Multidisciplinary Senior Design
Project Readiness Package
Due July 1st

Project Title:	Vertical Farming Pilot
Project Number: (assigned by MSD)	P18xxx *(P/ending year/project #, e.g. P15001 finishes in 2015 and is project number 001)*
Primary Customer: (provide name, phone number, and email)	*Bob Bechtold (?), Wegmans (?)*
Sponsor(s): (provide name, phone number, email, and amount of support)	*Bob Bechtold*
Preferred Start Term:	Fall 2017
Faculty Champion: (provide name and email)	*Sarah Brownell*
Other Support:	As applicable
Project Guide: (assigned by MSD)	

Gabriel Kramer 6/7/2017
Prepared By Date

Received By Date

Items marked with a * are required, and items marked with a † are preferred if available, but we can work with the proposer on these.

Project Information

* Overview:

The third "green revolution" is upon us as the amount of required agricultural land to provide for the world's ever-increasing population surpasses what is feasibly available. Dickson Despommier championed the idea of farming vertically at the start of the millennium, using the same approach we have taken towards human compactness with high-reaching buildings. Given that the concept has been around for little over a decade, transitions from conventional farming to this highly efficient model are apparent. Infiltration from disease and micro-pests can be mitigated using the proper techniques, water use can be cut by up to 90% compared to traditional methods, and the facility can be advantageous towards carbon sequestration. The next step is figuring out how to optimize a setup to reach these goals.

This project will investigate the optimal balance between a variety of variables including water and nutrient provisions, light, crop type, and breathing environment. We will work with faculty members to run tests in labs and record our data for future use by any parties that wish to access it. Beyond this, food and health information in the city of Rochester will be investigated and the cost-benefit analysis on top of the life-cycle assessment of implementing a vertical farm in the city will be reviewed.

Before long, the resources to continue to provide for the accelerating population will dwindle, and we will have to turn to techniques to mitigate our impact on the planet. Basic provisions such as food and water will be valued highly, and their use should be maximized to its fullest potential. This is the reasoning behind investigating this sort of technology; to push the limits of what we know we can do to provide food. Places such as *country1 and country2* are already seeing the effects of food insecurity. Other issues such as dwindling medicinals are causing an influx of counterfeit medications, notably towards the cure for malaria. Giving our agricultural land a chance to replenish its soils will allow for greater plant growth, resulting in a massive conversion of CO_2 in our atmosphere into O_2.

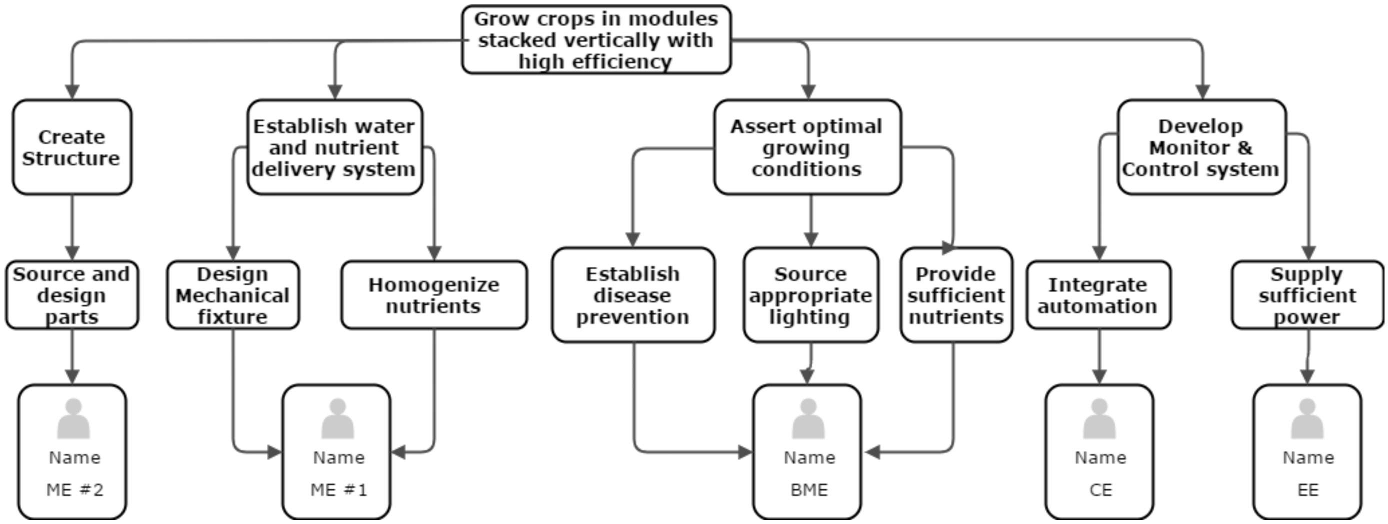
* Preliminary Customer Requirements (CR):

1. Minimizes plant growth period
2. Simple plant installment/removal
3. Accommodates various kinds of plants
4. Energy efficient
5. Reduced water use
6. Easily scalable, starting at household scale
7. Lightweight but sturdy
8. Ability to accurately monitor and control water, light, & environment

* **Preliminary Engineering Requirements (ER)**:

Customer Requirement	Engineering Requirement	Units	Tolerable Value	Ideal Value
1	Initiation to harvest cycle	days	40-60	20-40
2	Time needed to replace plant	min	15	10
2	Replacement system lifetime	yrs	2	3
3	pH control of solution	pH	6-7	5.5-8
3	Adjustable buffer dimensions	in (wxh)	∓6x6	∓12x12
4	Minimize energy use	Wh/kg	100	25
4	Use energy efficient equipment	W	TBD	TBD
5	Precision flow control minimizes water use	L/kg	100	20
6	Module is easily reproducible and stackable	yes/no	yes	yes
7	Module is lightweight	kg	10	5
8	Range of light wavelengths	K	5000-7000	2200-7000
8	Temperature sensing range	F	40-120	20-180
8	Temperature sensing accuracy	F	∓2	∓0.5

[†] **Functional Decomposition** (will not be given to the students, but will be provided to the team's guide for reference):



[*] **Constraints:**

- Reduce carbon footprint wherever possible
    - Utilize reusable or recycled material
    - Run on renewable energy
- Provides safe to eat crops
    - Within as many FDA regulations as possible
- Be within reasonably comparable efficiency as conventional crop growing in the framework of lifecycle assessment

[†] **Potential Concepts:** (will not be given to the students, but will be provided to the team's guide for reference):

- Mesh fabric to avoid the need for soil or other planting mediums
- Sonication to mix nutrients and water
- Spray nutrient-rich water directly on roots to reduce water use
- Materials used should be reflective for maximum photosynthetic absorption

[*] **Project Deliverables:**

Minimum requirements:

- All design documentation (e.g., concepts, analysis, detailed drawings/schematics, BOM, test results)
- working prototype
- small-scale testbench
- technical paper
- poster

- All teams finishing during the spring term are expected to participate in ImagineRIT

† **Budget Information:**

List major cost items anticipated, and any special purchasing requirements from the sponsor(s).

- Mixing apparatus (sonicator) - $500
- Lights - $50
- Processor - $100
- Energy storage - $200
- Energy source - $100 (potentially free)

* **Intellectual Property:**

Patent potential for this project is a possibility. The intellectual property of this project shall belong to the members involved. Should any members wish to opt out of using the information gleaned from this project, a non-disclosure form shall be drafted and signed by all relevant parties.

Project Resources

† Required Resources (besides student staffing):
Describe the resources necessary for successful project completion. When the resource is secured, the responsible person should initial and date to acknowledge that they have agreed to provide this support. We assume that all teams with ME/ISE students will have access to the ME Machine Shop and all teams with EE students will have access to the EE Senior Design Lab, so it is not necessary to list these! Limit this list to specialized expertise, space, equipment, and materials.

Faculty list individuals and their area of expertise (people who can provide specialized knowledge unique to your project, e.g., faculty you will need to consult for more than a basic technical question during office hours)	**Initial/ date**
Environment (e.g., a specific lab with specialized equipment/facilities, space for very large or oily/greasy projects, space for projects that generate airborne debris or hazardous gases, specific electrical requirements such as 3-phase power)	**Initial/ date**
Equipment (specific computing, test, measurement, or construction equipment that the team will need to borrow, e.g., CMM, SEM,)	**Initial/ date**
Materials (materials that will be consumed during the course of the project, e.g., test samples from customer, specialized raw material for construction, chemicals that must be purchased and stored)	**Initial/ date**
Other	**Initial/ date**

† Anticipated Staffing By Discipline:
Indicate the requested staffing for each discipline, along with a brief explanation of the associated activities. "Other" includes students from any department on campus besides those explicitly listed. For example, we have done projects with students from Industrial Design, Business, Software Engineering, Civil Engineering Technology, and Information Technology. **If you have recruited students to work on this project (including student-initiated projects), include their names here, as well!**

Dept.	# Req.	Expected Activities
BME	1	Investigate plant growth properties, compare to artificially controlled environments
CE	1	Develop environmental monitoring system

EE	1	Potential for creating chips that will allow for automated control of system. Fine tuning and protection of electronics in exposed environment.
ISE		
ME	2	System design, part acquisition, material testing. Figuring out nutrient and water solution delivery.
Other		

*** Skills Checklist:**
Indicate the sills or knowledge that will be needed by students working on this project. Please use the following scale of importance:
1=must have
2=helpful, but not essential
3=either a very small part of the project, or relates to a "bonus" feature
blank = not applicable to this project

Mechanical Engineering

	ME Core Knowledge		ME Elective Knowledge
1	3D CAD		Finite element analysis
	Matlab programming		Heat transfer
2	Basic machining		Modeling of electromechanical & fluid systems
1	2D stress analysis		Fatigue and static failure criteria
1	2D static/dynamic analysis		Machine elements
	Thermodynamics		Aerodynamics
1	Fluid dynamics (CV)		Computational fluid dynamics
	LabView	3	Biomaterials
	Statistics		Vibrations
1	Materials selection		IC Engines
			GD&T
			Linear Controls
			Composites
			Robotics
			Other (specify)

Electrical Engineering

	EE Core Knowledge		EE Elective Knowledge
	Circuit Design (AC/DC converters, regulators, amplifies, analog filter design, FPGA logic design, sensor bias/support circuitry)		Digital filter design and implementation
1	Power systems: selection, analysis, power budget		Digital signal processing
	System analysis: frequency analysis (Fourier, Laplace), stability, PID controllers, modulation schemes, VCO's & mixers, ADC selection		Microcontroller selection/application
2	Circuit build, test, debug (scope, DMM, function generator	3	Wireless: communication protocol, component selection
2	Board layout		Antenna selection (simple design)

	Matlab		Communication system front end design
2	PSpice		Algorithm design/simulation
	Programming: C, Assembly		Embedded software design/implementation
	Electromagnetics: shielding, interference		Other (specify)

Industrial & Systems Engineering

	ISE Core Knowledge		**ISE Elective Knowledge**
	Statistical analysis of data: regression		Design of Experiment
	Materials science		Systems design – product/process design
	Materials processing, machining lab		Data analysis, data mining
	Facilities planning: layout, mat'l handling		Manufacturing engineering
	Production systems design: cycle time, throughput, assembly line design, manufacturing process design		DFx: manufacturing, assembly, environment, sustainability
	Ergonomics: interface of people and equipment (procedures, training, maintenance)		Rapid prototyping
	Math modeling: OR (linear programming, simulation)		Safety engineering
	Project management		Other (specify)
	Engineering economy: Return on Investment		
	Quality tools: SPC		
	Production control: scheduling		
	Shop floor IE: methods, time studies		
	Computer tools: Excel, Access, AutoCAD		
	Programming (C++)		

Biomedical Engineering

	BME Core Knowledge		**BME Elective Knowledge**
	Matlab		Medical image processing
1	Aseptic lab techniques		COMSOL software modeling
	Gel electrophoresis		Medical visualization software
	Linear signal analysis and processing	2	Biomaterial testing/evaluation
1	Fluid mechanics	2	Tissue culture
3	Biomaterials		Advanced microscopy
	Labview		Microfluidic device fabrication and measurement
	Simulation (Simulink)		Other (specify)
	System physiology		
	Biosystems process analysis (mass, energy balance)		
1	Cell culture		
	Computer-based data acquisition		
	Probability & statistics		
	Numerical & statistical analysis		
	Biomechanics		
	Design of biomedical devices		

Computer Engineering

	CE Core Knowledge		**CE Elective Knowledge**

	Digital design (including HDL and FPGA)		Networking & network protocols
	Software for microcontrollers (including Linux and Windows)		Wireless networks
1	Device programming (Assembly, C)		Robotics (guidance, navigation, vision, machine learning, control)
1	Programming: Python, Java, C++	3	Concurrent and embedded software
	Basic analog design		Embedded and real-time systems
	Scientific computing (including C and Matlab)		Digital image processing
	Signal processing		Computer vision
	Interfacing transducers and actuators to microcontrollers		Network security
			Other (specify)