Architecture & Drones

Accommodating Unmanned Aerial Vehicles

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in
Architecture

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ABSTRACT
(Academic Audience)

Throughout history, technological advancements have reshaped the built environment and its architecture. The cities that we live in today were only made possible by the technologies of the first, second, and third industrial revolutions. Today, we are witnessing another technological revolution based on open source data and artificial intelligence.

As there is an enormous amount of prosperous innovations that would directly impact architecture design tools, building and finishing materials, and construction methods, there are also other innovations that would require spaces, buildings, and cities to be designed to accommodate them. Among the latter mentioned innovations is the Unmanned Aerial Vehicle (UAV), also know as drones.

Like the automobile, drone technology will influence not only the way we live but also our design thinking and the components of our built environment. Along with drones' ability to fly, UAV's digital infrastructure is much more flexible and most importantly invisible. Autonomous drones' intelligent abilities allow them to provide a wide range of services in various fields such as freight and delivery, transportation, infrastructure and buildings maintenance, survey, surveillance, policing, fire fighting, agriculture, and even construction, all of which will effectively reduce the amount of ground vehicle traffic, especially in populated cities. Today, as these possibilities are available and constantly under development, it is important for architecture and urban design disciplines to address the challenge and provide comprehensive solutions to accommodate such a technology and allow its possibilities to prosper even further.

The intent of this thesis is to study UAV technology and design a mixed-use complex that embraces and accommodates UAV services such as delivery, transport, freight, and maintenance. The complex hosts a residential tower, a vertical garden tower, ground level commercial spaces, and an underground drone hub.

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ABSTRACT
(General Audience)

Today, we are witnessing another technological revolution based on open source data and artificial intelligence. As there is an enormous amount of prosperous innovations that would directly impact architecture design tools, building and finishing materials, and construction methods, there are also other innovations that would require the built environment of our cities to be designed to accommodate them. Among the later mentioned innovations is the Unmanned Aerial Vehicle (UAV), also known as drones.

Autonomous drones are flying robots with intelligent abilities which allow them to provide a wide range of services in various fields such as; freight and delivery, transportation, infrastructure and buildings maintenance, survey, surveillance, policing, fire fighting, agriculture, and even construction, all of which will are available today and constantly under development. Therefore, it is important for architecture and urban design disciplines to address the challenge and provide comprehensive solutions to accommodate such a technology and allow it to grow even further.

The intent of this thesis is study drones and their future possibilities and to design a mixed-use complex that embraces and accommodates drone services such as; delivery, transport, freight, and maintenance. The complex hosts a residential tower, a vertical garden tower, ground level commercial spaces, and an underground drone hub.

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DEDICATION

To my idols, Rajab Elmagri and Abdulrahim Naas…

You both had started from nothing and chose the path of education to build a legacy of tremendous accomplishments. You gave me love, shared your wisdom, and taught me many valuable lessons. I'll forever be grateful to be your grandson and will do my best to live up to your standards. May you rest in peace.

To my parents, Mom and Dad…

You are my grandparents' greatest gift to me. From an early age, you gave me the freedom of choice and encouraged me to pursue my goals. Thank you for your unconditional and never ending love and support, thank you fo believing in me, and since I can't list them all here, thank you for everything you have done for me since day one.

To my sister, Shadda…

I'm dedicating this to you as an encouragement to pursue your own. Even though you were thousands of miles away and lived in the other side of the world, you were there for me to push me forward. Thank you, for your support little sis.

To the rest of my family and friends…

Thank you to every one of you who helped me through this journey even with a thought, a prayer, or a wish.

ACKNOWLEDGEMENT

I was fortunate enough to go on this journey under the guidance of Susan, Paul, and Scott. Thank you all for your patience, perspective, critique, feedback, references, advice, encouragement, motivation, enthusiasm, and guidance. You challenged me to draw more, arrange my thoughts, narrow things down, explore further, and stay focused on the main topic every time I got carried away. I am honored and grateful to have you as my committee. I wouldn't have been able to go this far without you.

I would also like to thank all my professors at the WAAC. You've enriched my architectural knowledge and gave me a new perspective.

Marium, #thesisbuddies, WE MADE IT! The last couple of months weren't a walk in the park but your company has turned it to an enjoyable and memorable experience. Also, many thanks to Anahita, Dennis, Paige, Randa, Saanika, and Sangyoon for the late night company, help and support.

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INTRODUCTION

In my first semester, I was asked to write a paper from the perspective of 50 years from now. The task was to choose a topic that would have a major impact on how our cities and built environment will evolve. I chose Technology. I enjoyed the task and was intrigued to use the same methodology in my thesis.

When I first started this thesis I had a broader scheme in mind. I wanted to look into the latest trending technologies that would, directly and indirectly, influence architecture and urban evolution of our built environment. However, I had to narrow it down to one technology and build my thesis around it.

Technology had been the driving force of Architecture throughout history. The more technologically advanced civilization was the more prosperous was its Architecture. After the first and second industrial revolutions, major cities around the world were reshaped to fit the modern age while other cities emerged faster and larger than ever. Innovations in transportation and freight played an important role in that process. Therefore, Architects and planners of the modern school had put in tremendous efforts to transform our cities' built environment and infrastructure to accommodate trains, streetcars, automobiles, trucks, and buses.

Later on, due to urban congestion and pollution, post-modernists took initiative to reduce the public's reliance on automobiles by enhancing cities' walkability, bike-ability, and means of mass transportation. Technology, after decades from the beginning of the digital revolution, took it a step further by introducing on-demand shared transport which will later evolve to an autonomous system by the introduction of Artificial Intelligence.

Today, Unmanned Aerial Vehicles, aka drones, are one of the most promising trending technologies. Like the automobile, Unmanned Aerial technology will influence not only the way we live but also our design thinking and the components of our built environment. Drones' ability to fly will change the pattern of how the city functions. The vacant spaces above horizontal surfaces and around vertical urban elements will be put in use to interlace the urban environment three-dimensionally.

Unmanned Aerial Vehichle (UAV)

AKA Drones





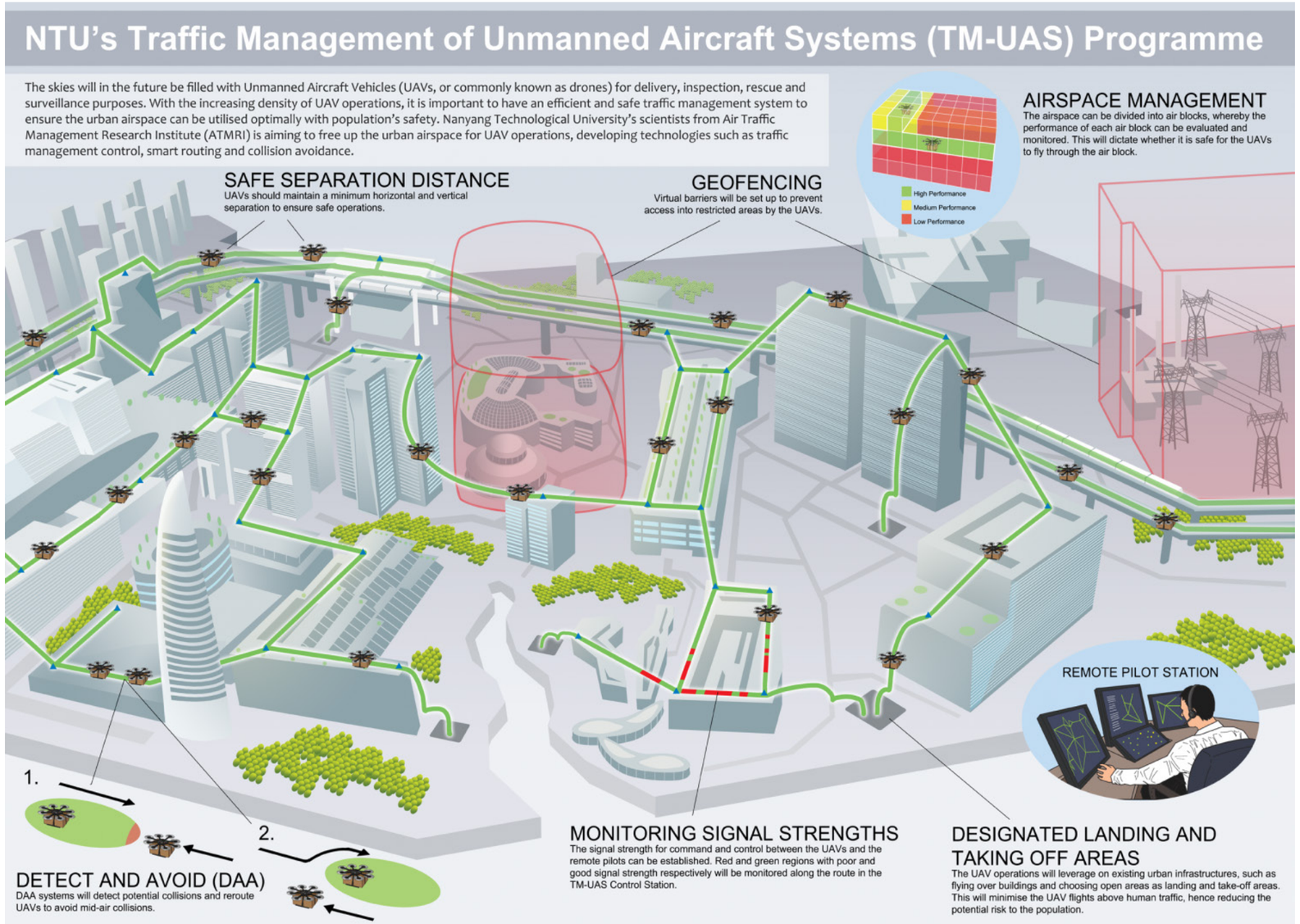




UAVs rely on a digital infrastructure and Artificial Intelligence, which allows them to be more effective and more vigilant to the natural and man-made habitat. Autonomous Drones' intelligent abilities allow them to provide a wide range of services in various fields such as: freight and delivery, transportation, infrastructure and buildings maintenance, survey, surveillance, policing, fire fighting, agriculture, and even construction, all of which will effectively reduce the amount of ground vehicle traffic, especially in populated urban habitat.

UNMANNED AIRCRAFT SYSTEM (UAS)

UAS is the digital infrastructure system which will control, manage, and monitor UAV's traffic by utilizing and optimizing air space of urban habitat and areas of service. The system will divide air space according to speed and function. Every drone of every drone service provider must be registered in the system in order to operate. UAS can also provide geofencing to prevent drones from accessing the airspace of specific areas. As it relays on open data and artificial intelligence the system can adjust and change routes according to the conditions and circumstances. The figure below illustrates a UAS system as envisioned by researchers from Air Traffic Management Research Institute of Nanyang Technological University.



(NTU's Traffic Management of Unmanned Aircraft System (TM-UAS) Programme, phys.org)

CONCEPTUAL IDEAS, PATENTS, AND PROJECTS

In December 2015, Amazon filed a patent for a multilevel beehive tower which functions as a fulfillment center for drone delivery services. They envision those beehive towers to service a highly populated urban area. The patent is based on the program and the function of the tower rather than its Architecture.

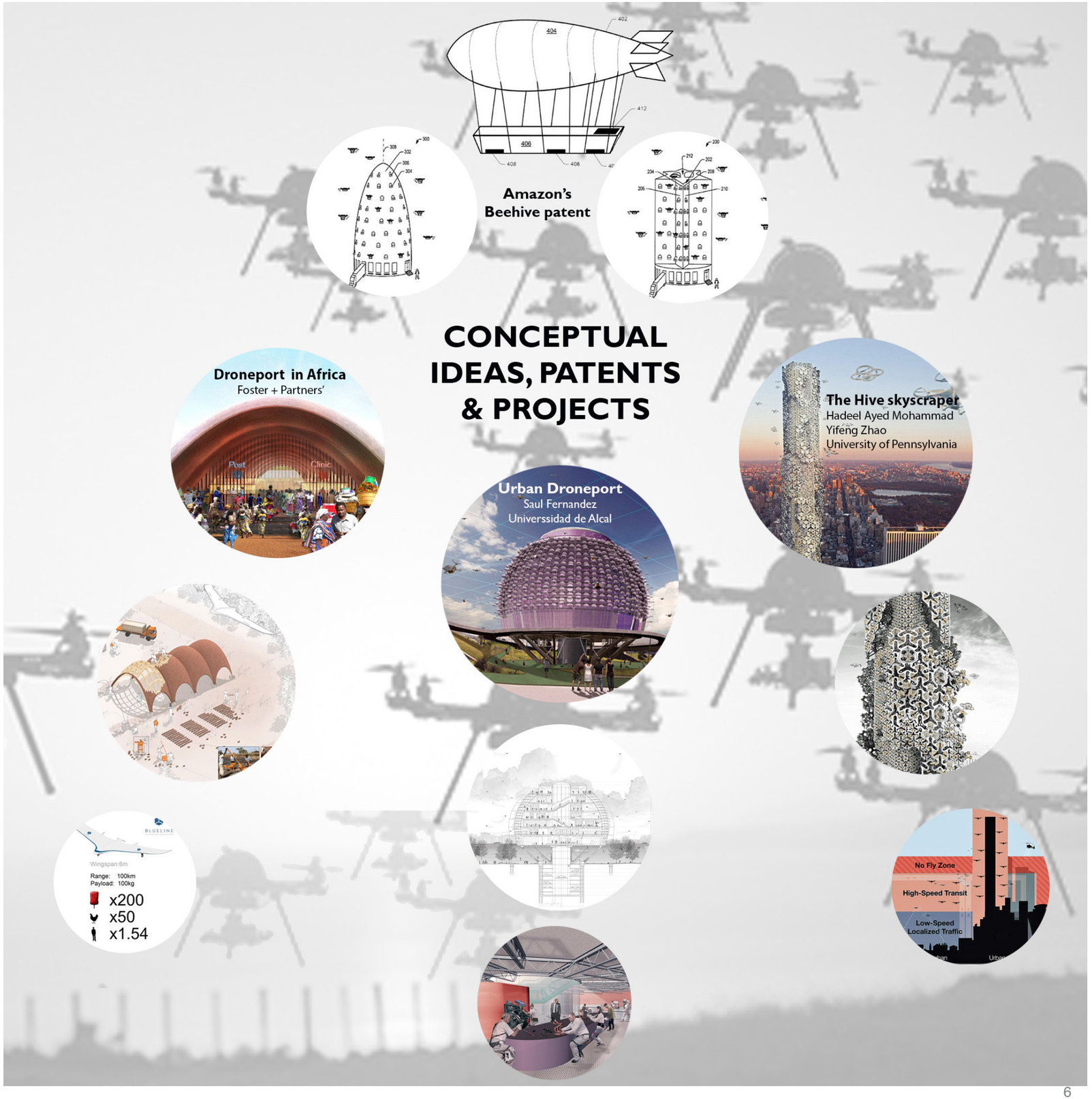
Ever since the technology hasn't been implemented yet, there were only a few architectural examples to look at. The first example is the Droneport designed by Foster + Partners' in East Africa. Due to the poor road conditions, it is very difficult to deliver medical and emergency supplies to those who live in a remote area. The idea was to provide a space that will receive packages delivered by UAVs.

"The Droneport project is about doing 'more with less', capitalizing on the recent advancements in drone technology – something that is usually associated with war and hostilities – to make an immediate life-saving impact in Africa," Lord Foster, Chairman and Founder of Foster + Partners.

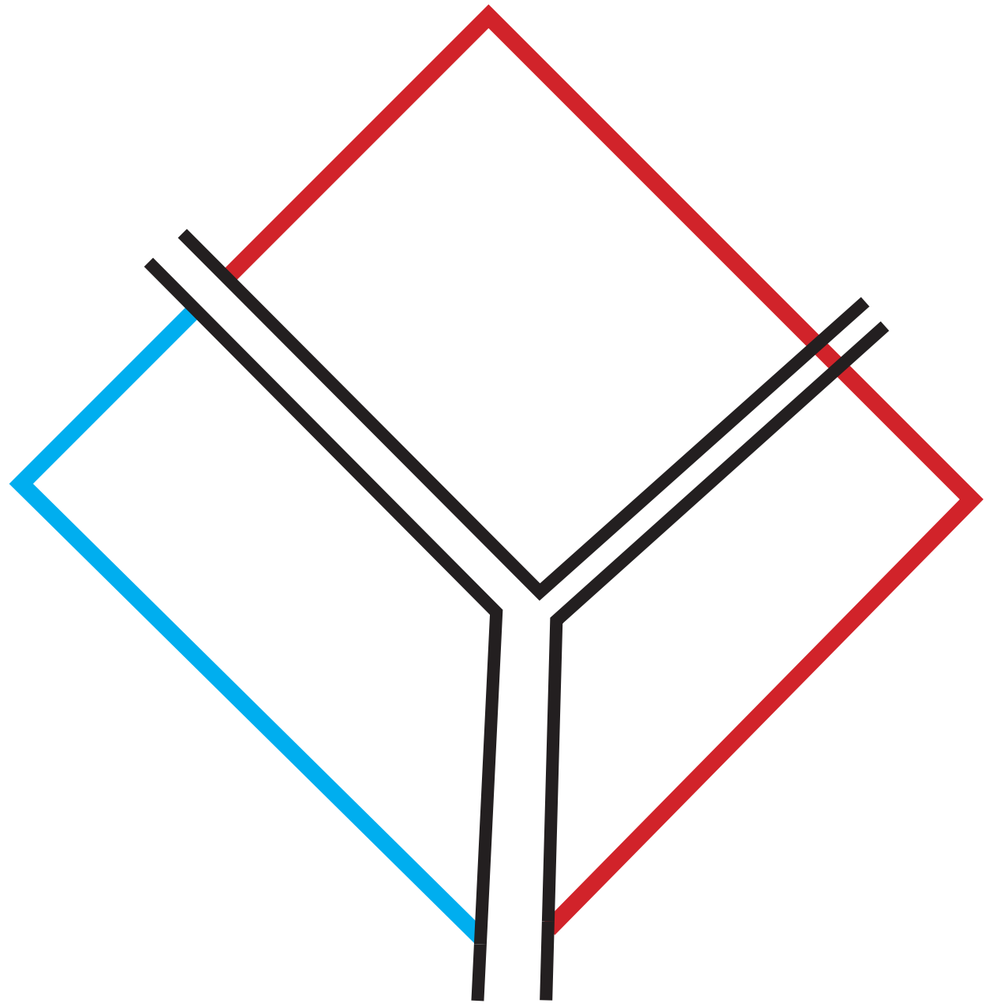
This example provided a practical solution to an on-going problem using the technology as it is available today.

The second example, is Droneport thesis project by Saul Fernandez from Universidad de Alcalá, Madrid. The building has a spherical shape and drones' landings are placed along its facade. From there, drones are picked up from the inside to charge, reload, store, or fix them at the logistics center. Unlike the previous example, this thesis is addressing a solution for a future where UAV technology is more advanced and regulated.

The last example is the "Hive" Skyscraper by a group of students from the University of Pennsylvania. The intent of this project is to design the exterior facade of a drone depot skyscraper. Even though the idea is conceptual and the only designed part of the tower is its facade, they have addressed the current air-traffic restrictions and proposed a plan in which they envisioned how air space should be divided to three categories; High-Speed Transit, Low-Speed Localized Traffic, and No-fly zone.

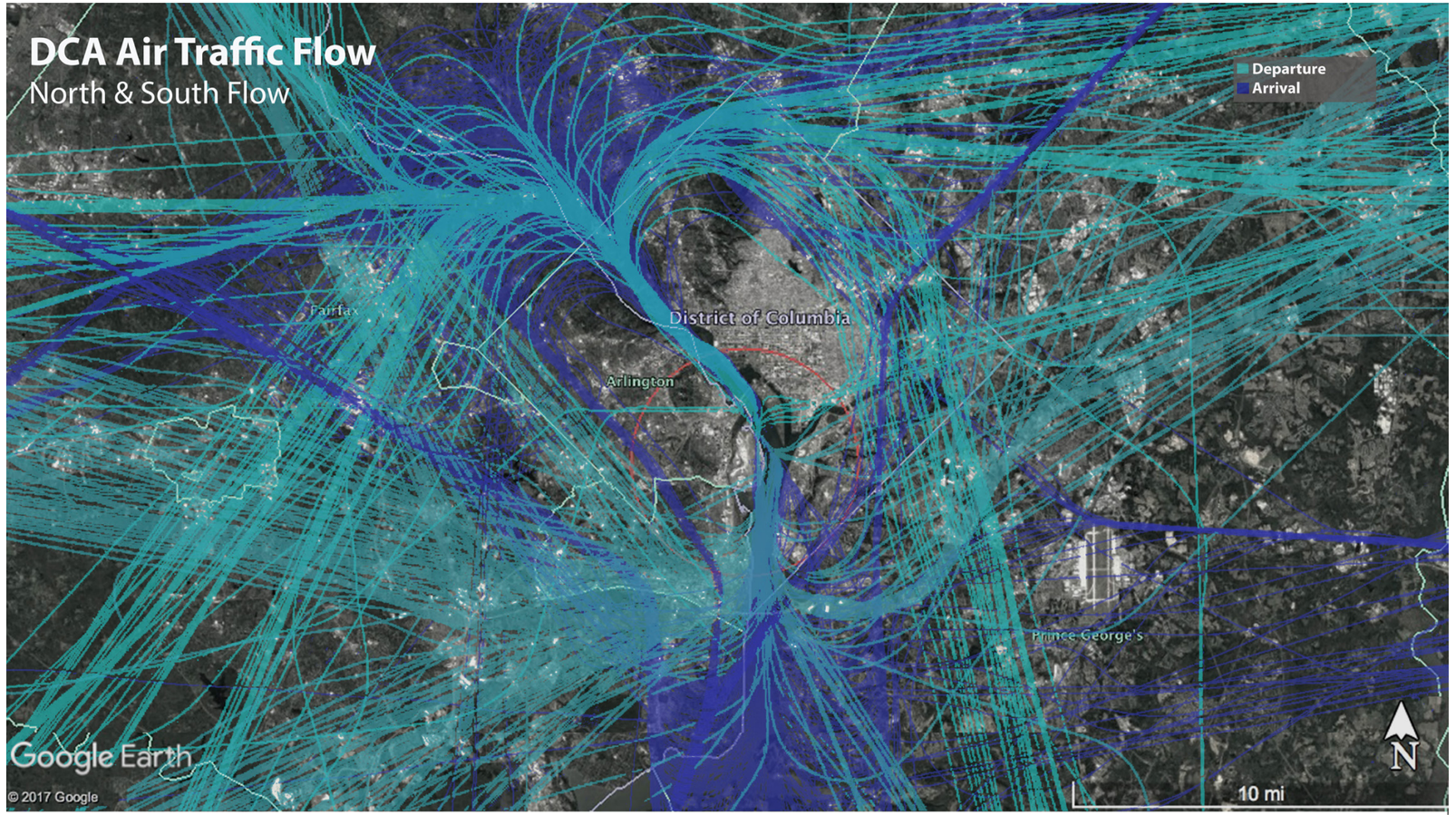


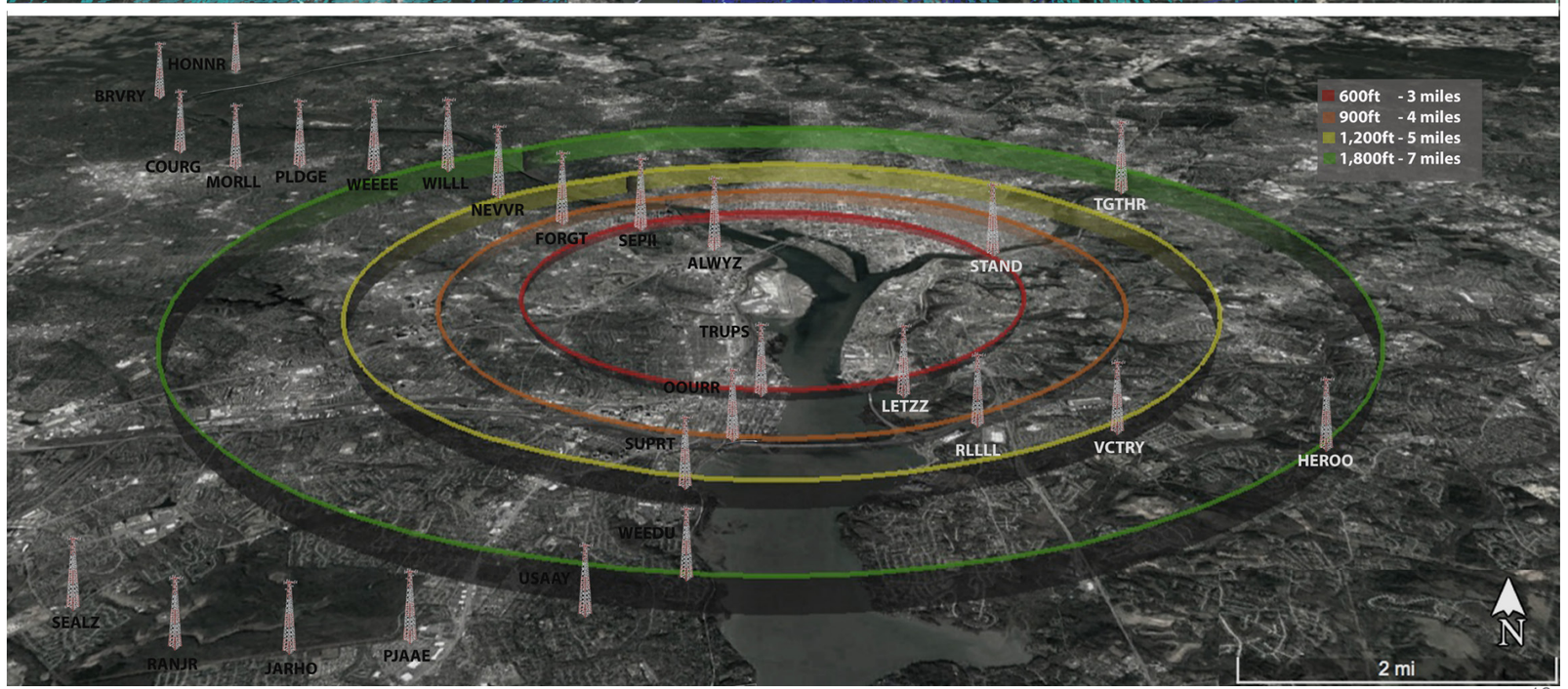
SITE EXPLORATION



SITE

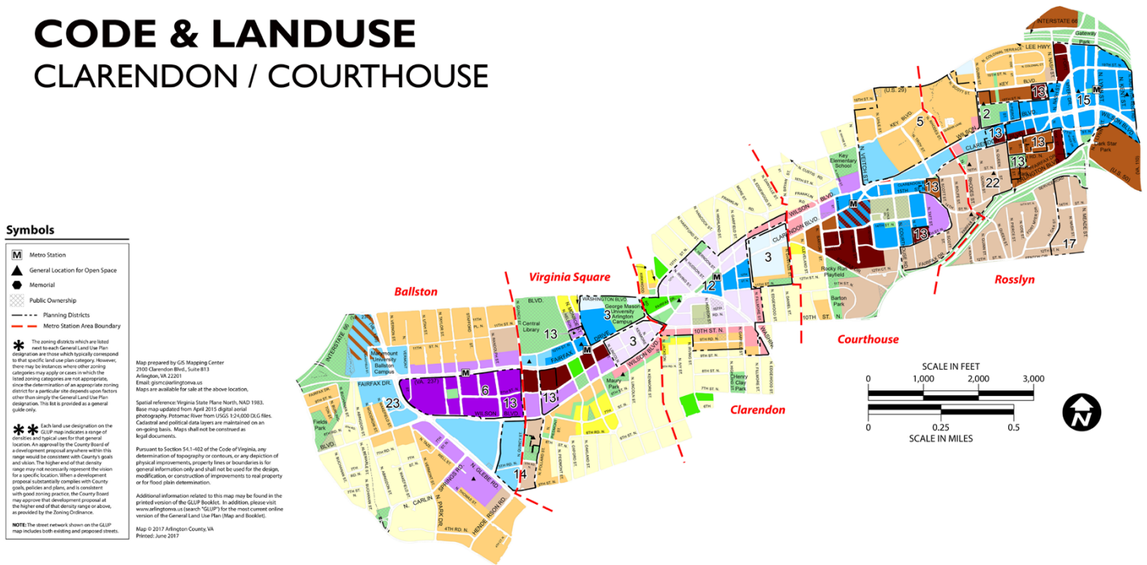
Washington D.C. area has two airports, Ronald Reagan Washington National Airport (DCA) and Dulles International Airport (IAD). The area also has very strict air traffic regulations and many No-Fly zones. As shown in the DCA Air Traffic figure below, planes follow the river to land and depart to avoid flying over prohibited areas such as; military bases for security reasons and D.C.'s northwest quadrant and Arlington, VA as requested by their residents. The lower drawing shows the rings that mark the planes' minimum altitude which applies to both departing and arriving planes. The closest ring has a 3 miles radius from DCA and an altitude of 600 feet.





As this project aims to serve areas of high density to reduce ground traffic, NW D.C. and Arlington, VA both meet that criteria. Yet, NW D.C. has lower building height restrictions and not enough vacancy in dense and metro accessible areas. On the other hand, Arlington, VA, is rapidly growing by following transit-oriented development scheme.
The land-use and code figure below shows the concentration of density along Arlington's main corridor which runs through Roslyn, Courthouse, Clarendon, Virginia Square, and Ballston.
Even though Clarendon is located in the center of the main corridor and is the most vibrant due to the concentration of commercial uses on ground level, it is still the least densified among its neighbors. Today, Arlington County is working on adjusting and densifying Clarendon's land use and fixing its streets intersections to become more pedestrian friendly.

CODE & LANDUSE
CLARENDON / COURTHOUSE



According to **Arlington's Code**, buildings' height are relative to the site's area.
To achieve the **maximum height** for a mixed use building it must have a minimum **of 30% of its total area dedicated to residential.**

Buildings Maximum Height

SITE AREA	OFFICE / HOTEL	MULTIFAMILY
19,999 or less	100	151
20,000 to 29,999	110	162
30,000 to 39,999	120	171
40,000 to 49,999	140	180
50,000 to 59,999	150	189
60,000 to 69,999	160	198

To have use the **Maximum F.A.R** value for a mixed use building, **only 50% of its total F.A.R** can be dedicated to **Office and Commercial**.

Density

SITE AREA	TOTAL F.A.R	OFFICE + COMMERCIAL MAX
15,000	2.50	1.75
20,000	3.00	1.50
30,000	3.50	1.75
40,000	4.00	2.00
50,000	4.50	2.25
60,000	5.00	2.50

Legend

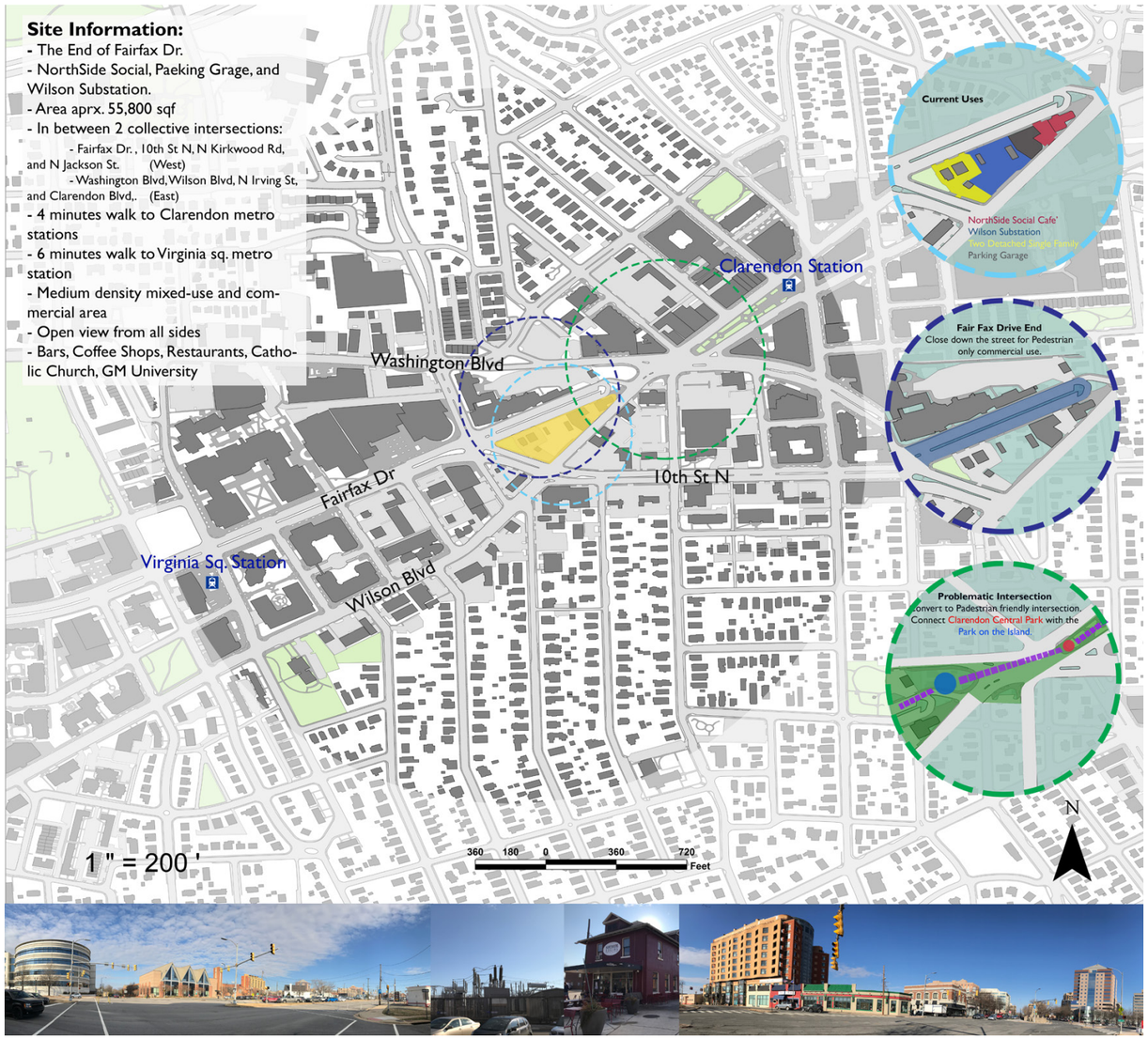
Land Use Category**	Range of Density/Typical Use	Zoning*
Residential		
Low	1-10 units per acre	R-20, R-10, R-10T, R-8, R-6, R-5
Low	11-15 units per acre	R2-7, R15-30T
Low-Medium	16-36 units per acre	R15-30T, RA14-26, RA8-18
Medium	Up to 37-72 units per acre	RA7-16, RA6-15, RA-H
High-Medium	Up to 3.24 F.A.R. *(Floor Area Ratio)* Residential	RA-4.8
High	Up to 4.8 F.A.R. Residential Up to 3.8 F.A.R. Hotel	RA-H-3.2, C-O Rosslyn

Land Use Category**	Range of Density/Typical Use	Zoning*
Commercial and Industrial		
Service Commercial	Personal and business services. Generally one to four stories, with special provisions within the Columbia Pike Special Revitalization District.	C-1-R, C-1, C-1-O, C-2, C-O-1.0
General Commercial	Shopper goods and other major mixed commercial uses, including offices. Generally a maximum of seven stories.	C-2, C-TH, C-3
Service Industry	Wholesale, storage, and light manufacturing uses, including those relating to building construction activity.	CM, M-1, M-2
Public and Semi-Public		
Public	*Parks (Local, regional, and federal),* Schools *(public).* Parkways, major unpaved rights-of-way. Libraries and cultural facilities.	S-3A, S-O
Semi-Public	Country clubs and semi-public recreational facilities. Churches, private schools and private cemeteries *(predominant use on block).*	S-3A, S-O
Government and Community Facilities	County, state and federal administration and service facilities *(police, fire, property yard, etc.)* Hospitals, nursing homes, and institutional housing. Utilities, military reservations, airports, etc.	P-S, S-D, S-3A

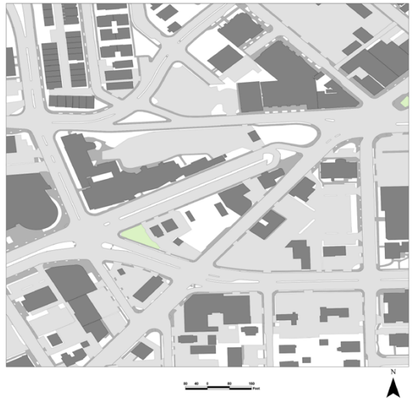
Land Use Category**	Range of Density/Typical Use	Zoning*
Office-Apartment-Hotel	Office Density / Apartment Density / Hotel Density	
Low	Up to 1.5 F.A.R. / Up to 72 units/acre / Up to 110 units/acre	C-O-1.5, C-O-1.0
Medium	Up to 2.5 F.A.R. / Up to 115 units/acre / Up to 180 units/acre	C-O-2.5
High	Up to 3.8 F.A.R. / Up to 4.8 F.A.R. / Up to 3.8 F.A.R.	C-O, RA-H-3.2, C-O Rosslyn
Mixed Use		
Medium Density Mixed-Use	Up to 3.0 F.A.R. with special provision for additional density within the "Clarendon Revitalization District" (See Note 12) and the "Special Coordinated Mixed Use District" for East End of Virginia Square (See Note 3)	C-R, C-3, MU-VS
High-Medium Residential Mixed-Use	Up to 3.24 F.A.R. including associated office and retail activities.	R-C
Coordinated Mixed-Use Development District	This is a high density mixed-use district with actual density determined by site size. Up to 6.0 F.A.R. with office not more than 3.0 F.A.R.	C-O-A

To narrow down possible sites, UAV potential traffic flow was the main determining factor. As buildings will rise high along the main streets of Arlington's corridor, drones that are providing a direct service to these buildings will fly above the streets in the low-speed zone to avoid flying above private properties. Therefore, a location by the collective intersection of Clarendon circle will be ideal. The site location is also ideal for on ground and underground transportation.
The drawing below shows more information about the site, its location, size, and surrounding context.

CLARENDON



SITE INFORMATION
(CLARENDON)



1" = 200'

SITE AREA = **55,800 sqft**

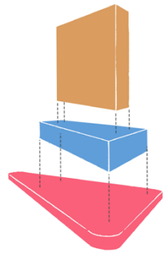
BUILT AREA =
Site Area - (10% of the site) = **50, 220 sqft**

F.A.R 4.5 = 50,220 x 4.5 = **225,990 sqft**

50% Residential = **112,995 sqft**

50% (Office + Commercial) = **112,995 sqft**

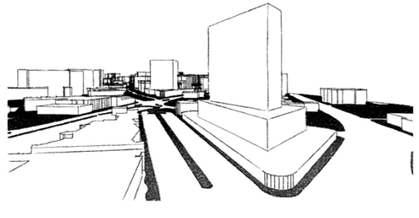
Max Height = **189 ft** (14-18 floors)

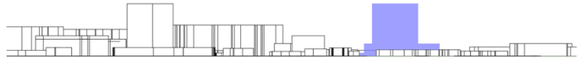


Residential 112,995 sqft
12 floors @ 9,416 sqft / floor
48-72 Units (4-6 units / floor)

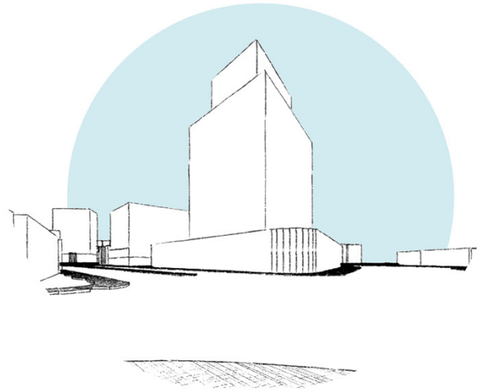
Office 67,797 sqft
4 floors @ 16,949 sqft / floor
16-24 Office Space (4-6 spaces / floor)

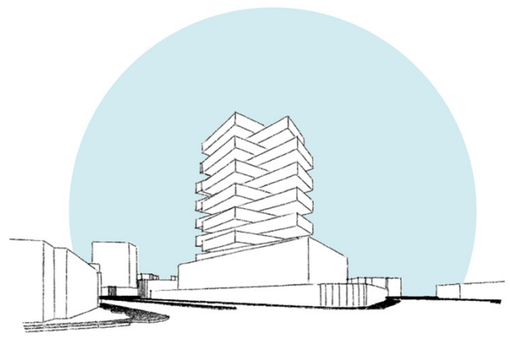
Retail 45,198 sqft
Ground Level
Diverse Spaces along the street.

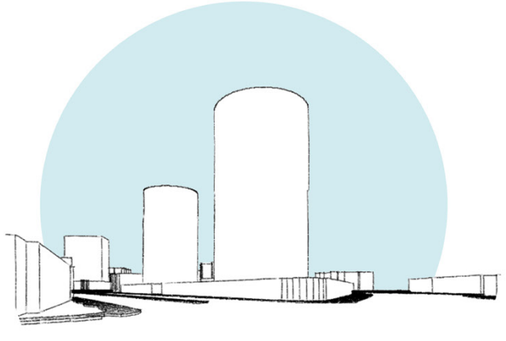




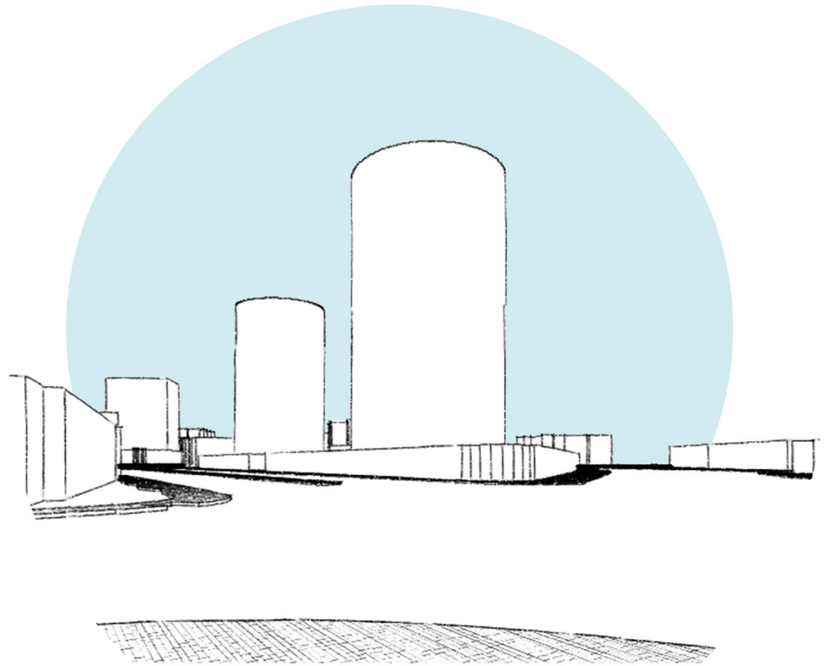
MASSING OPTIONS
(SKETCHES)







ARCHITECTURAL AND STRUCTURAL CONCEPT



Architecturally, there weren't many occasions where buildings were designed to accommodate flying objects. The closest example would be Dove Cotes or Pigeon Towers. Farmers built such structures near their farming land to collect pigeons' feces which is used as a soil fertilizer.
The pigeon towers of Isfahan-Iran were a good example to examine. In conclusion, most of the towers were vertical and cylindrical in form. If the form wasn't cylindrical, the plan would be circular. They had at least one entry zone at the highest point of the structure. The interior is in an open space with pigeon holes stacked across all walls and columns.

Pigeons & Drones
Conceptual Form and Function

Pigeons:
-Pigeons served as a source of food and message delivery while their feces was used for agricultural purposes.

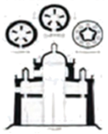
Dove Cotes (Pigeon Towers)
-Rise high as Towers
-Mostly Cylindrical in shape.
-If the form was in other shape, the plan would be circular.

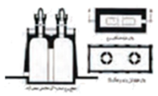

Gavart Village


Radan Tower


Hezar Jarib


Safa Tower

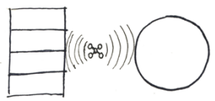




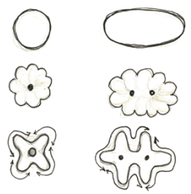
Drones:
-Drones will be used in delivery, policing, firefighting, agricultural, advertisement, service and maintenance, arts, etc.

Drone Friendly Structures:
-Rise Vertical
-Provide Open Vertical space within the site's boundaries.
-Allow smooth movement around the vertical surfaces with a minimum noise impact
-Provide access to all Drone Services.

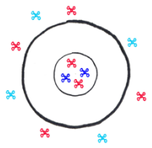
Angles vs. Curve

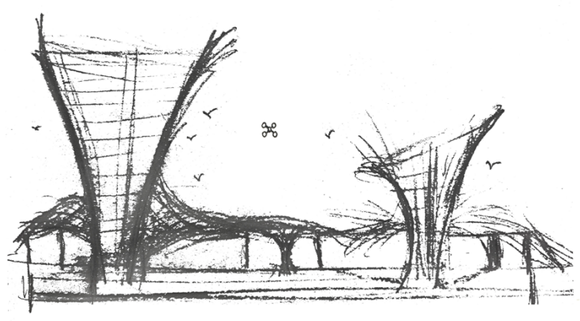


Vertical vs Horizontal

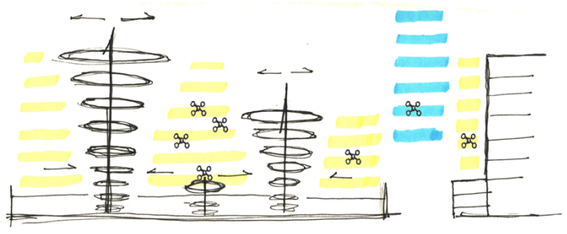


DELIVERY / MAINTENANCE
EMERGENCY



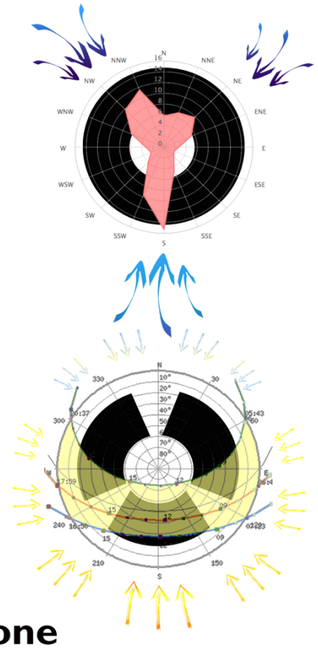


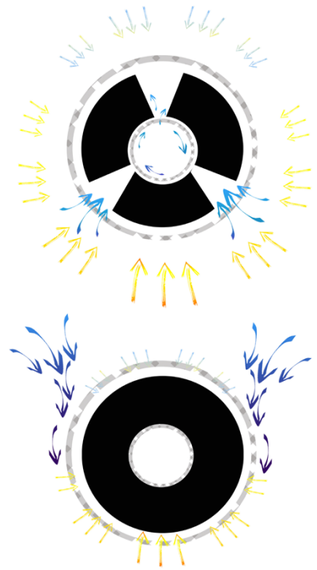
Vertical Spaces on Site

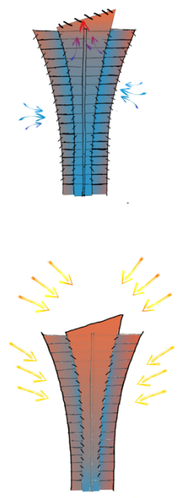


As shown in the sketch, schematically, the complex will have a commercial podium, a plaza, and two towers. To limit drones' movement around the towers for maintenance and emergency drones only, it would be best to bring in delivery drones into the building through the highest point, closer to the high-speed drone zone.
The way the pigeon towers were designed to host the pigeons in an atrium like interior space was inspiring. Introducing an atrium to the mixed-use complex towers can be utilized as a natural light source, allows passive heat exchange, and functions as a drones' shaft.

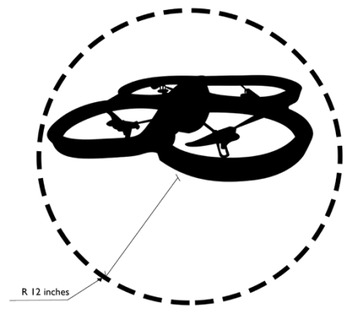
Passive Towers
Wind, Solar, and Interactive Components



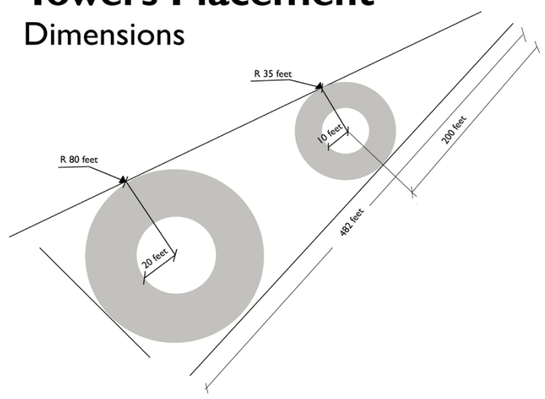




Drone
Dimensions

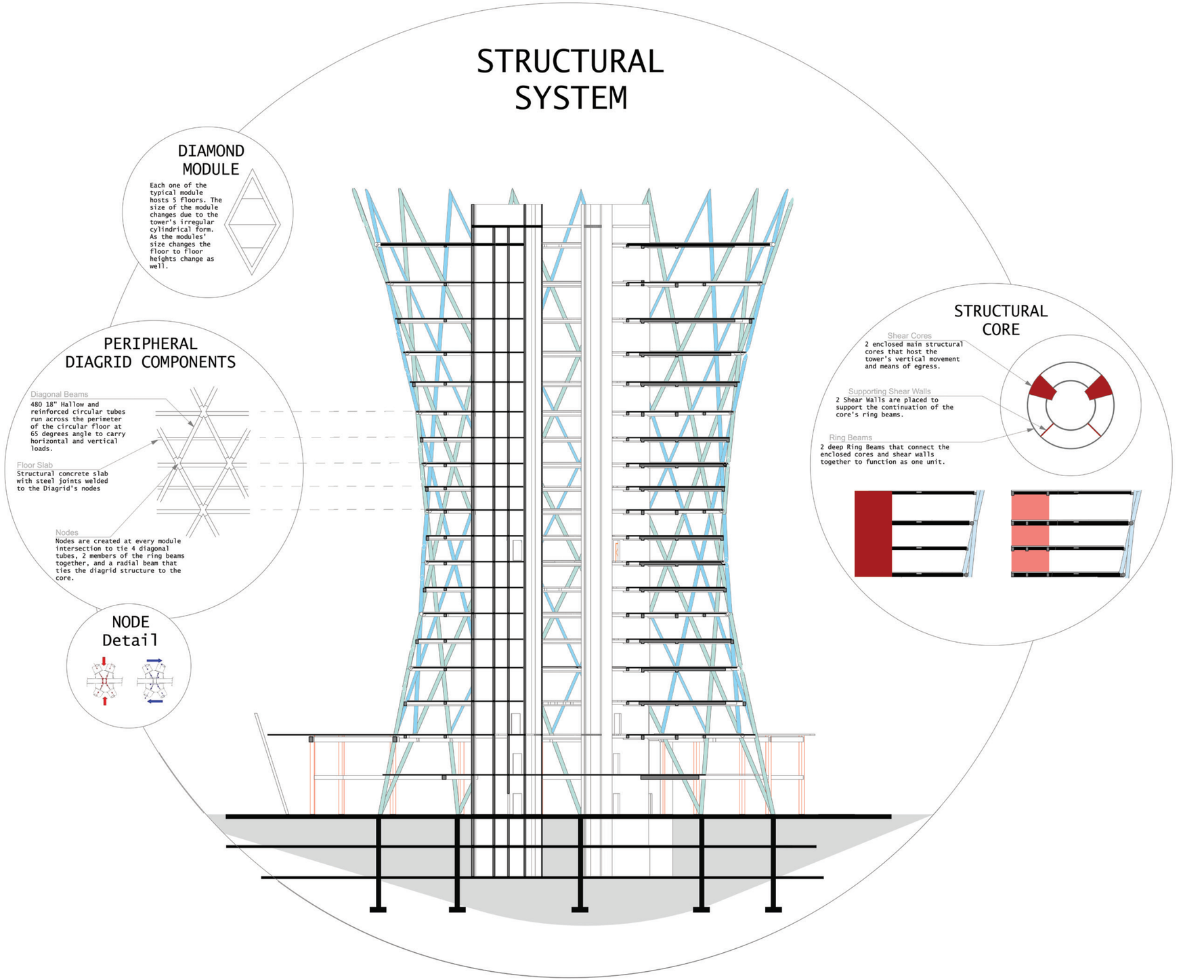


Towers Placement
Dimensions



STRUCTURAL SYSTEM CONCEPT

It was important to find a structural system that supports the architectural concept and form of the towers. Looking at examples of high rise towers of similar forms led to exploring the Diagrid Structural system. The Diagrid System uses peripheral intersecting diagonal members to carry both horizontal and gravity loads without the need to use vertical columns.
Adding an atrium that goes through the whole tower will require the addition of a shear core. However, the diagonal members will remain the main structural element that carries the building and the core can be broken to smaller supporting elements.



STRUCTURAL DIAGRAM

0 8' 16' 32'

MIXED-USE COMPLEX DESIGN

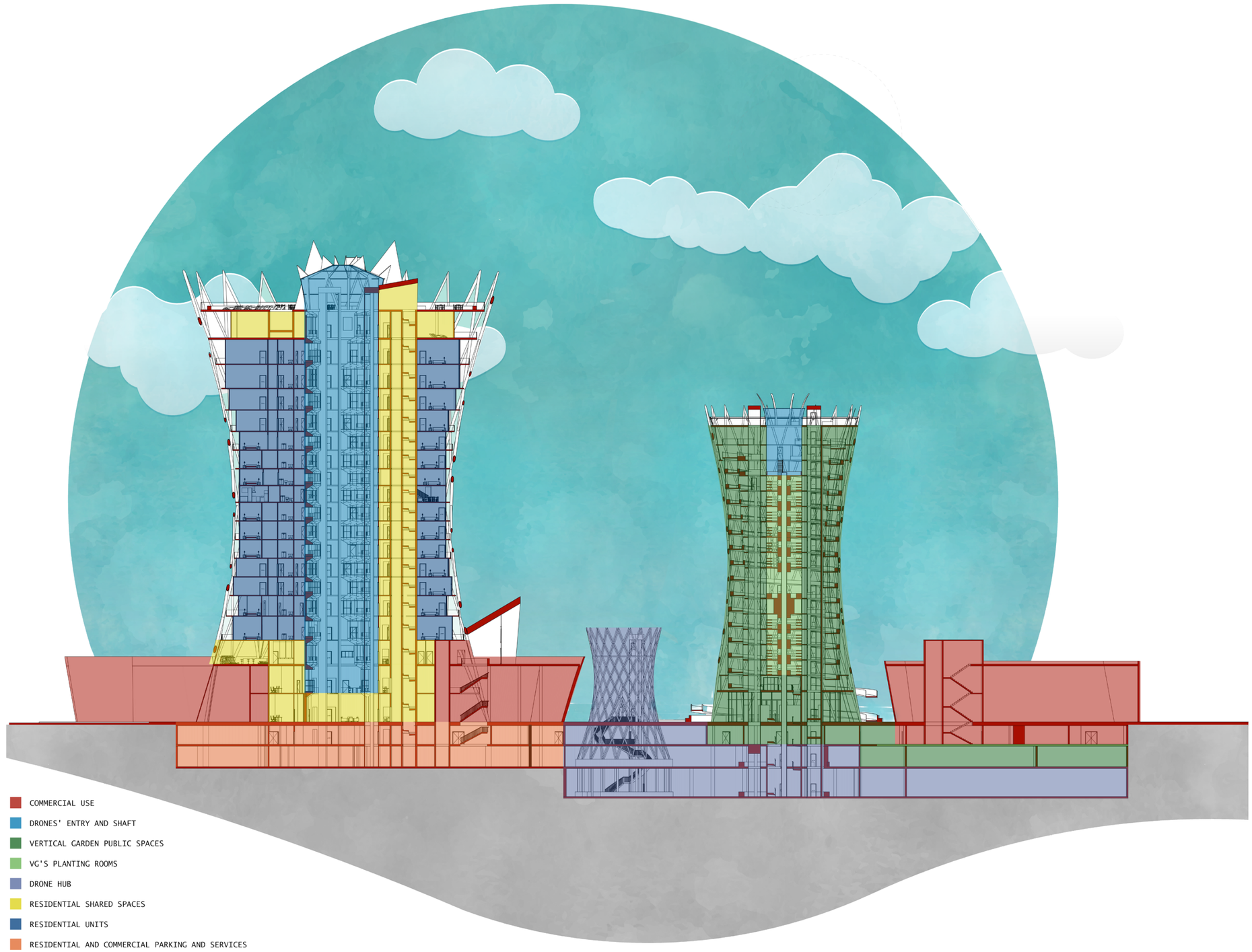
Slim Diagrid steel tubes rising from the ground wrapped with decidious colorful vines carrying floating floor plates.

PROGRAM

The mixed-use complex is composed of two towers, a 255-foot **Residential Tower** and a 168-foot **Vertical Community Garden Tower**. The residential tower has a double height **Commercial Podium**, while the other commercial space on the NE corner will host a coffee shop. Underground is utilized for parking and “ground” services while a large portion of it is dedicated to the **Drone Hub.**

The 1st floor of the **Residential Tower** hosts the reception lobby and administration offices topped with the 20-floor high atrium/drone shaft. Only administration offices on the second floor have access to drone mailboxes. From the lobby, one can use the stairs and elevators of the two cores or the round and panoramic elevators of the atrium. Amenities are distributed between the 3rd and 19th floors and the roof as apartments are spread in between from the 4th to the 18th floor.

The Vertical Community Garden has a double height exhibit on the ground level while all utility rooms, storage, control room, and propagation rooms are placed underground. To get to the second floor visitors may use the exterior ramp or the stairs and panoramic elevators from the lobby. As the stairs stop in the second level, a ramp starts on the interior periphery of the Diagrid and continuous all the way to the Observatory Deck on the last floor. The inside of the tower is split in two; a portion is used to stack up 15 floors for rest areas and planting rooms, while the other portion used as a drone shaft for the **Drone Hub**.

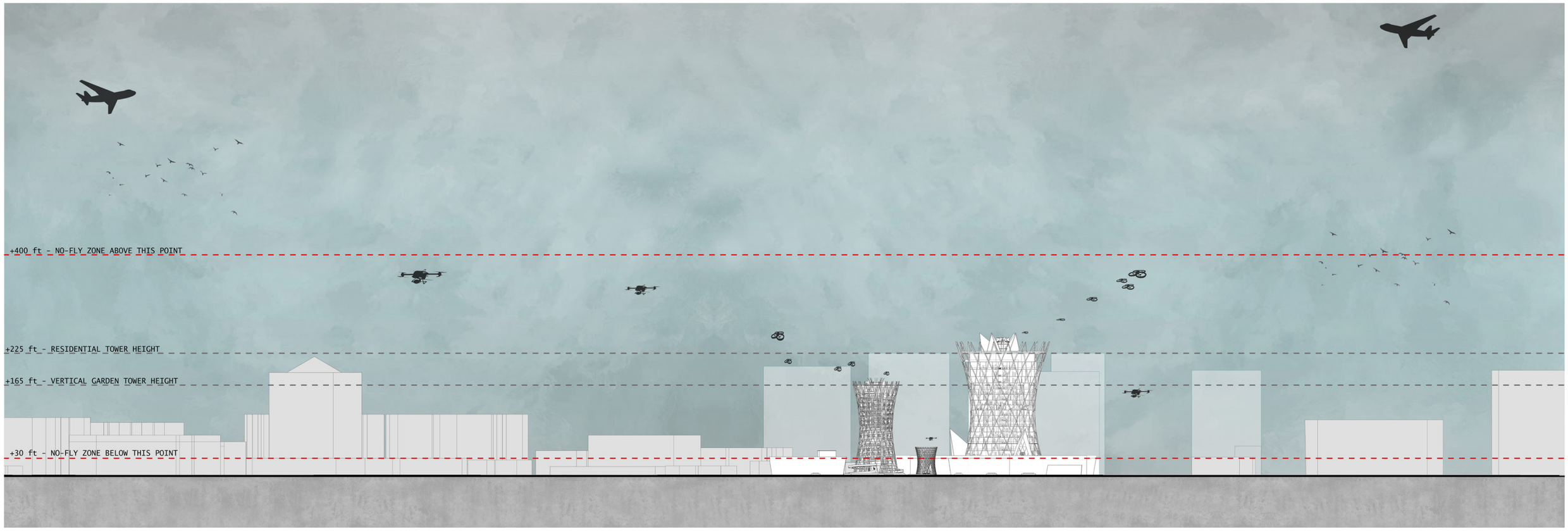


TOWERS' PROGRAM (S-1)

0 16' 32' 64'

DRONE ZONING

The diagram below shows the complex in a half a mile existing and proposed context section. As the site is on the edge of the planes' 600ft altitude ring, I proposed a scenario where all commercial drone services mustn't fly higher than 400 feet above ground level. Also, to avoid future air-rights problems in dense high rise areas, drones may only occupy the air above streets and public spaces until they enter the zone of the building which they're servicing. Lastly, to maintain a level of comfort and safety for pedestrians, a no-fly zone below 30 feet above ground is also implemented.



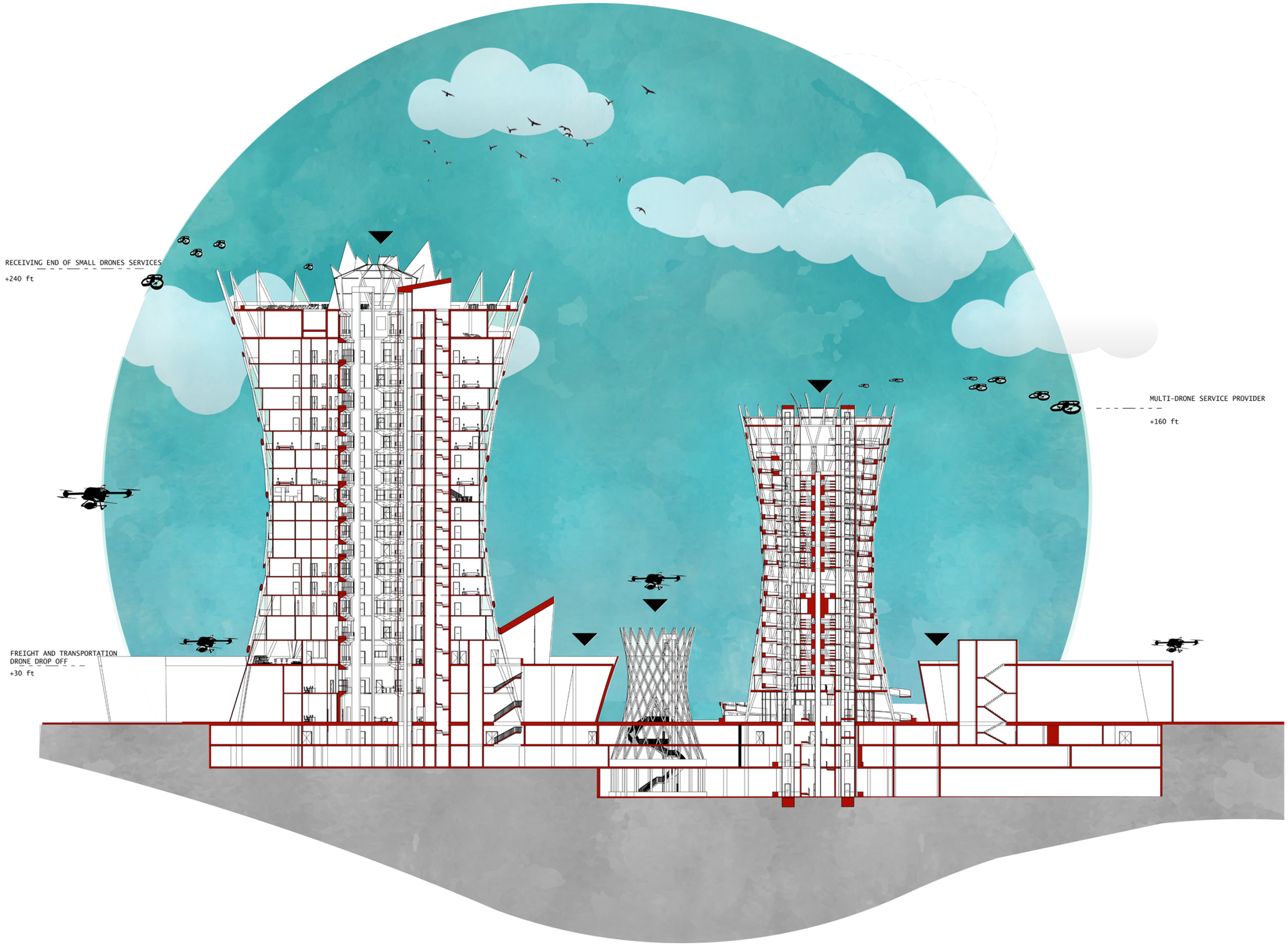
0.5 MILE CONTEXT ELEVATION (A)

DRONE TYPE & ACCESS

In this project drone services are categorized by size: small drones for commercial services and large drones for transportation and commercial freight.

To avoid disrupting the streetscape and landscape of dense areas, large drones services are provided landing spaces on the podium's roof level. There are four landing spots on the site. Two of which will serve the residential tower and its podium. One serves the coffee shop and the commercial area on ground level. The last one is placed on top of the Drone Hub's entry/skylight.

As I have previously mentioned, the higher the drones go the faster they may fly; therefore, small drones will access the building from the highest point into the drone shaft.



DRONES' ACCESSIBILITY (S-1)

0 16' 32' 64'

SITE PLAN

The first approach to the site was to close down Fairfax Dr for pedestrian use only and move the existing parking spaces underground. Commercial spaces to occupy most of the site's ground level to ensure the continuity of pedestrian vibrancy along Clarendon's commercial corridor.

A two-story high coffee shop with an accessible rooftop and outdoor seating is placed on the NE corner of the site overlooking Clarendon Circle.

The Vertical Community Garden has a double height lobby, exhibit, and an external harvest sale/share space on the ground level. To go up, visitors can either use the stairs and elevators in the lobby or the external ramp that wraps around the tower.

As the Drone Hub only occupies spaces underground, it can be accessed from its entry mini-tower or from the Vertical Garden's lobby.

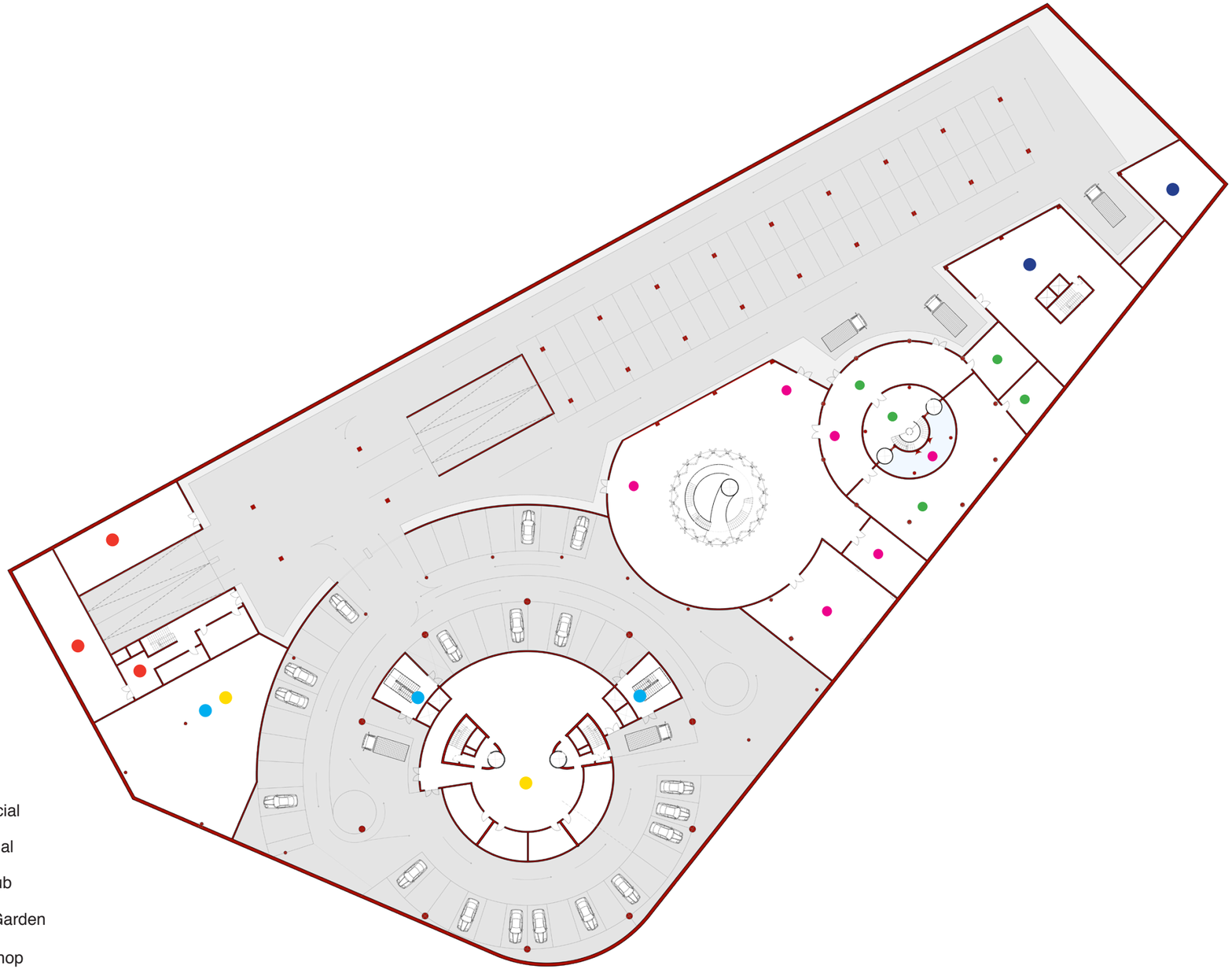
The commercial podium of the Residential Tower occupies the largest portion of the SW half of the site as the tower's main entrance to the lobby is placed on Wilson Blvd.

SITE PLAN

UNDERGROUND - FIRST LEVEL

Underground is the site's secondary level of access where all parking spaces, ground services, and loading zones are placed.

The current parking lot on Fairfax Dr is replaced with underground public parking. The ramp used to access the public parking is also used to access the mix-use complex's private parking and loading zones.



- Commercial
- Residential
- Drone Hub
- Vertical Garden
- Coffee Shop
- Plaza's Core, Storage, and Utilities.

N

0 16' 32' 64'

UNDERGROUND - FIRST LEVEL

THIRD FLOOR

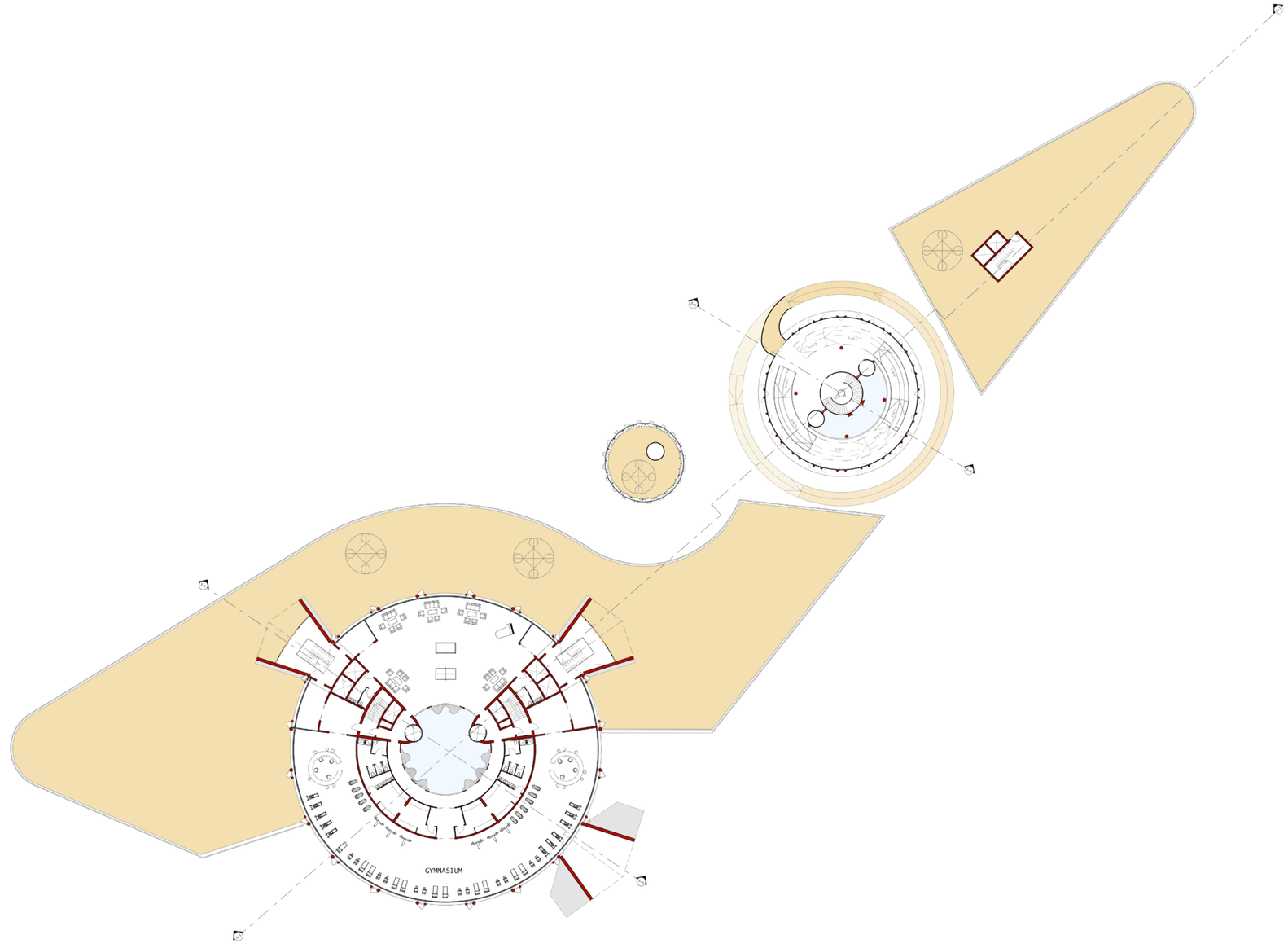
The third floor is utilized as terrace spaces as well as the third and last access level for those approaching the site using commercial freight and transportation services.

Two drone landings are placed on top of the commercial podium of the residential tower. From the terrace, users are provided access to the lounge and gym of the residential tower and both commercial cores.

One drone landing at the west corner of the Coffee Shop's roof top near its core.

One that is used exclusively by the Drone Hub's place on top of its entry/skylight tower.

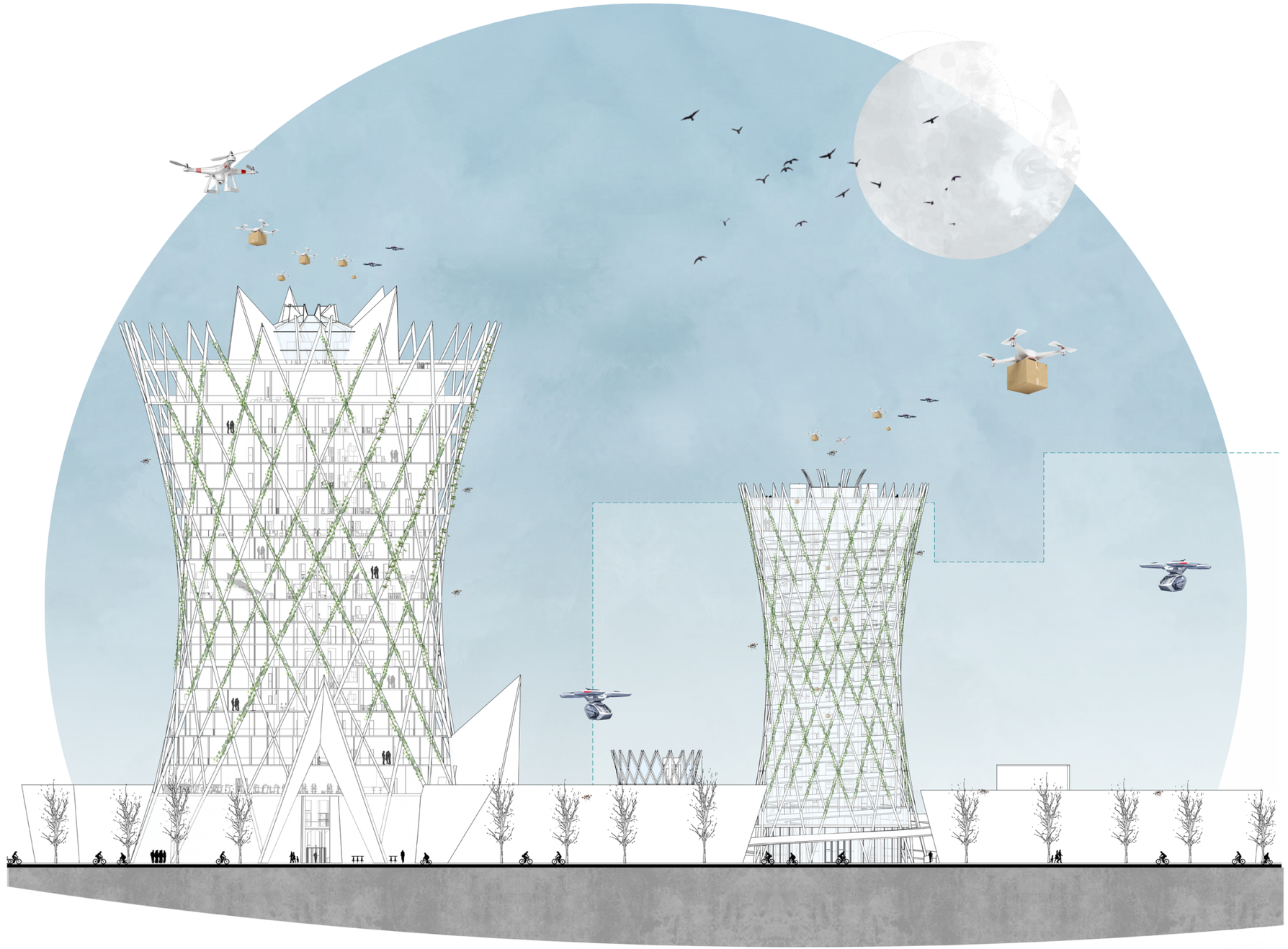
Also on the third level, the Vertical Garden's external ramp ends and the internal ramp begins.



THIRD FLOOR

N

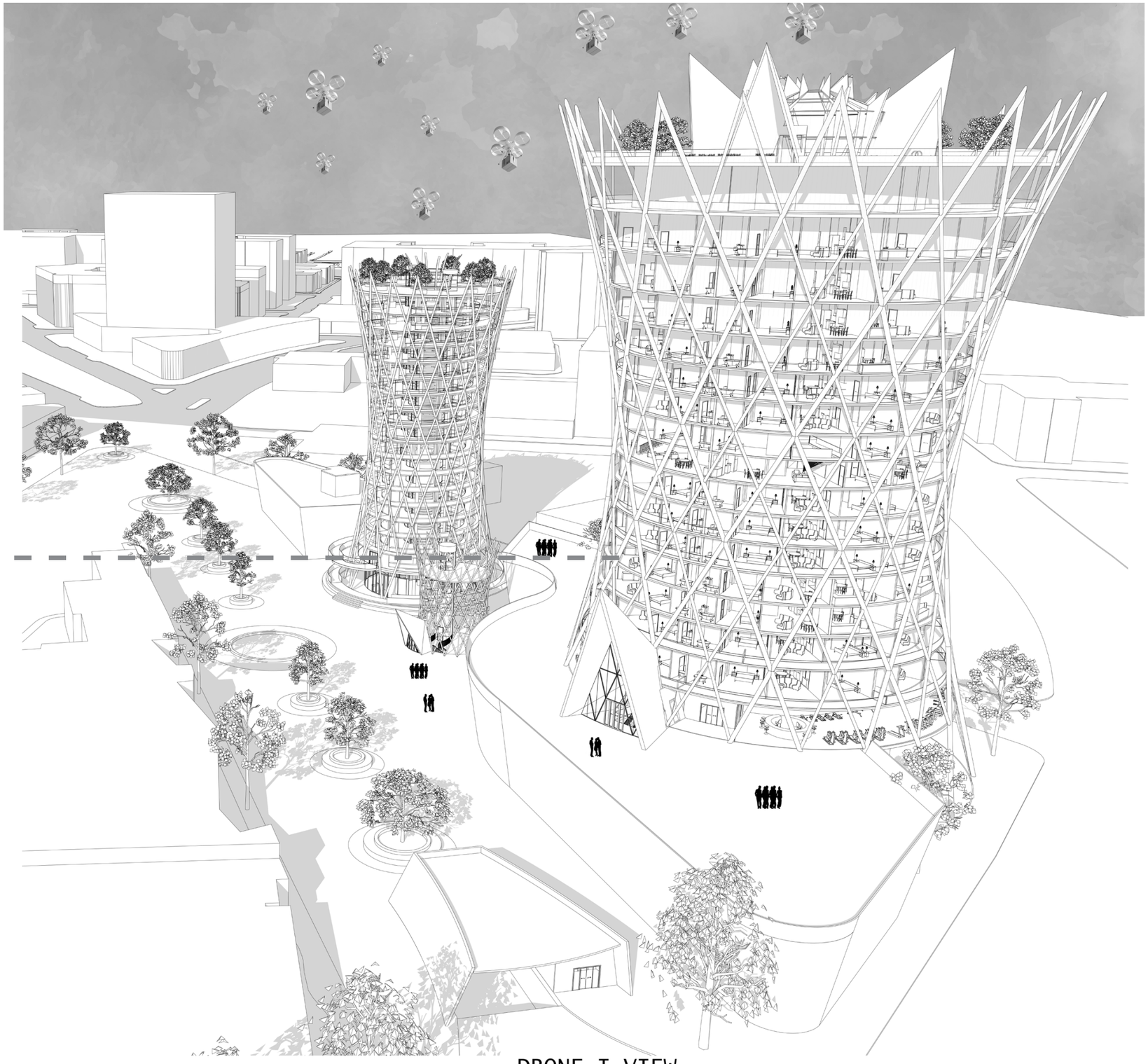
0 16' 32' 64'



SOUTH ELEVATION (C)

0 16' 32' 64'

RESIDENTIAL TOWER DESIGN



DRONE-I VIEW

RESIDENTIAL TOWER
TYPICAL A

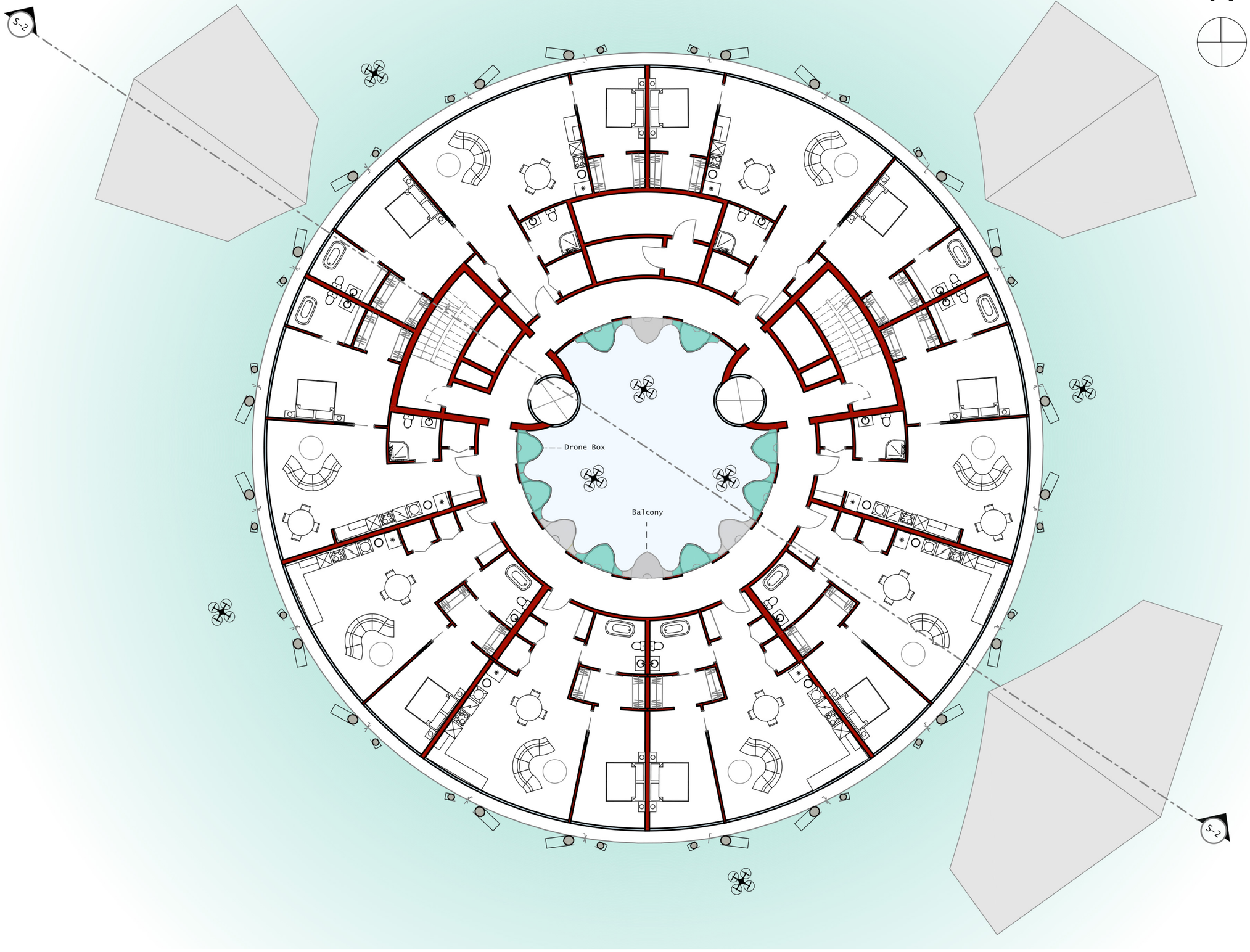
Floors: 6,7,15,16,17, 18

Around the corridor:
8 Apartments
- Two 1bedrooms 2baths
- Four 1bedroom 1bath
- Two 2bedrooms 2baths

1 Mechanical room
1 Data room

On the atrium:
8 Drone Boxes
4 Seated Balconies
2 Round Panoramic Elevators

2 Cores
- 2 Egress Stairs
- 2 Trash shoot
- 2 Elevators



RESIDENTIAL TOWER
TYPICAL B

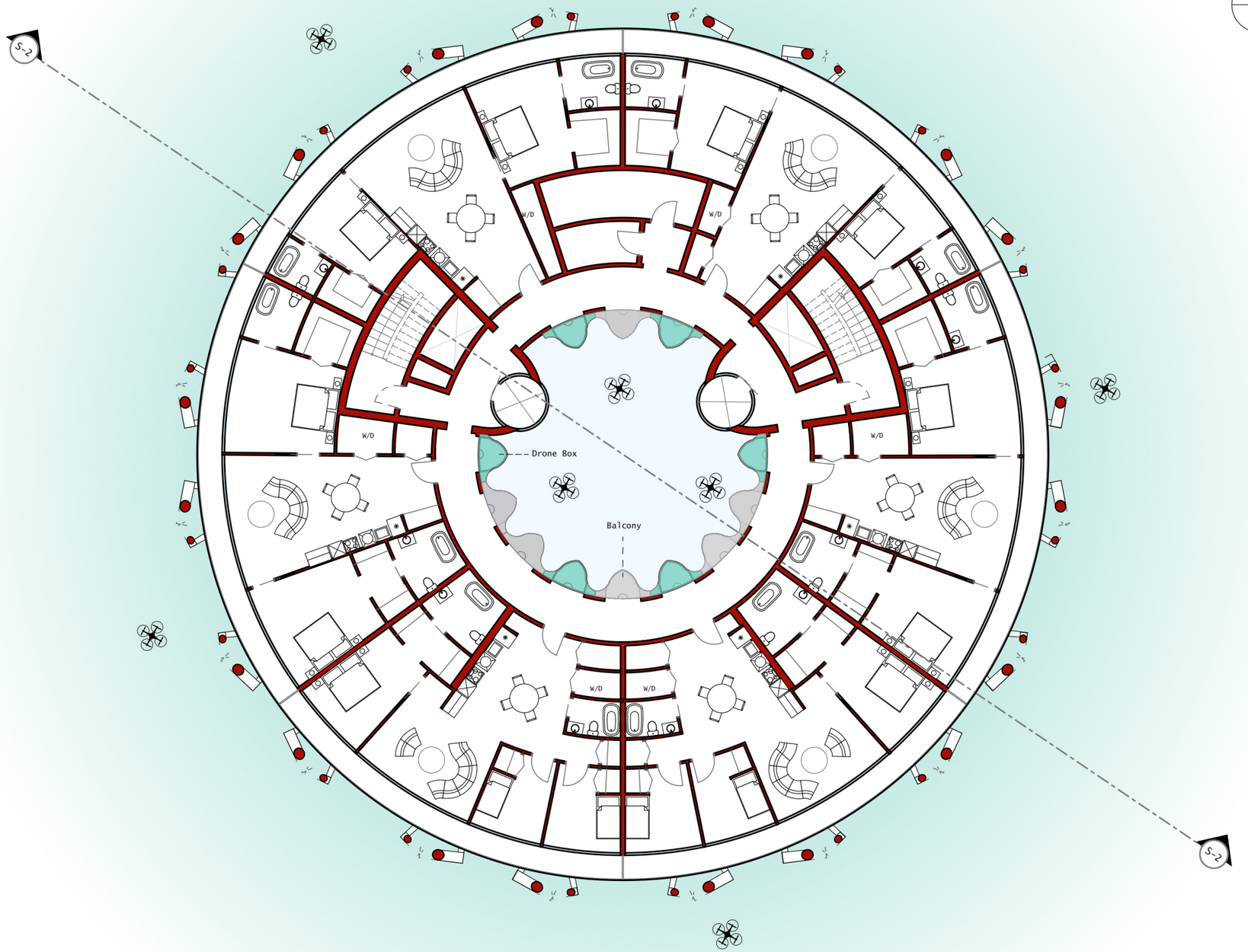
Floors: 4,5,8,910,13, 14

Around the corridor:
6 Apartments
- Two 3bedrooms 2baths
- Four 2bedrooms 2baths

1 Mechanical room
1 Data room

On the atrium:
6 Drone Boxes
6 Seated Balconies
2 Round Panoramic Elevators

2 Cores
- 2 Egress Stairs
- 2 Trash shoot
- 2 Elevators



N

0 8' 16' 32'

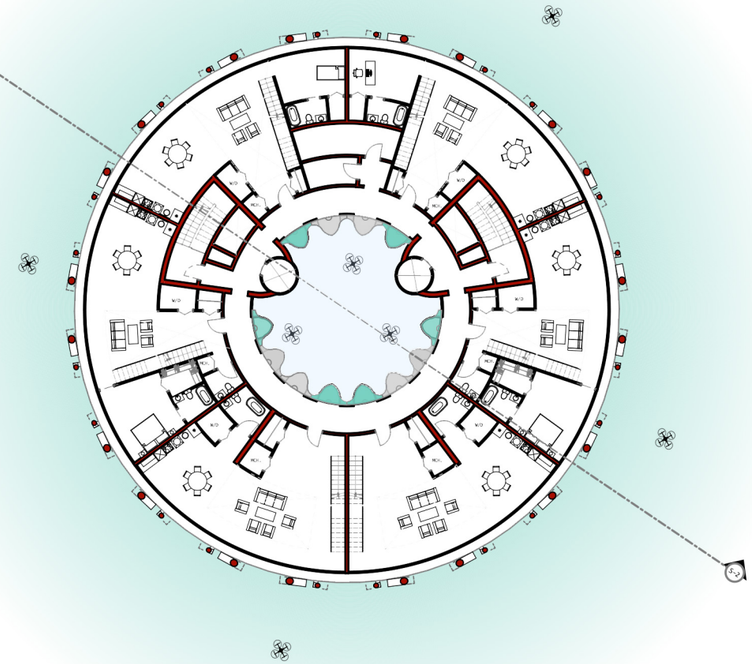
RESIDENTIAL TOWER
DUPLEX

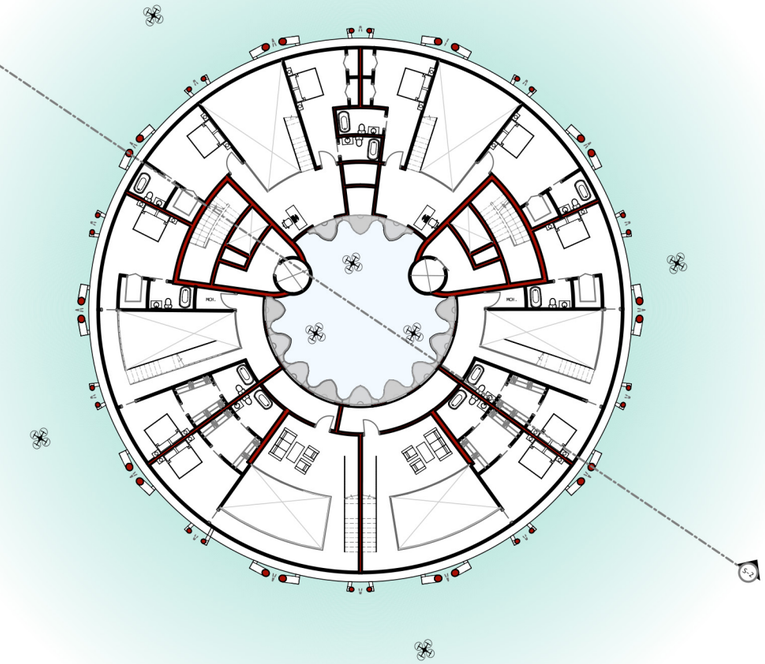
As Diagrid module's size changes the floor to floor height differ. The minimum floor to floor height is 8 feet at the smallest floor radius. This has created an opportunity to diversify residential units and place Duplex apartments to occupy the 11th and 12th floors.

Just like the Typical B, the first level of the duplex has 6 drone boxes and 6 seated balconies. However, the 2nd level has 6 seated balconies and 6 bay windows.

6 Apartments
- 2 1bedrooms 2baths 1loft
- 2 3bedrooms 4baths
- 2 2bedrooms 3baths 1den

1 Mechanical room
1 Data room



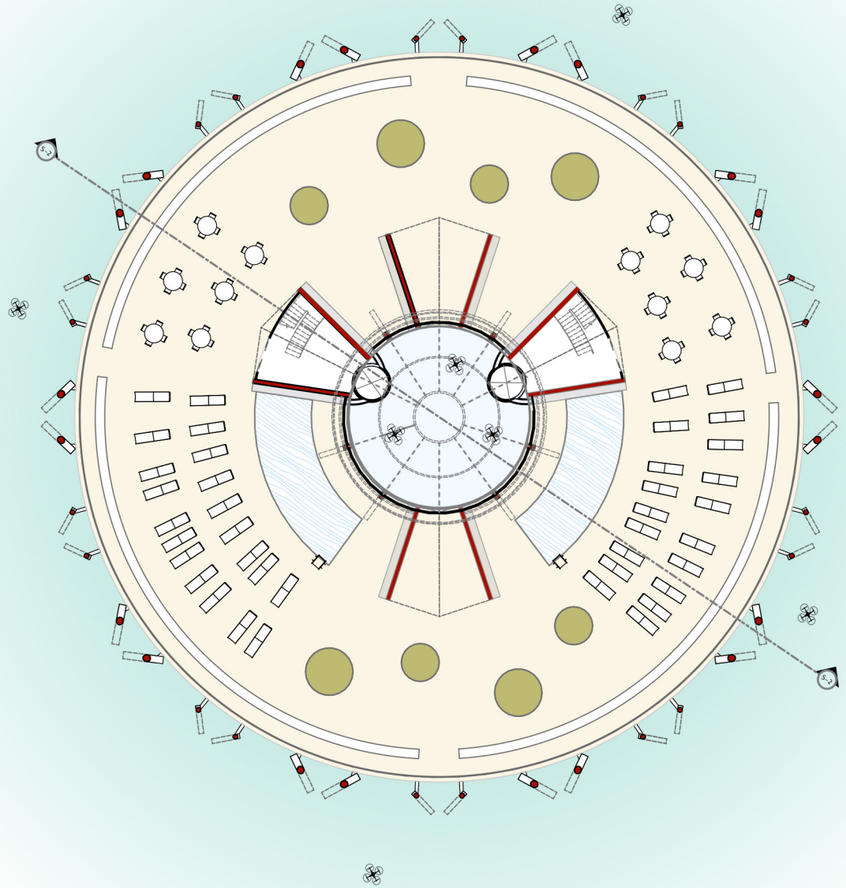


N

0 16' 32' 64'

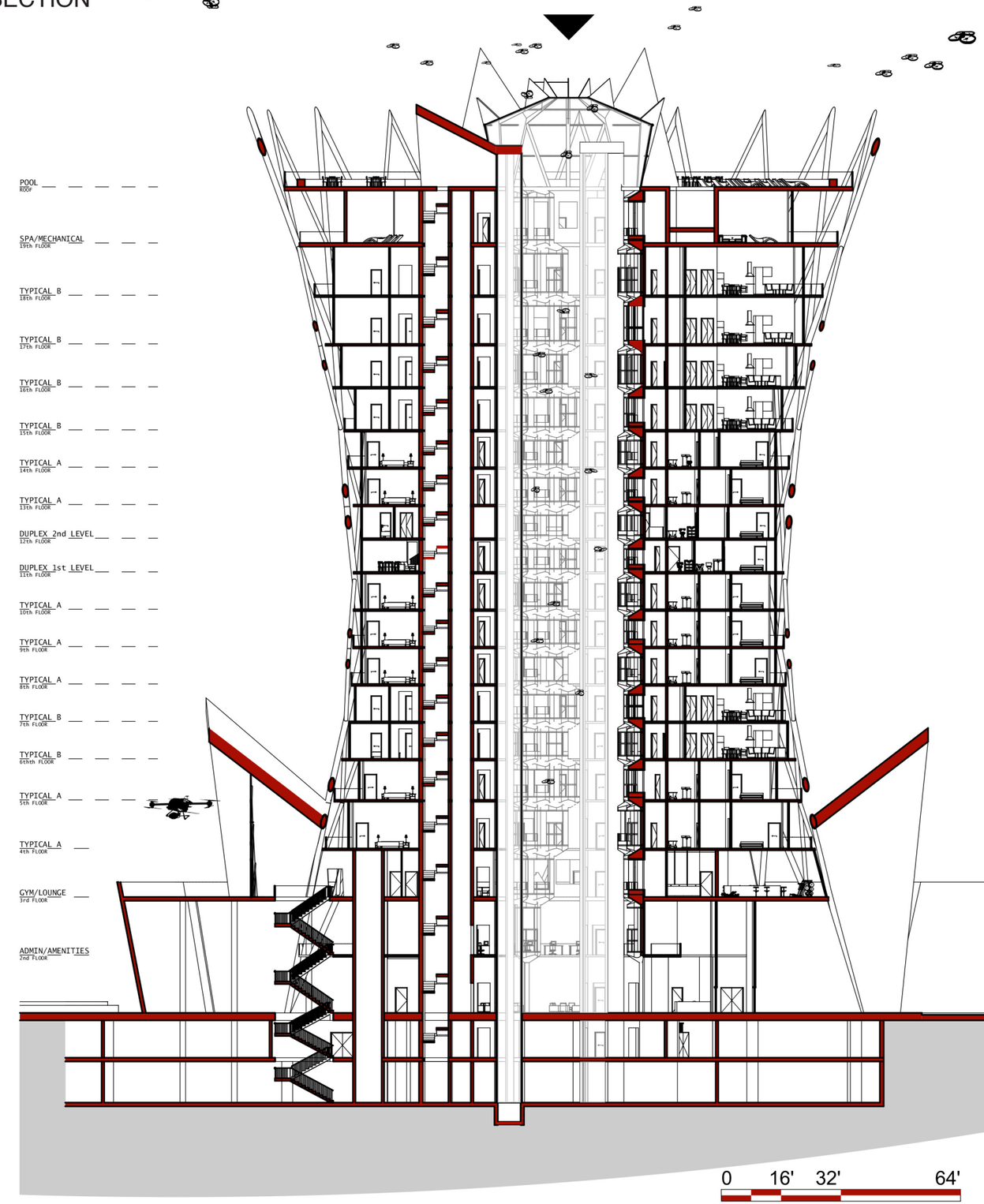
RESIDENTIAL TOWER
ROOF DECK

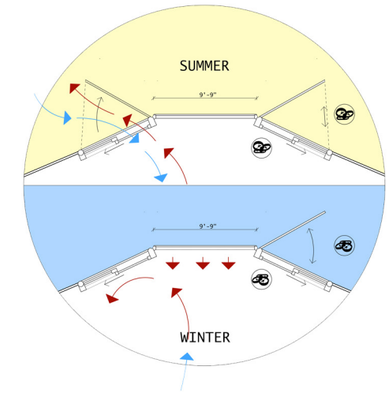
N

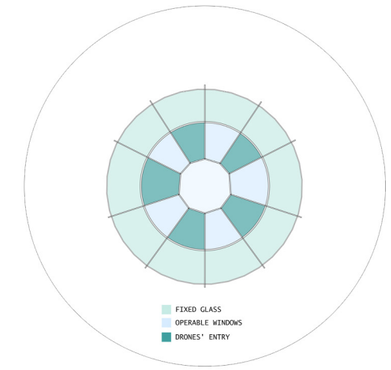


0 16' 32' 64'

RESIDENTIAL TOWER
SECTION





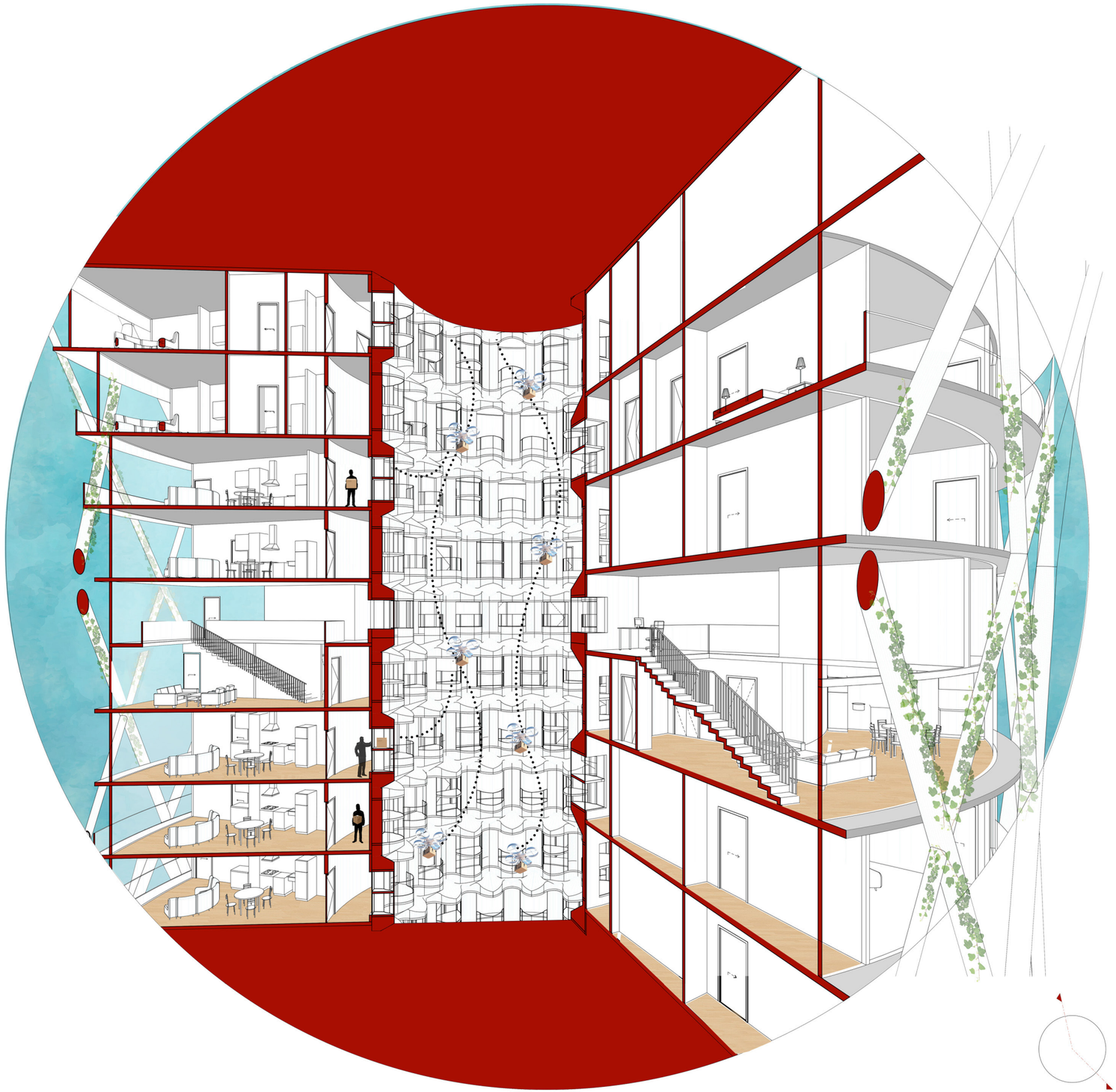


THE ATRIUM

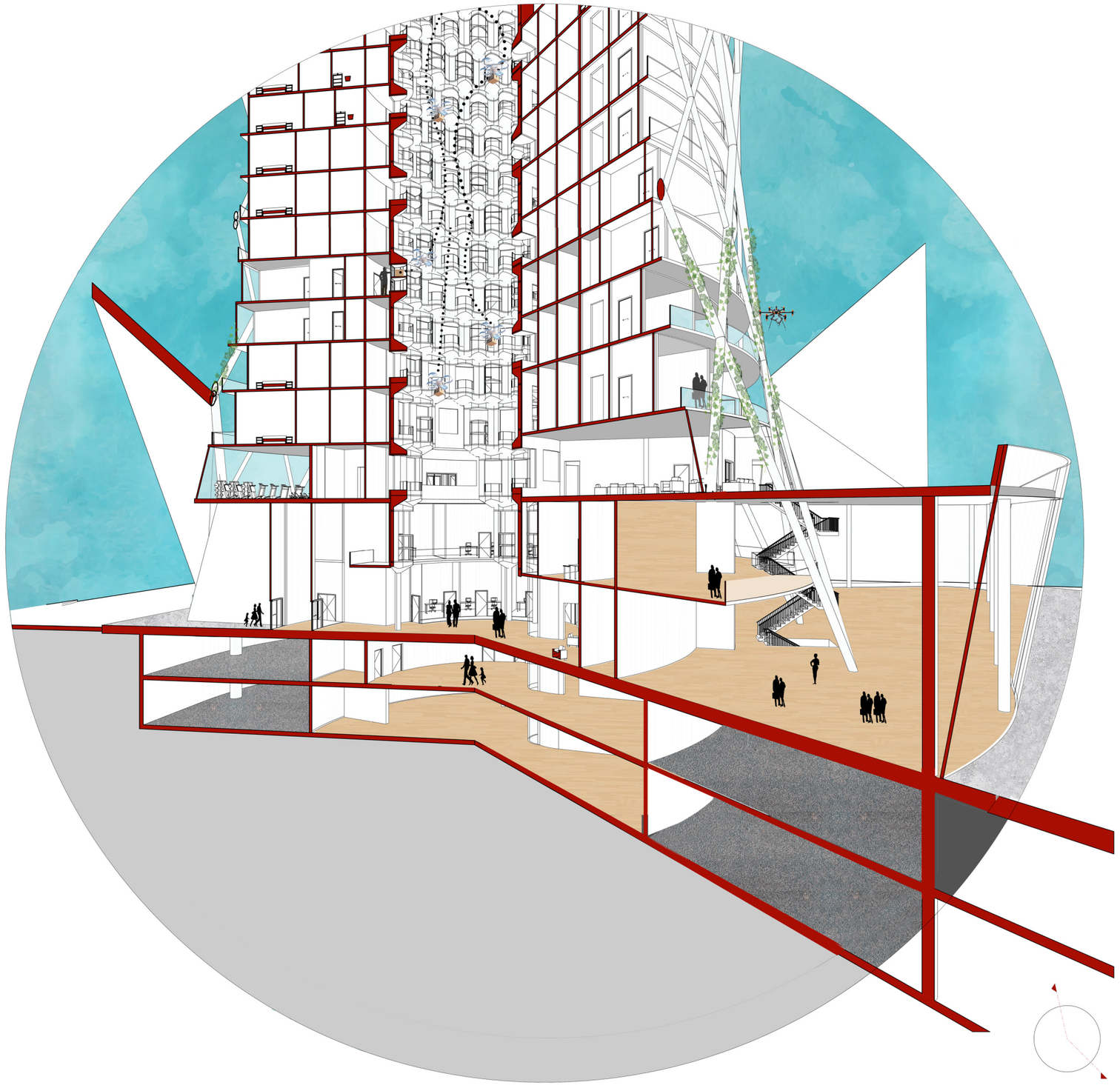
The atrium is the main architectural element internally as everything else wraps around it. It functions as a light well, passive air exchange shaft, a drone shaft, and the host of the panoramic elevators creating a harmony of visible and invisible vertical movements, which users can either participate in from the panoramic elevators or observe from the atrium's balconies' seats.

RESIDENTIAL TOWER
SECTION PERSPECTIVE

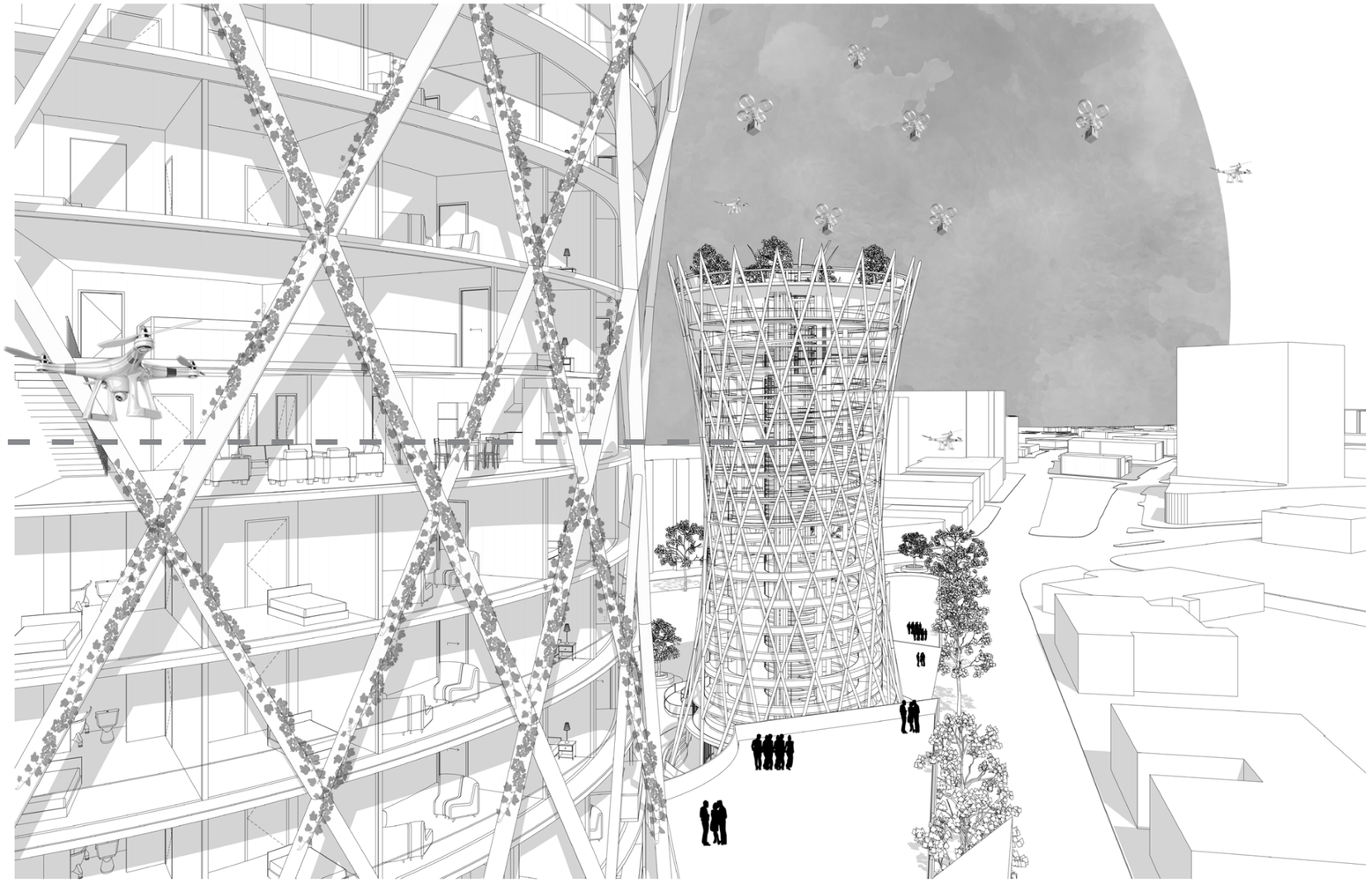
RESIDENTIAL TOWER
SECTION PERSPECTIVE



RESIDENTIAL TOWER
SECTION PERSPECTIVE



VERTICAL GARDEN TOWER DESIGN



VERTICAL GARDEN
TYPICAL AND OBSERVATORY DECK

Each typical floor of the Vertical Garden has a landing, a resting area, a circular smart planting room in the middle, and two panoramic elevators overlooking the drone shaft which occupies the other half of the tower. Each planting room has an environmental control system which can be adjusted to create the optimum environment for the plants all year long.

The observatory deck is the last floor accessible by the ramp. The space in the middle, which lies on top of the planting rooms, is open to the sky and functions as the drones' entry "hall".

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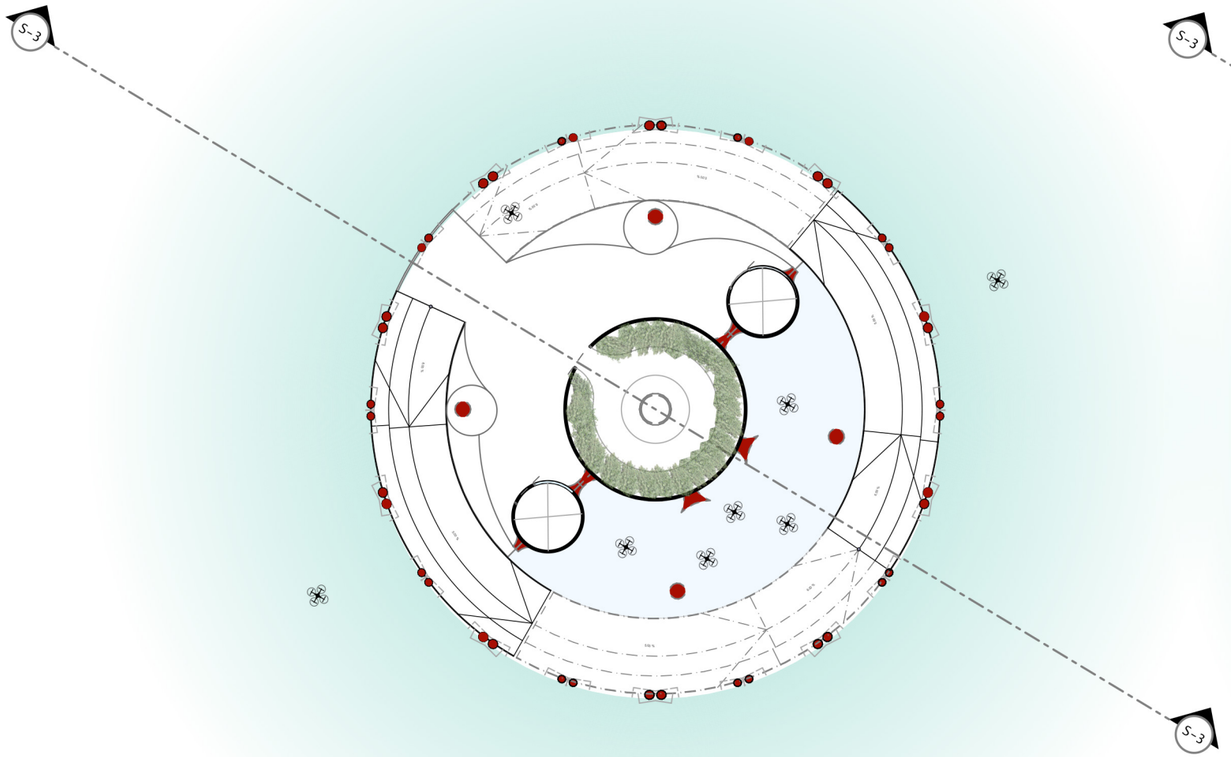

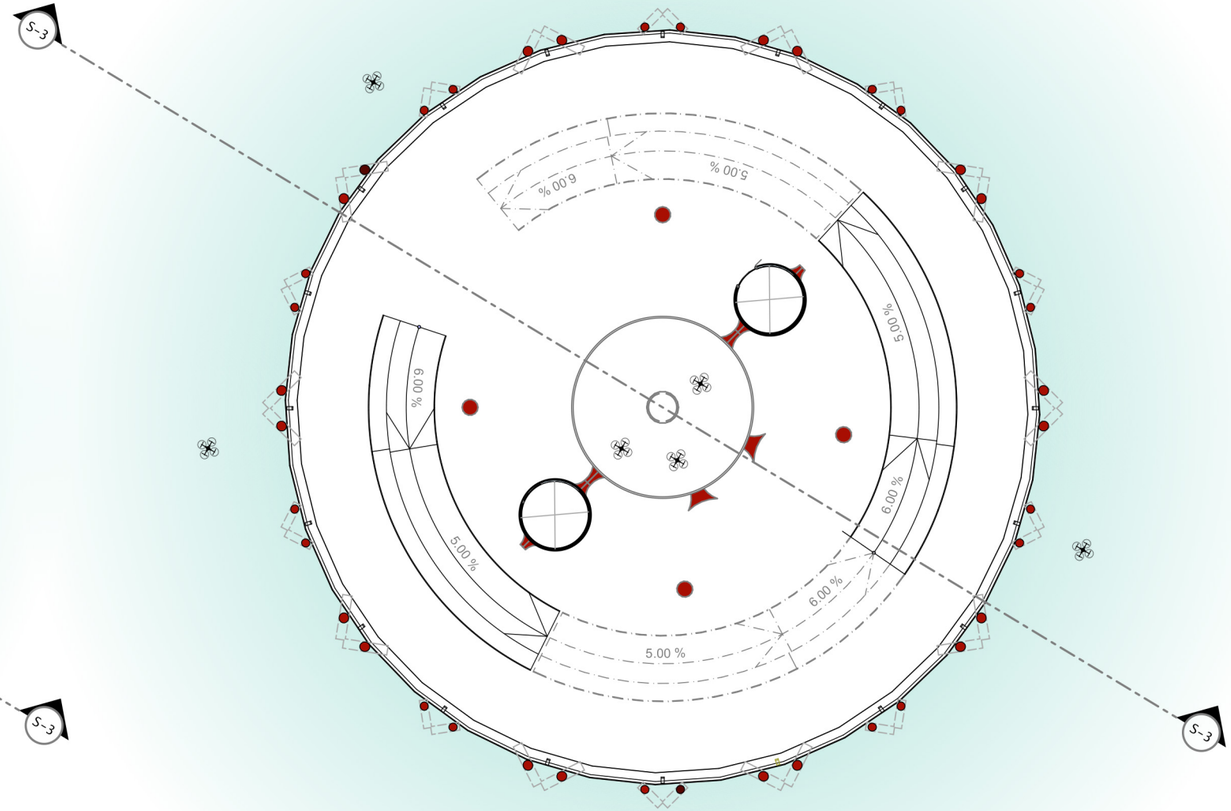

0 8' 16' 32'

VERTICAL GARDEN
ROOF DECK

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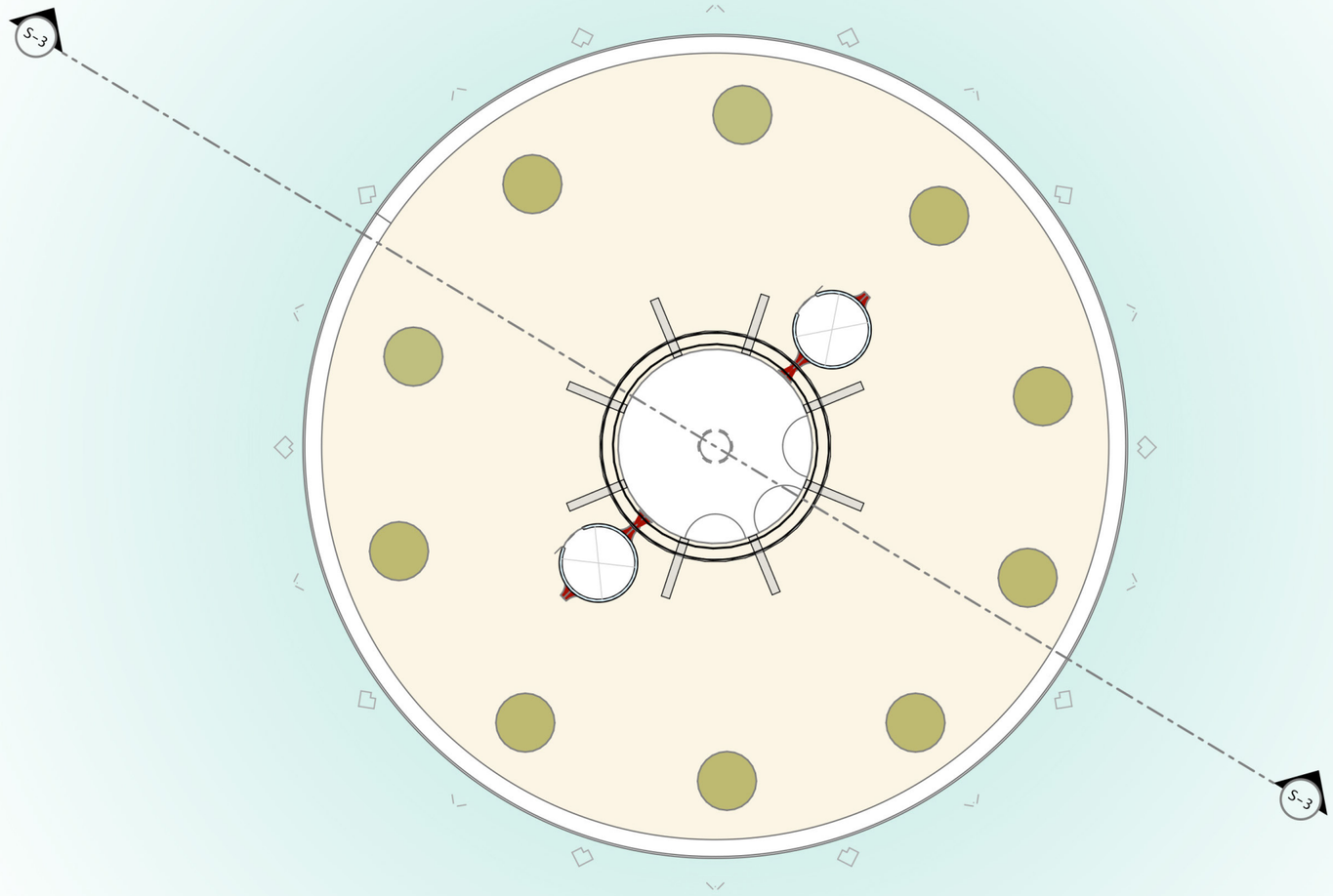
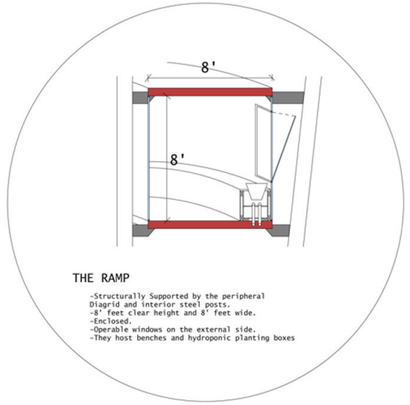
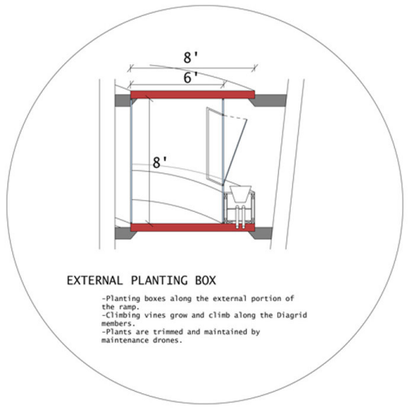


VERTICAL GARDEN
DIAGRAMS AND SECTION



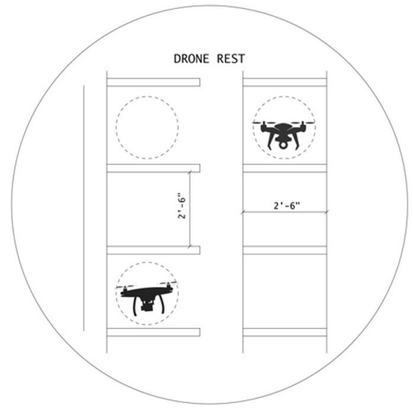
THE RAMP

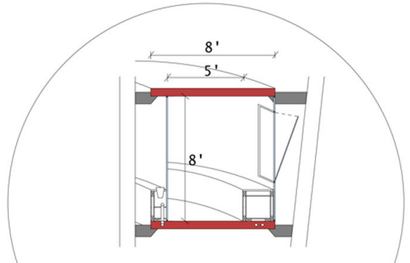
-Structurally Supported by the peripheral Diagrid and interior steel posts.
-8' feet clear height and 8' feet wide.
-Enclosed.
-Operable windows on the external side.
-They host benches and hydroponic planting boxes



EXTERNAL PLANTING BOX

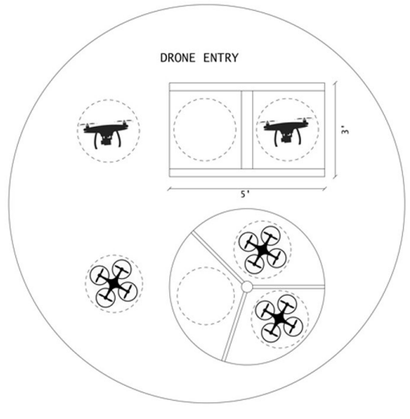
-Planting boxes along the external portion of the ramp.
-Climbing vines grow and climb along the Diagrid members.
-Plants are trimmed and maintained by maintenance drones.

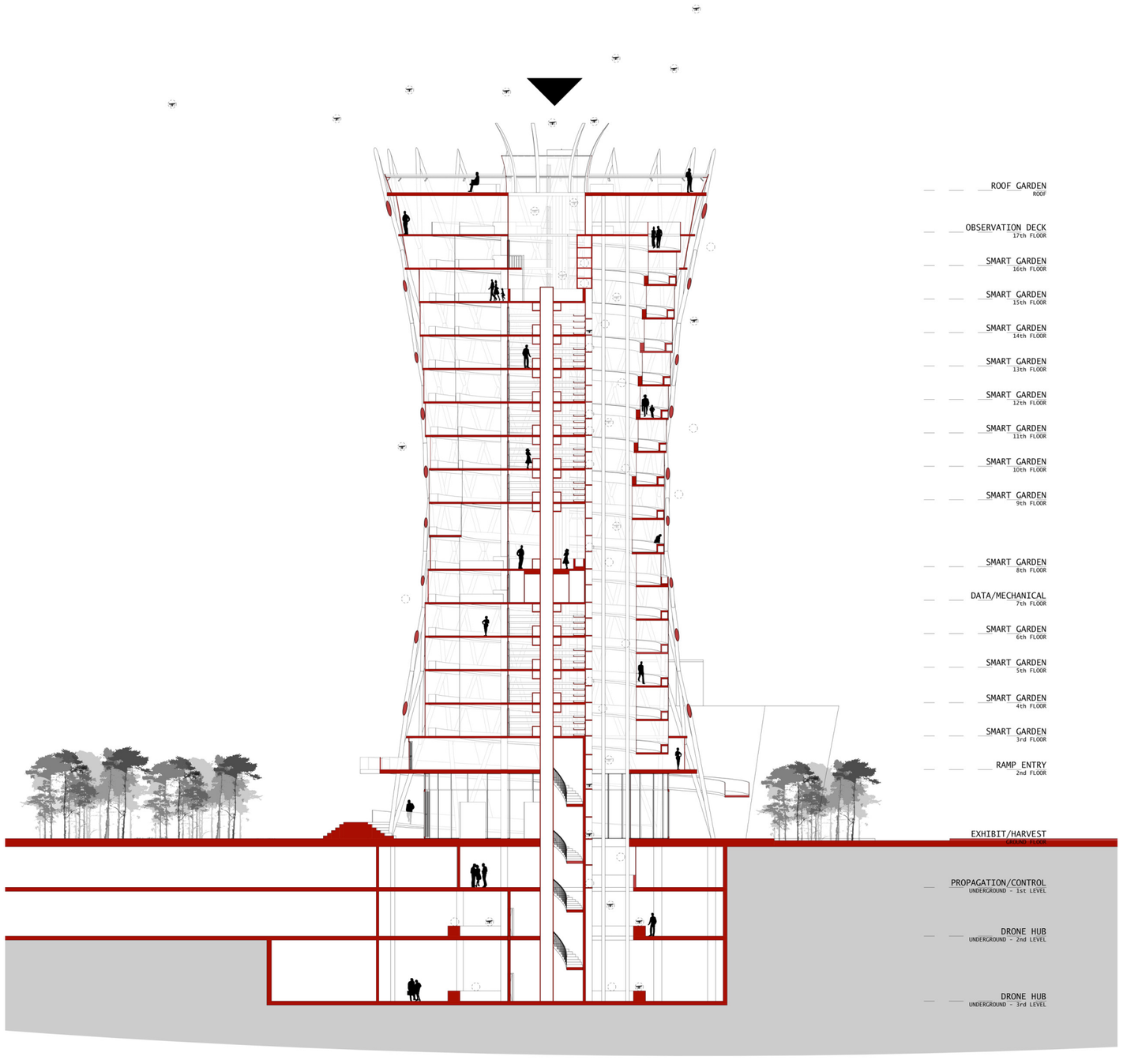




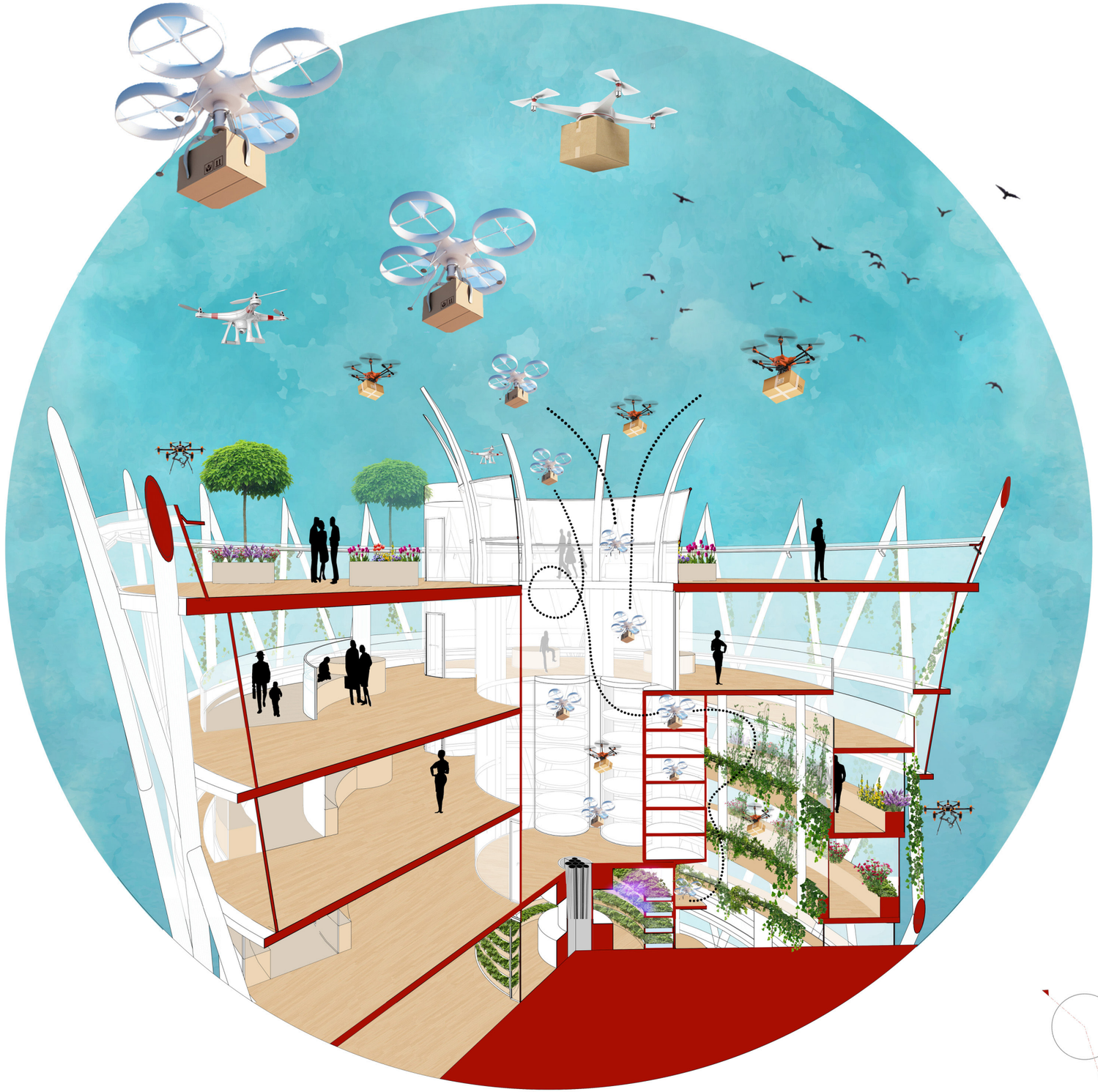
INTERNAL PLANTING BOX

-Planting boxes along the ramp on the drones' well.
-Climbing vines grow and climb along the glass wall of the ramp and supporting posts
-Plants are trimmed and maintained by maintenance drones.





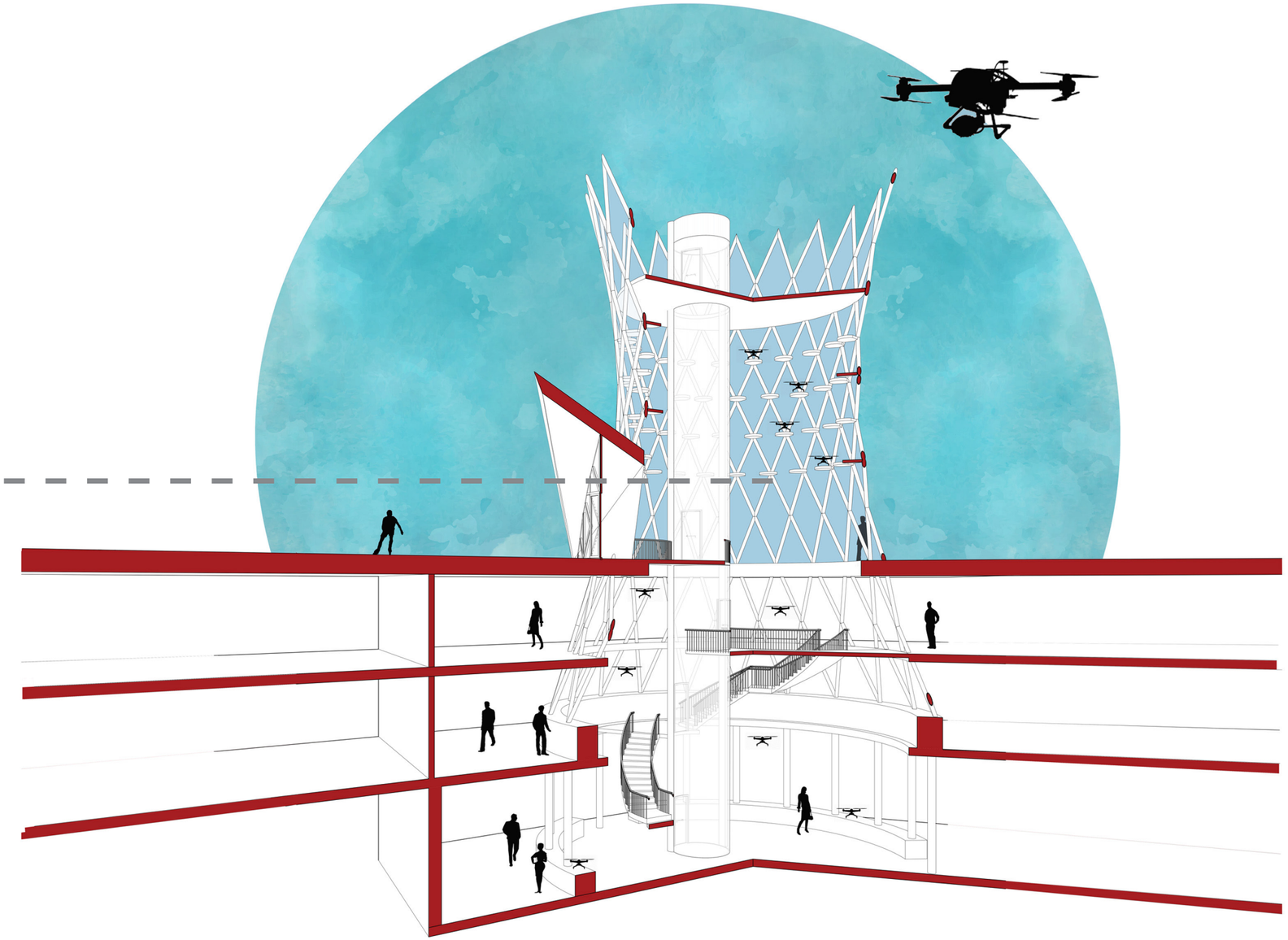
VERTICAL GARDEN
SECTION PERSPECTIVE



VERTICAL GARDEN
SECTION PERSPECTIVE

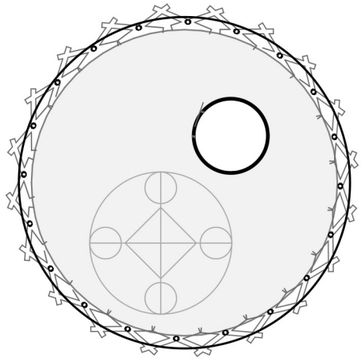
VERTICAL GARDEN
SECTION PERSPECTIVE

DRONE HUB DESIGN

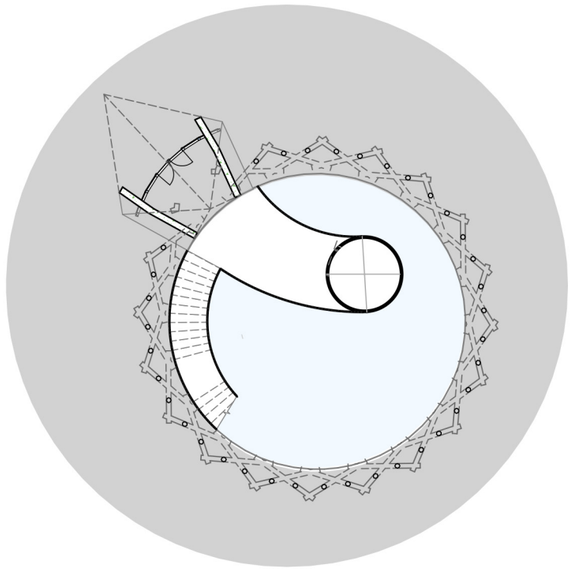


DRONE HUB
PLANS

The Drone Hub in this scenario is a small drone services center. Since it requires large dead spaces for storage, servers, and control rooms, the drone hub was placed underground. While the Hub uses the Vertical Garden Tower to accommodate its drone shaft, a Diagrid skylight tower is erected from the second level below ground to three floors above ground to provide natural lighting to the open working spaces and host the stairs to the ground level entrance, rest/charge pads for drones, and a large drone landing spot 30 feet above ground.

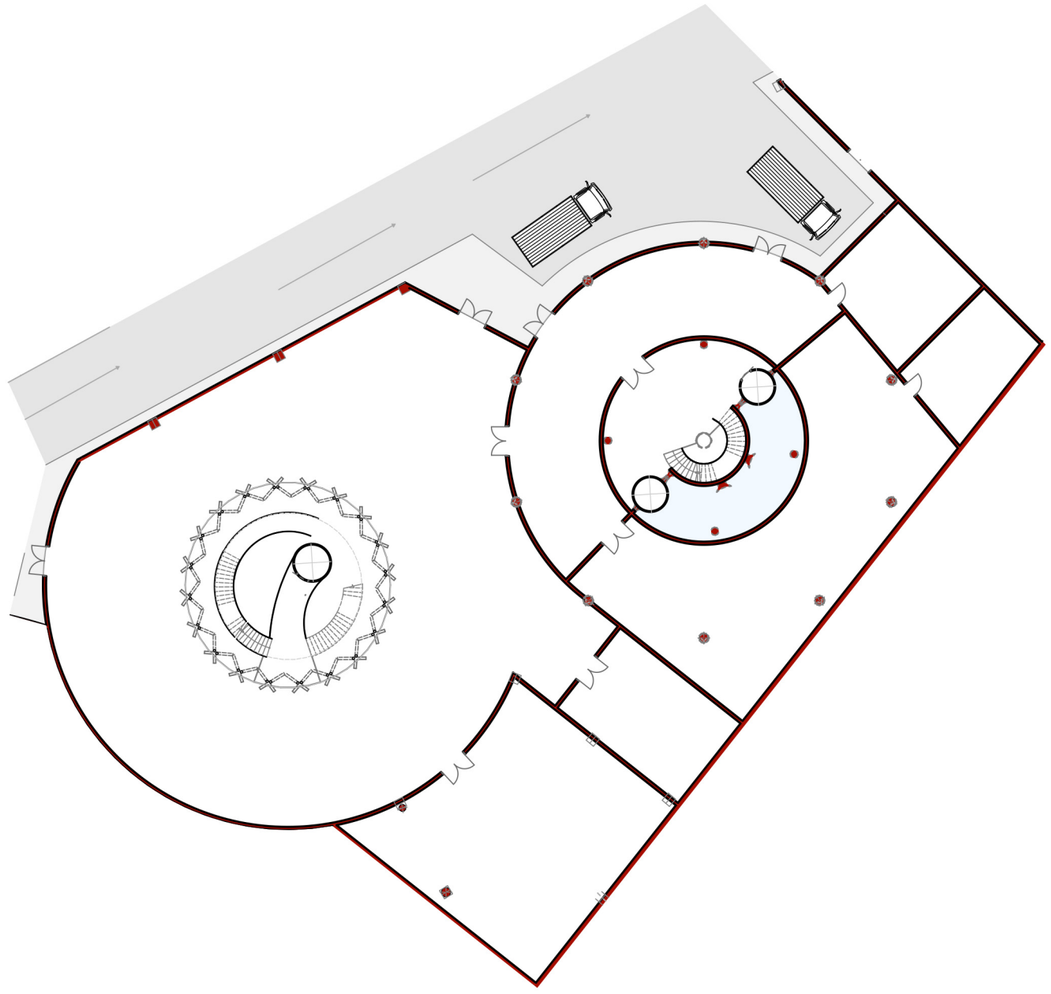


Roof - Drone Landing



1st Floor Entrance

0 8' 16' 32'



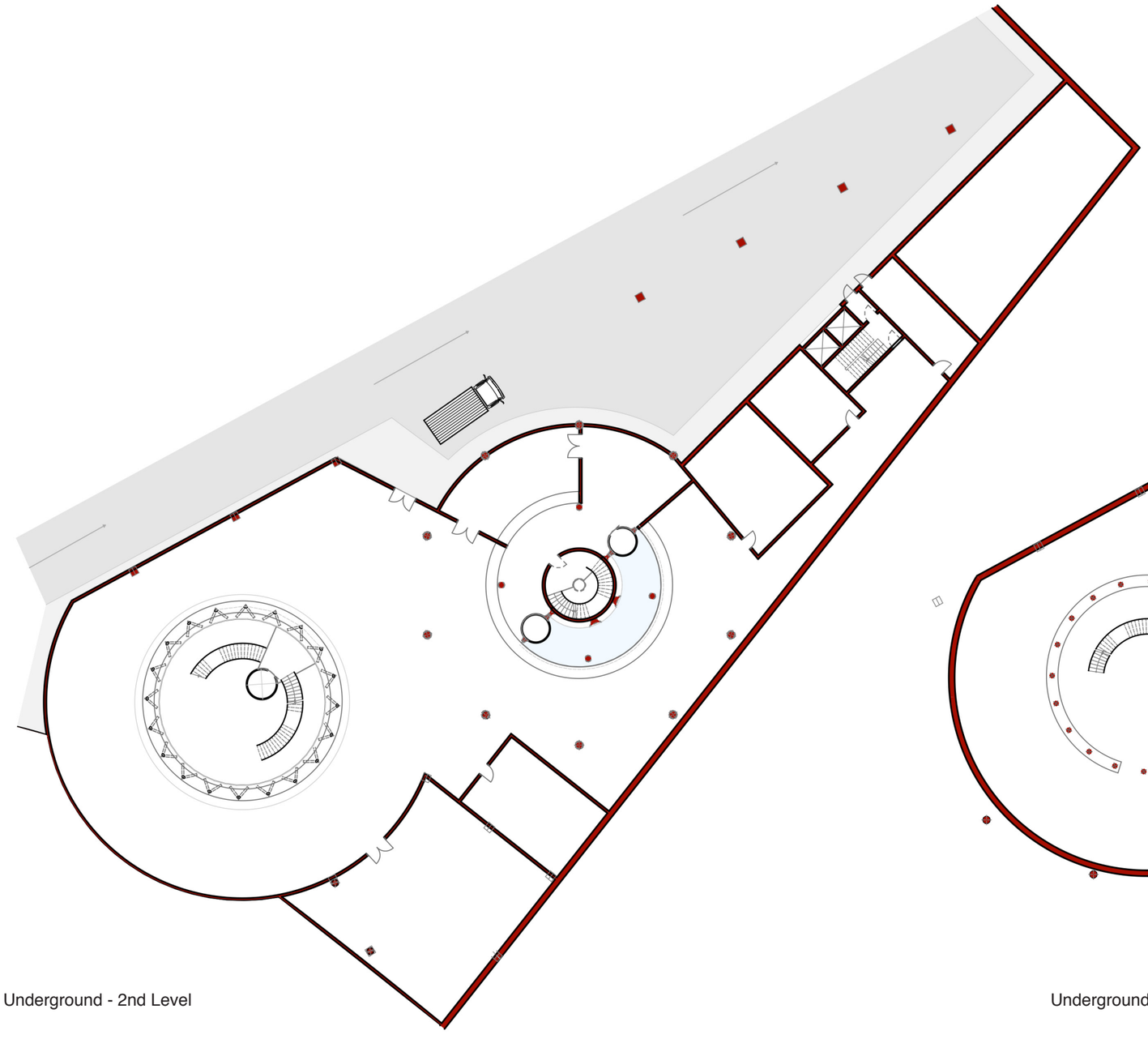
Underground - 1st Level

0 16' 32' 64'

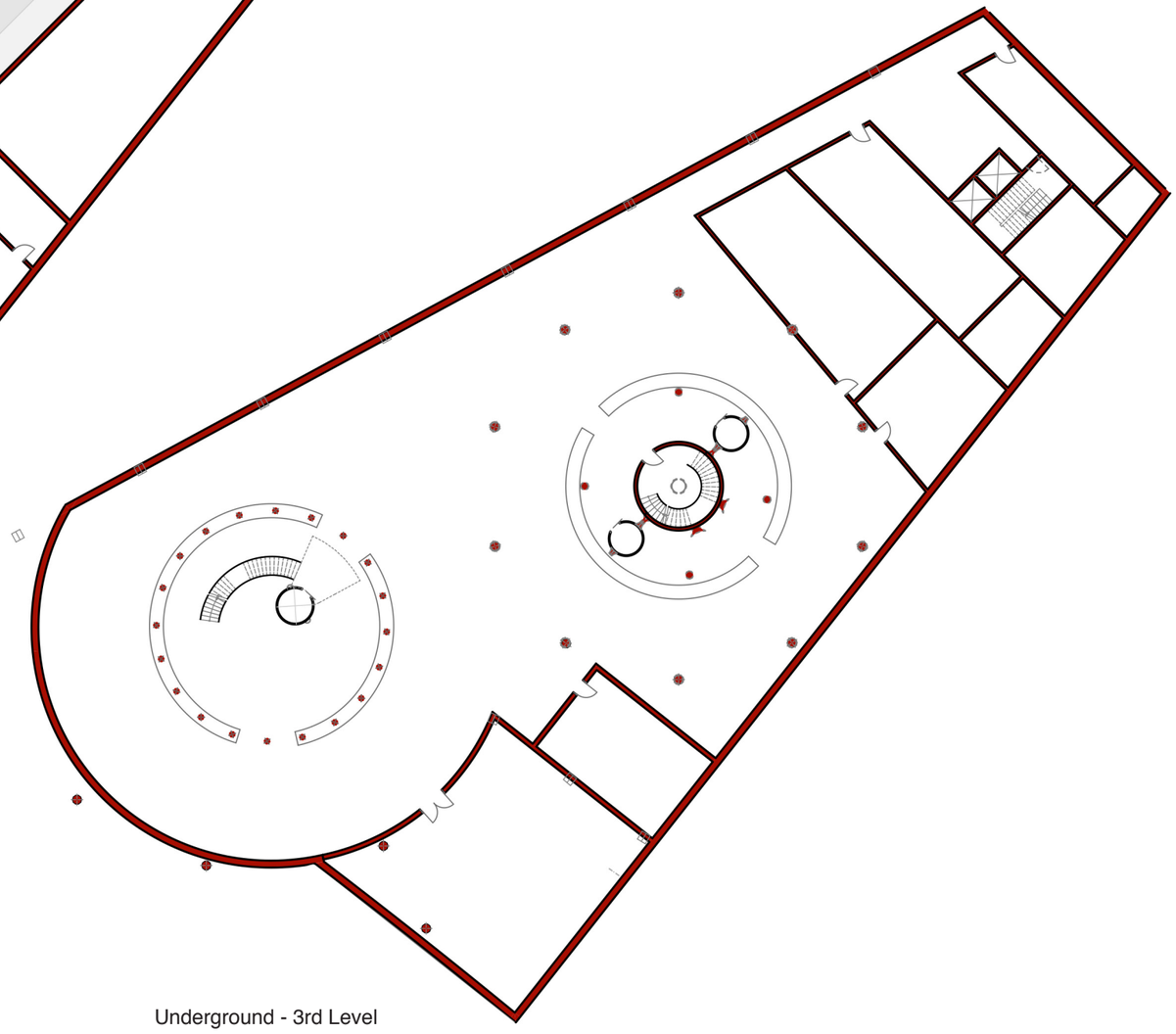
N

DRONE HUB
PLANS

N



Underground - 2nd Level



Underground - 3rd Level

0 16' 32' 64'

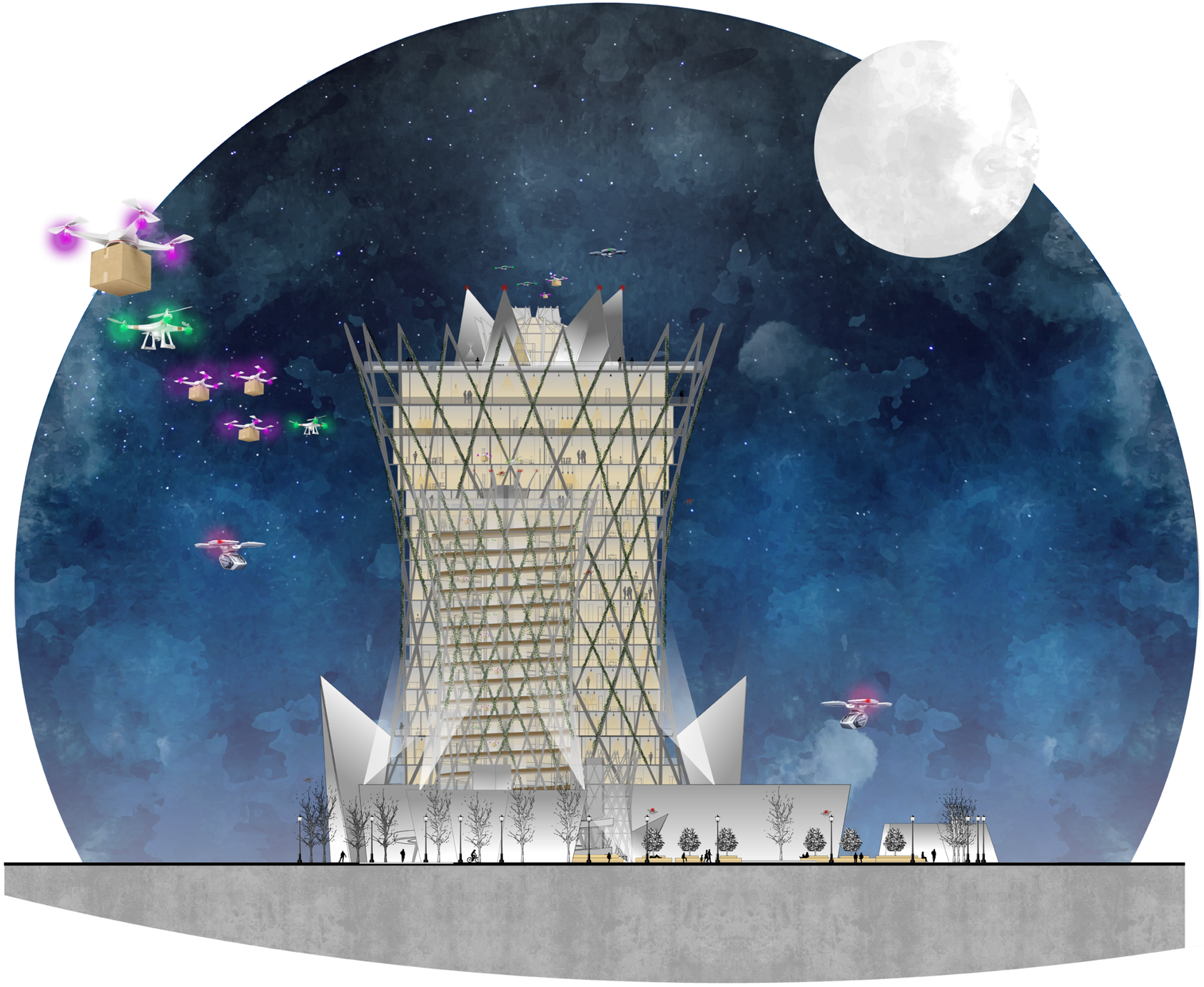
CONCLUSION

The future doesn't happen by itself, it's molded by today's choices, decisions, and actions. Even though we can't fully predict how the future will be, but we can still imagine possible scenarios that could take place based on the decisions that are being made today.

Unmanned Aerial Vehicles today are more than a fantasy or a concept. The conversation is already happening and decisions are being made with minimum consideration to the impacts of such a technology on our built environment and architecture. This thesis intent is to highlight the importance of architecture and urban planning to be included in UAV's future plans, codes, policies, and decision-making process.

This project takes initiative to tackles the overall basic and general issues of UAVs and their system; how to separate fly zones and determine No-Fly zones, how drones interact with the built environment, how can architecture accommodate drone services, what elements are needed to be added to buildings and built environment, and how we can utilize architecture to make drones introduction to our cities more appealing to the public.

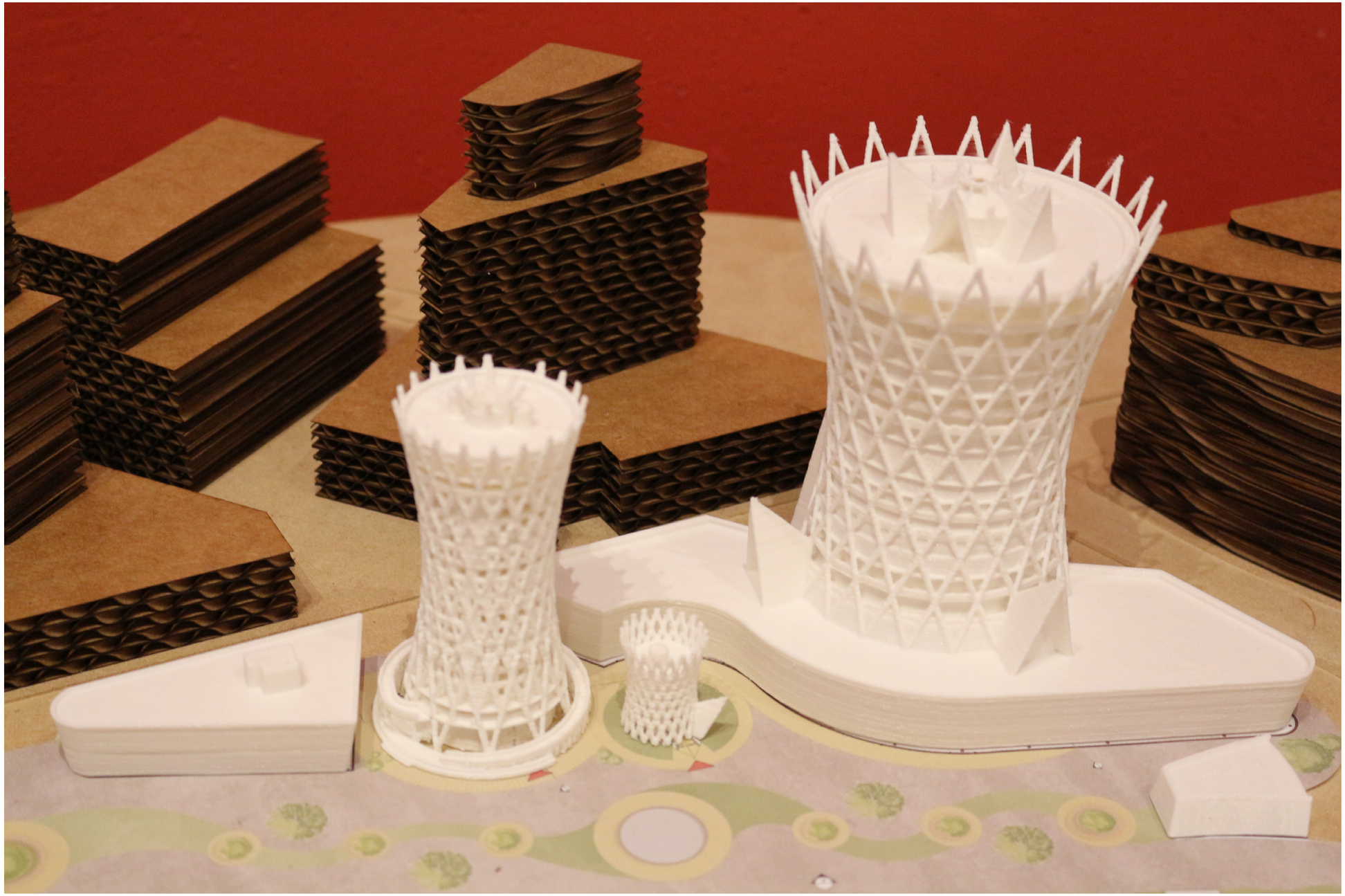
It is our time to get involved. This project's approach is one of many that can be implemented. I encourage researchers, architects, and urban designers and planners to take the challenge and address the matter to provide a decent vision before the technology is implemented.



EAST ELEVATION (B)

0 16' 32' 64'

PHYSICAL MODEL



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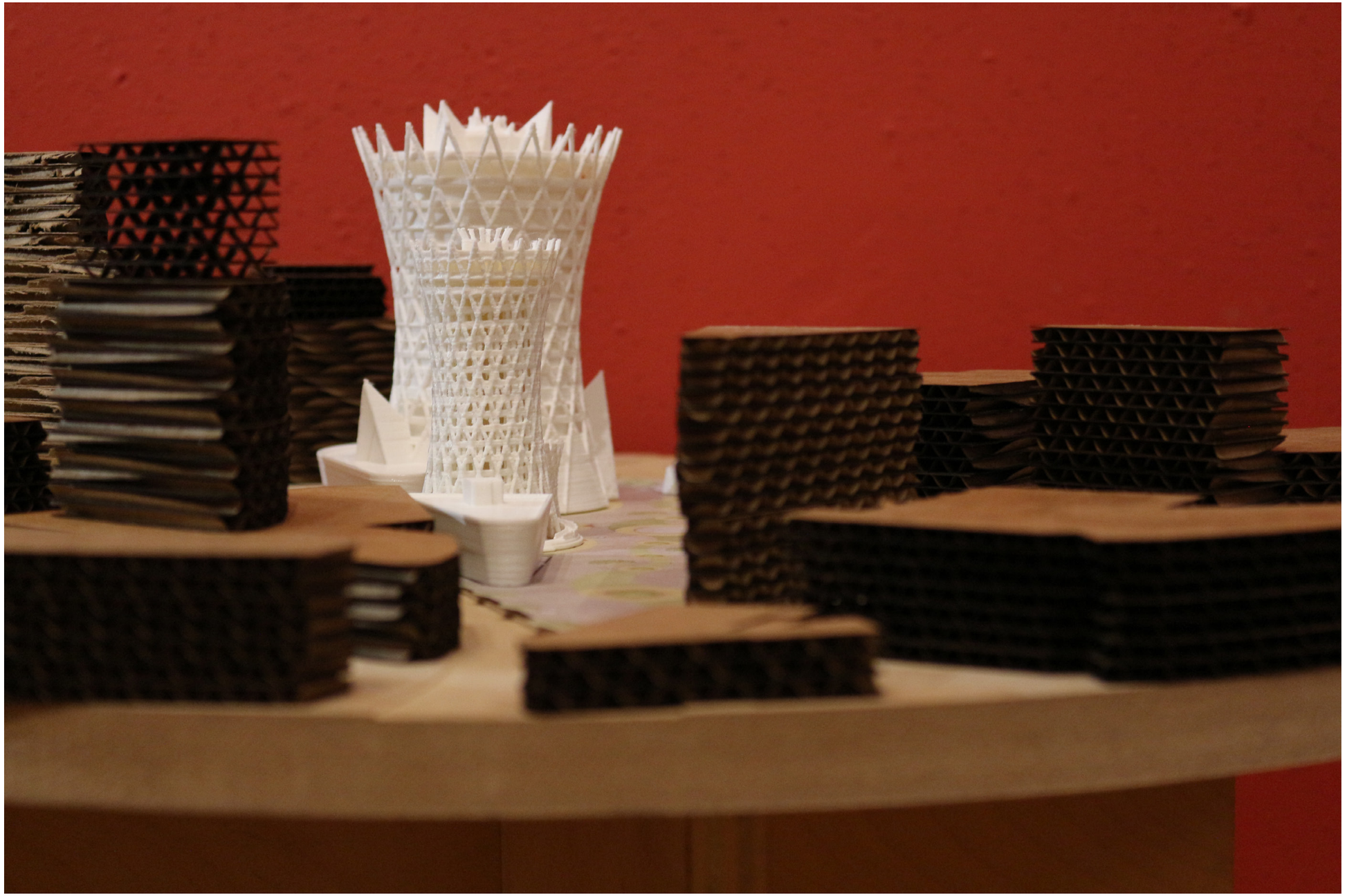

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IMAGE SOURCES

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Page 4: NTU's Traffic Management of Unmanned Aircraft System (TM-UAS) Programme. https://phys.org/news/2015-08-air-traffic-aims-safer-drone.https://phys.org/news/2016-12-traffic-solutions-drones-singapore-airspace.html

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