

# Systems Integration

Mezzacello is an advanced urban farm that marries solid biological, agricultural, and botanical practices with state of the art engineering and robotics principals and technology. This is made possible with the systems integration tech of the sanitation, ecological, telecom, weather, sensor, code, and security systems in place at [Mezzacello](#).



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## **Sanitation Systems**

### **Sinks**

Mezzacello has four sinks and two sanitation wash stations available on campus. Each sink includes 99.5% pure potable water and antibacterial soap and compostable hand towels. There are two additional large sinks for larger items that must be sanitized. There are two boot rinse stations located at the tool shed and the greenhouse (building 2 and building 4).

Hand sanitizer is distributed to each camper and available to campers and visitors are able to use the two sanitizer stations located at the hand sanitization sinks.

### **Mattes**

There are four key areas where sanitation is critical on walking surfaces: The chicken coop, the chicken run, the walkway outside the livestock and tool sheds (building 1 and 2) and the area between the classroom and the greenhouse (building 3 and building 4). These are 4'x6' rubber horse mattes and or concrete pads that are sterile and clean easily.

### **Walkways**

Most walkways at Mezzacello are grass but there are a few exceptions in the agricultural section to the west of Mezzacello. These include grass and lattice hybrids and gravel walkways that can be rinsed and provide stable footing and surface pressure for moving 1 metric ton of Compost from one

location to another.

There is an additional walkway option; a portable 10'x20' vinyl tarp that can be deployed on demand to control water, mud and toxins. The vinyl can be swept and rinsed and is a great solution in this instance. Because it is made of PVC, it also doubles as a whiteboard.

## **Ecosystems**

There are six ecosystems (all entirely integrated) at Mezzacello. The systems component of each of these ecosystems is critical and will be covered here. When discussing any ecosystem there are three things one must consider: The existing resources and life there, what it can take in and what it can export out.

This distinction is critical in an enclosed sustainable ecosystem like Mezzacello. If there are more resources and energy required to go into a system than will come out of it, it is not an ecosystem but a closed loop system. There are quasi-ecosystems in this list, such as the pond, livestock, and potager gardens, but they contribute heavily to other ecosystems and are this important.

See the [General Map of Ecosystems](#) or [The rule of 3 to 5](#) to learn more.

### **1. Formal Gardens, Lawns, and Allee**

- This is the largest ecosystem at Mezzacello.
- It comprised all trees, bushes, flowers, grass, and their by-products as well as the life that exists there, such as birds, reptiles, insects, and various pollinators.
- It is designed to mimic a forest floor and this does not require water or fertilizer generally.
- It contains various species of plants, animals, insects, micro-organisms and fungi as well as mammals.

- It also contains zoned areas that create a support different conditions that are beneficial to various forms of life at Mezzacello.
- It is a very managed and curated ecosystem, but it fits the definition.
- The formal garden ecosystem dominates the gardens at Mezzacello comprising ~2/3 of the land use.
- IMPORTS:
  - Its main imports are seeds, compost, and managed trimming and some watering in extreme drought, CO<sub>2</sub>, pollutants.
- EXPORTS:
  - Its main exports are leaves, green and brown, grass clippings, flowers, twigs and branches for creating potash, pollinators, water, shelter for birds, reptiles, small, mammals, and beauty, shade, privacy, and respite from heat and noise for the humans of Mezzacello, fresh air and oxygen..

## **2. Parterre Gardens**

- This is the first hybrid ecosystem at Mezzacello.
- It qualifies as an ecosystem because it contains a specific set of life and conditions than elsewhere.
- It is also modeled after a forest floor.
- It has the addition of a boxwood hedge that create microclimates that allow specific plants , insects, microfungi, and animals to coexist there.
- IMPORTS
  - Compost, water, seeds, cages and supports, CO<sub>2</sub>
- EXPORTS
  - Food, herbs, fertilizer, compost biomass, pollinators, reptiles, shade, shelter, moisture, medicinal ingredients, oxygen, fresh air, beauty, structure

## **3. Pond**

- This is a quasi-ecosystem and is quite unique at Mezzacello. It has the heaviest reliance on imports to export ratio.
- The benefits of this “artificial ecosystem” are too numerous to discount it from this list.
- If this were left as a “natural” ecosystem it would quickly become toxic as it is the only ecosystem that has no natural inputs and outputs.
- Left untreated, it would become a cesspool within a season.
- But without its repository of water and nutrients, other ecosystems would collapse.
- It has a series of microclimates, resources, and levels of life that are critical and inter-dependent on the unique aquatic environment.
- That distinction makes the pond the “Batman” of the ecosystem heroes;
  - It is not super-powered but it brings a lot to the fight.
- IMPORTS
  - Power, pumps, filters, algaecide, feed, water, capital resources, fish, manual effort.
- EXPORTS
  - Algae, ammonia, year-round access to fresh water, food, pollinators, oxygen, comfort, and beauty.

#### **4. Potager Gardens**

- This is a quasi-ecosystem and is quite unique at Mezzacello. Again, the ratio of imports to exports is very high, but the benefits outweigh the detractions.
- This qualifies as an ecosystem again because it has unique assets that other ecosystems and living populations around Mezzacello rely upon.
- It also has unique conditions and resources that unique populations of life require and thrive

upon.

- It also has a series of microclimates and levels of life that are critical and inter-dependent on the unique environment.
- IMPORTS
  - Seeds, compost, water, effort, maintenance, manure, select minerals, pest control, support structures, harvesting, CO<sub>2</sub>, sunlight.
- EXPORTS
  - Food, compost biomass, animal feed, robust environment for insects, pollinators, microorganism, Mycorrhizal Fungi, animals, oxygen, fresh air.

## **5. Livestock facilities**

- This ecosystem is quite unique at Mezzacello.
- It is an almost entirely artificial environment that contains and secures living things.
- Consider it as the stomach and digester ecosystem.
- The main populations is small and enclosed, but it does have special climates and conditions.
- It does support various levels of life and inter-dependent roles.
- It does have a valuable purpose at the urban farm, and other systems would collapse or become unsustainable if it did not exist.
- IMPORTS
  - Power, shelter, maintenance, feed, water, animals, microorganisms, medicines, additives, straw, and infrastructure.
- EXPORTS
  - Manure, ammonia, nitrogen, fixed nitrogen, food (meat, eggs, insects), compost biomass, water (rain barrel), more animals, pest control, soil turners, microorganism, and mycorrhizal populations, home for excess food scraps that can't easily be composted.

## 6. Compost and Abatoir

- This is a unique and complete ecosystem.
- This is the end of life/regenerative ecosystem at Mezzacello.
- It has its own climate, inputs, outputs and life systems.
- There are animals, insects, microorganisms that exist ONLY in this ecosystem.
- This system is also a closed loop for animals in the larger ecosystem that produces waste products that can be recycled or sold/traded as well.
- While it does exist in a convenient closed-loop environment, it would exist naturally even if it did not.
- All Other Ecosystems At Mezzacello Depend on this ecosystem. **All of them.**
- IMPORTS
  - Biomass, water (occasionally), ammonia, ethanol, sugars, effort, maintenance.
- EXPORTS
  - Compost, fertilizer, carbon, nitrogen, amendments, heat, insects, pollinators, birds, small mammals, feathers, meat, manure, iron and carbon supplements, soil nutrients (bone meal, bloodmeal)

## Automation

The automation at Mezzacello is still relatively benign but improves with each passing season. Currently there are three automated systems in effect at Mezzacello. These include doors, outdoor lighting, and the bioreactor system.

### Doors

The chicken coop door located on the northwest face of the livestock shed (building 1) is automated to open and close automatically. This system uses a powered Arduino array that



can be programmed using press keys and a door obstruction sensor.

- PROS and CONS

- The pros of this system are that it is automatic and reliable.
- The cons are that when the system loses power, the program is invalidated, and the sensor does not anticipate the stubbornness of ducks who will often REFUSE to come in when it gets dark.

## **Outdoor Lights**

The lights around Mezzacello are all solar powered automatic motion-sensor activated lights. They come on when they sense activity. Additionally they are capable of being connected to the wifi system to activate various cameras on demand.

The outdoor lights of Mezzacello are on the north face of the Livestock shed (building 1), the north face of the tool shed (building 2) and the interior of the tool shed, the south face of the classroom (building 3), the back porch of the house, the attached greenhouse of the house and the abattoir in the service yard on the east face of the garage. And additional light is located on the west side of the garage over the garage door.

## **Bioreactor**





## Bioreactor tower

The bioreactor tower is a self contained system that collects and distributes water to its 1000L water tower and also makes compost in its lower 1000L IBC by adding accelerant to the compost slurry based on sensors and timers built into the

system.

## Telecommunications

There are two systems available for conveying data and communication around Mezzacello. These two systems are telegraphs, computer stations for data entry, and walkie-talkies.

- **Telegraphs**

- The telegraphs are tied to the wifi of the farm and located at three different ecosystem stations around the campus. These locations are in the allee, in the potager gardens, and in the livestock shed (building 1). They send Morse Code (Morse Code Kiosks are in place for reference) to efficiently transmit data to a central control station. [See Maps and Plans](#).

- **Computer Workstations**

- The central pergola patio between the two parterres is also empowered and equipped with wifi to house three computer workstations and centralized mobile workstation for three operators. These computers consist of a Raspberry Pi computer and a 24" display with an integrated keyboard and a mouse.
- This workstation must be assembled and disassembled each time they are used. It is stored in the classroom, and deployed on its casters to the pergola. There may be a lockable tarp available to keep the system in place during the week. Stay tuned.

- **Walkie Talkies**

- The walkie talkies are capable of 10 channel communication and there are four complete (two unit) kits that are housed in the classroom and are rechargeable. The central communications officer determines the frequency each team will

use for the day. Teachers and adults will have an independent network of walkie talkies that are off network.

## Computers

There are multiple computer systems available at Mezzacello. They consist of three types: Servers, raspberry Pi, and Arduino Units. Each of these systems have unique operating and performance windows and require complex overlapping of other resources at Mezzacello, including power, wifi, and accessories.

- Servers

- There are two servers at Mezzacello. One is a web server, the other is a systems server for coordinating sensors, security feed, and readings from computers and various electrical systems, and power generation facilities.

- Raspberry Pi

- These are the mobile workhorse computers at Mezzacello.
- They are portable and cheap, easy to deploy and use.
- In general they are used in conjunction with the mobile computer labs.
- The raspberry pi is a self-enclosed computer and keyboard, requires an HDMI monitor and a mouse.
- All other functions exist as either embedded software or on the cloud in AirTable.
- No local data is stored locally on these devices.

- Arduino

- Arduino chipsets are used throughout Mezzacello as part of sensor packet arrays and as relays for systems to share and trigger automated actions.
- All Arduino chips are in semi-or water-proof cases, and some bundle modules contain multiple sensor arrays.

- Many of the robotic units also contain Arduino chips and all communicate on the 4G Wifi Network or in certain instances over bluetooth.

## Wifi

There is an extensive and independent set of wifi options available at Mezzacello and they include traditional 4G and newer 5G frequencies. In addition there are portable units and repeaters for both as well as a radio tower antenna and communications relay on the bioreactor tower.

- 4G WiFi

- This is the resident wifi for Mezzacello. It is for general use and not intended for use other than for research or data monitoring on specific sensors. It is more robust and easy to pair to than 5G.
- The 4G LTE WiFi signal is stronger and more reliable than 5G. The router also has the added benefit of being able to broadcast to a much larger number of devices with little signal degradation. But it is a privately paid service.

- 5G WiFi

- This is a next-gen portable 5G modem. It has a strong antenna (especially when wired into the telecommunications relay). It can transfer data at high rates of speed.
- It's two main drawbacks are that it does not get good coverage in downtown Columbus as there are not a lot of 5G antennas yet, and buildings block the line of sight there is to those towers. And it cannot connect to multiple devices simultaneously so the signal degrades rapidly the more devices try to connect with it. This is a very real limitation.

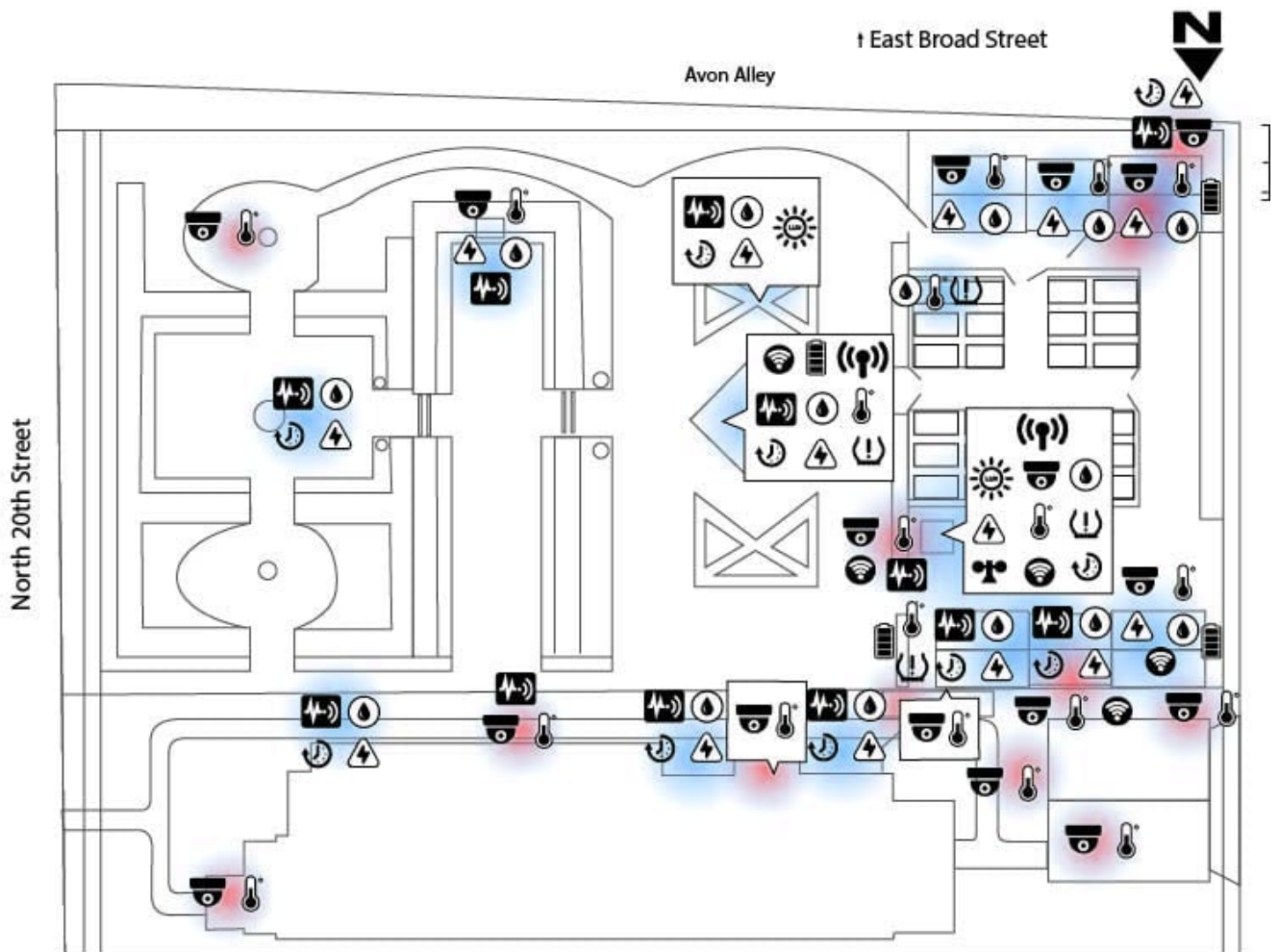
- Repeaters

- There are two repeater systems that are capable of

toggling between 4G and 5G signals.

- The first is located within the attached greenhouse at the back of the house.
- The second is attached to the side of the house at the roofline. This provides excellent line of sight and spread of the WiFi signal across Mezzacello.
- Telecommunications Relays
  - The telecommunications relay located atop the bioreactor tower is capable of amplifying signals that are in its frequency range. This includes FM radio and Bluetooth frequencies. This array works with most of the communications devices at Mezzacello.
  - This is a passive and not a powered antenna. It's primary purpose is to passively amplify and help relay sensor data and communications channels around Mezzacello. It is still in beta testing as to its effectiveness.

## **Sensor Schematics**



This map is for demonstration only. The very large area of sensors in the back are the Bioreactor tower.



Lux Sensor



Voltage Sensor



Wind Sensor



Motion Sensor



Video Sensor



Temperature Sensor



Pressure Sensor



Battery Levels



Humidity/Moisture Sensor



WiFi Sensor



Automated Timer



Telecom Antenna

There are 10 unique sensor configurations in use at Mezzacello and 3 of the 10 are cloud configurable. These sensors include light, video, moisture, voltage, temperature, pressure, wind, wifi, and programmability. The sensors are array all around the campus.

These sensor locations are approximations and do not account for the mobile units (Ground robots and drones) that are also in use periodically. Nor does this schematic include sensors deployed by the solar power and wind turbine systems at Mezzacello.

## **Data and Graphs**

data collection Pages

## **Stores and Resources**