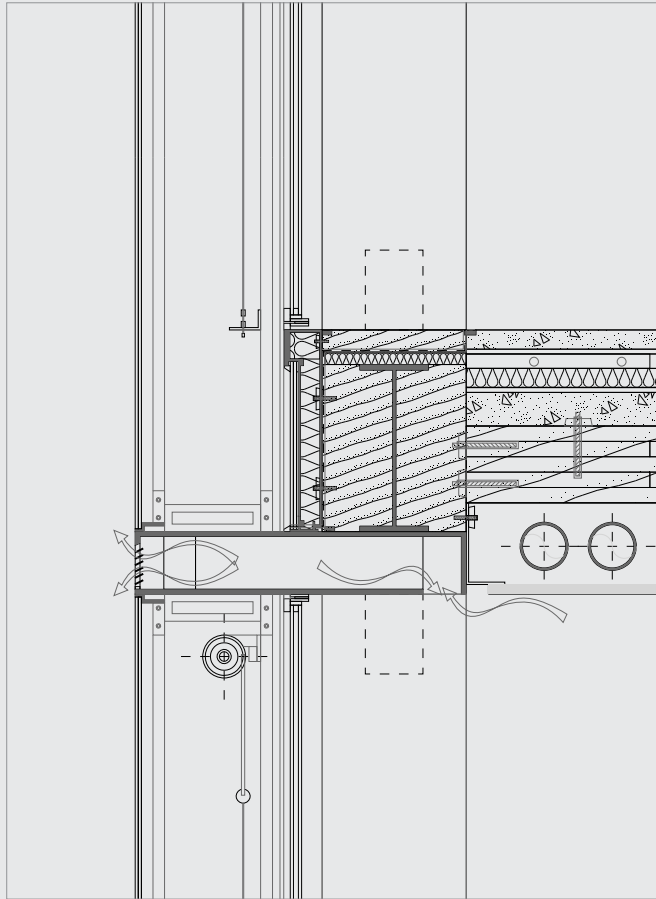
Facade Elevation H & V  
1 : 20



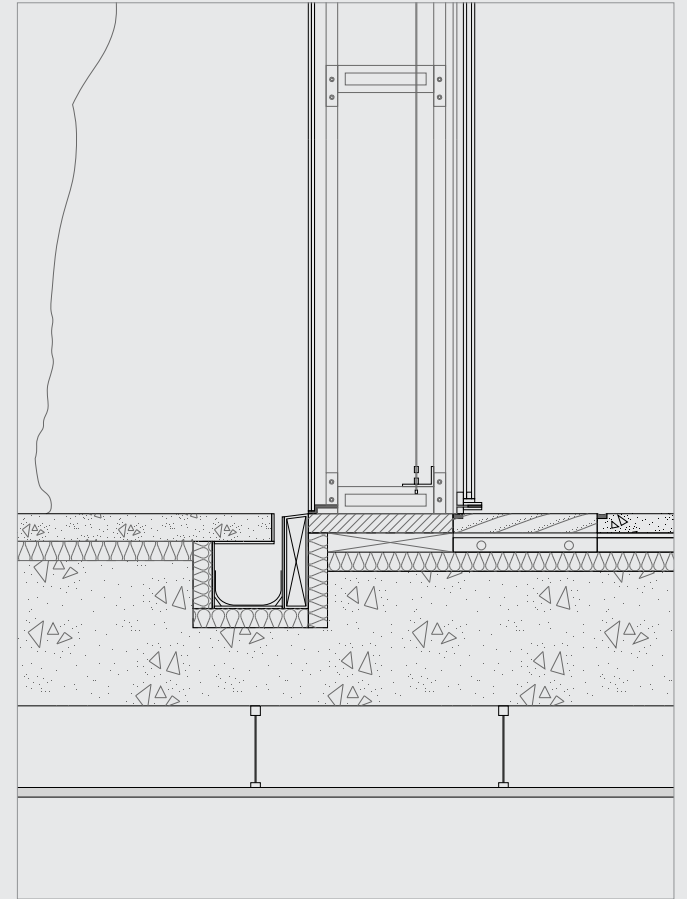
Facade Section  
1 : 20



**Facade - Roof Detail**  
1:5



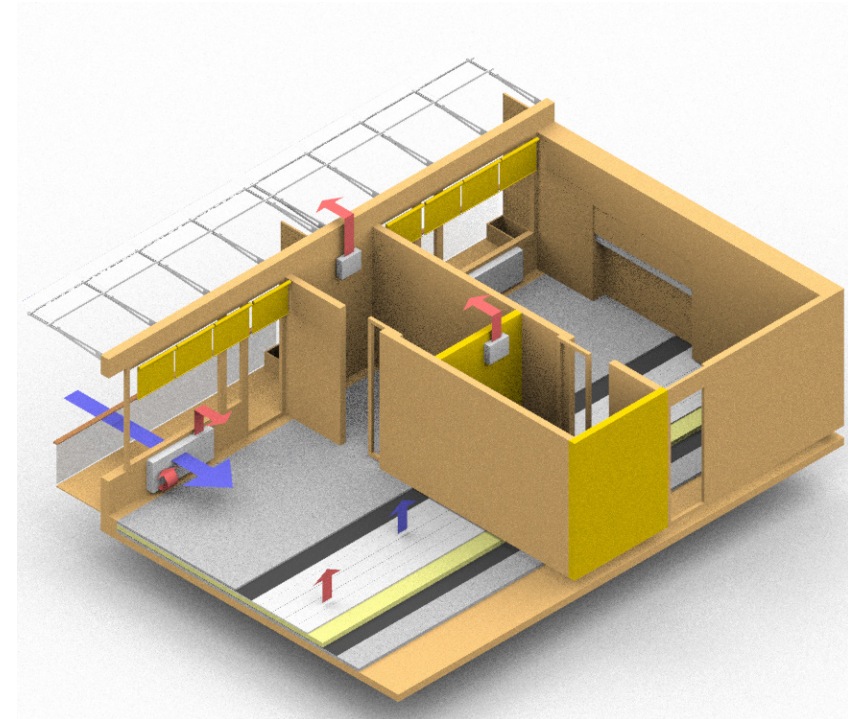
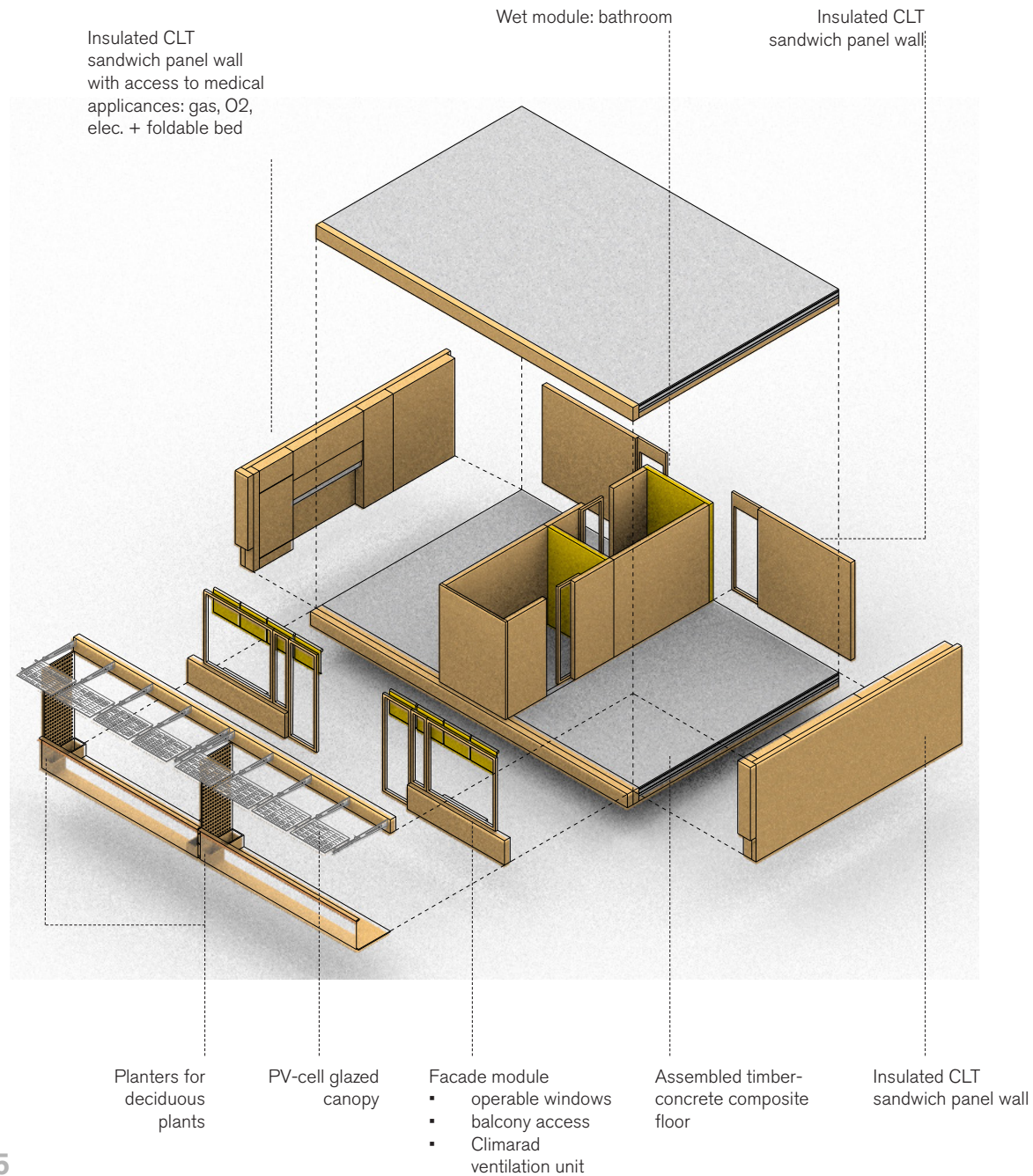
**Floor - Floor Detail**  
1:5



**Facade - Ground Detail**  
1:5

**Patient Wards Dry Construction Process**  
Assembly Strategy

**Room Module**  
Ventilation, Heating & Cooling



**Room Module (10.75 x 7.5 m)**

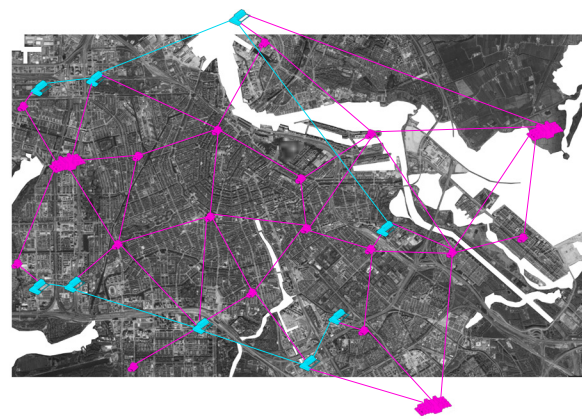
- Prefabricated unit including:
  - an activated assembled timber-concrete composite floor with disconnected elements (acts as roof as well) with modular underfloor heating panels
  - Insulated CLT sandwich walls
  - a wet unit (bathroom) with humidity sensor + extractor
  - prefabricated facade with mechanised shutters
  - attached balcony with visual + acoustic screen, planting unit, automate shading shutters and PV cell-incorporated glazed canopy
- Dry Construction
- Fast assembly



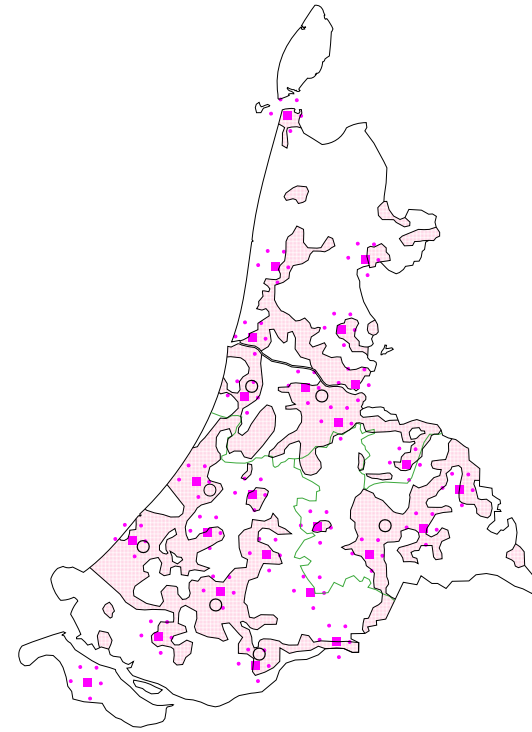
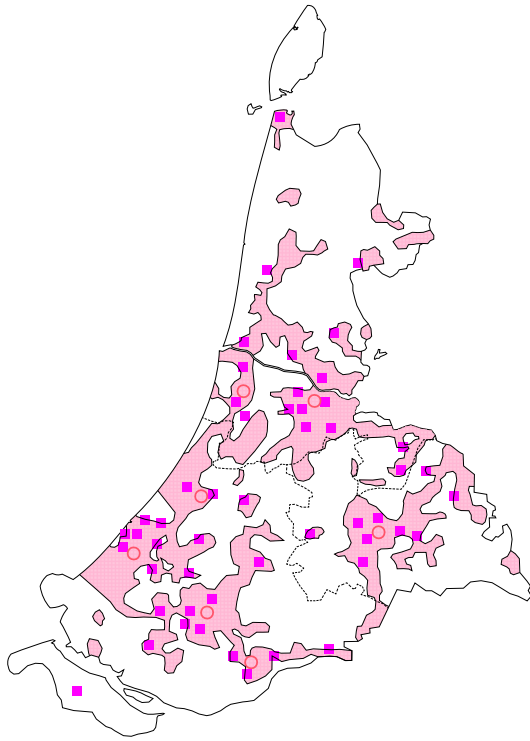


**Buildability**  
Proof of Concept

## *Backcasting*

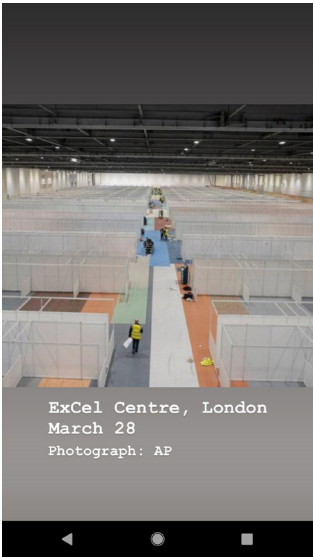




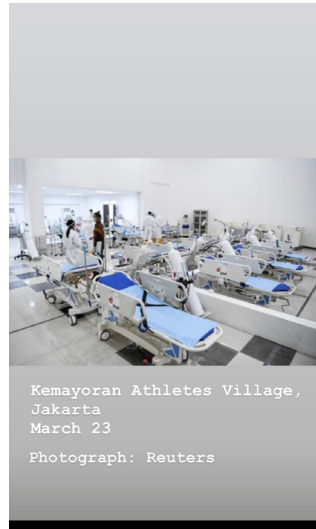


○ Main Cities/Towns      ■ Hospitals  
University & General

**Extension of system onto wider territory**  
Decentralised Care



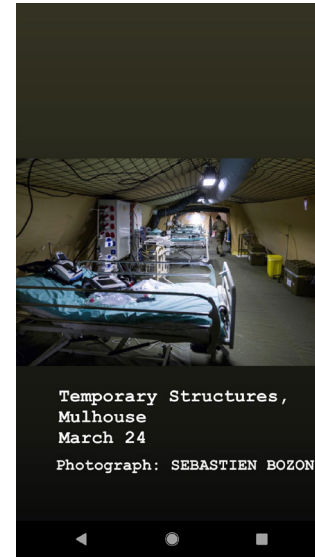
ExCel Centre, London  
March 28  
Photograph: AP



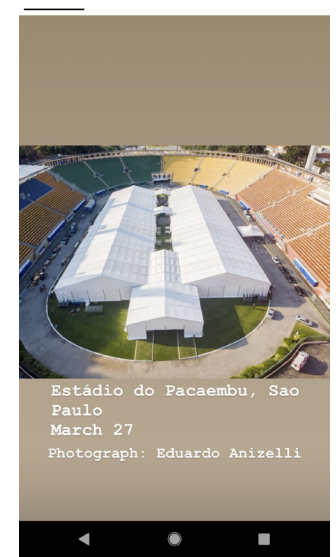
Kemayoran Athletes Village,  
Jakarta  
March 23  
Photograph: Reuters



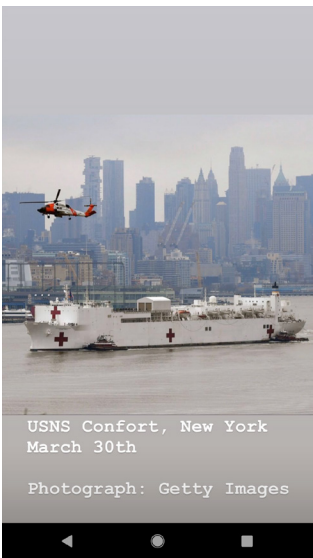
Trade Fair, Belgrade  
March 24  
Photograph: VLADIMIR ZIVOJINOVIC



Temporary Structures,  
Mulhouse  
March 24  
Photograph: SEBASTIEN BOZON



Estádio do Pacaembu, Sao  
Paulo  
March 27  
Photograph: Eduardo Anizelli



USNS Comfort, New York  
March 30th  
Photograph: Getty Images



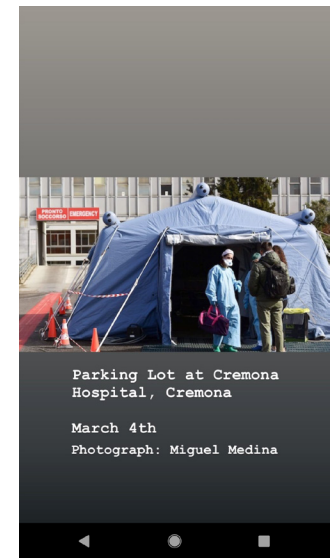
Emergency Hospital,  
Central Park, New York  
March 29th  
Photograph: G.N. Miller



Estado de Hidalgo  
March 13th  
Photograph: Infobase



King County's Sport Field  
March 13th  
Photograph: Associated Press



Parking Lot at Cremona  
Hospital, Cremona  
March 4th  
Photograph: Miguel Medina

Andres Jaques  
Office for Political Innovation  
Columbia University

# NEWS

## Technology

### Coronavirus: Why Singapore turned to wearable contact-tracing tech

By Saira Asher  
BBC News, Singapore

5 July 2020

f WhatsApp Twitter Email Share

Coronavirus pandemic





# HEALTHCARE IN TRANSITION

*Architecture(s) and processes at the  
convergence of healthcare and technology*

Ian Omumbwa

N° 4933613

P5

Transitional Territories Studio