PeaPod - Design Proposal

Outlining a Proposal to the PeaPod Design Brief

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1 Introduction

1.1 Purpose

The purpose of this document is to outline the fuction and features of a proposal to the PeaPod Design Brief.

It accomplishes this by answering the following questions on a recursively-scoping basis:

1. **What** is the design? What does it accomplish/what is its function?
2. **How** does it accomplish this? What are its features?
3. **Why** that functionality? Why that way?

2 Design

Functions of the design are derived from the input and output requirements.

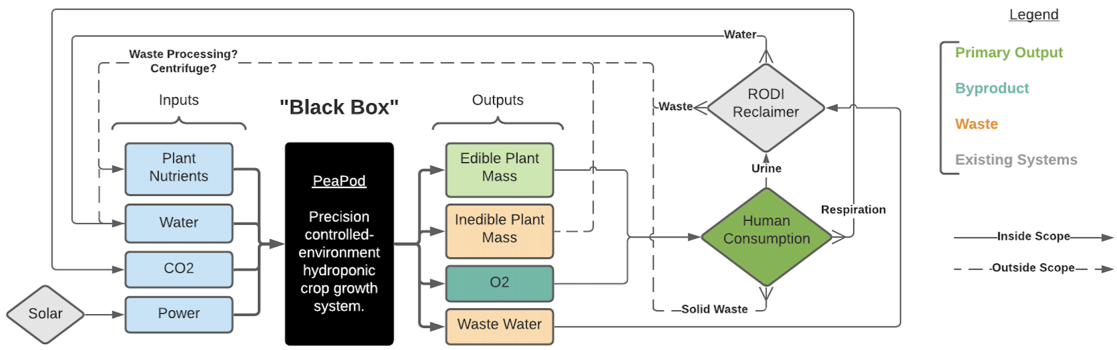

Figure 1: "Black box" input-output model of PeaPod.

Features of the design are developed to meet the function, and are derived from the opportunity statement:

PeaPod is "an automated and isolated aeroponic crop growth system, able to generate any growth environment from a combination of independent environment parameters, with both environment and crop growth data collection".

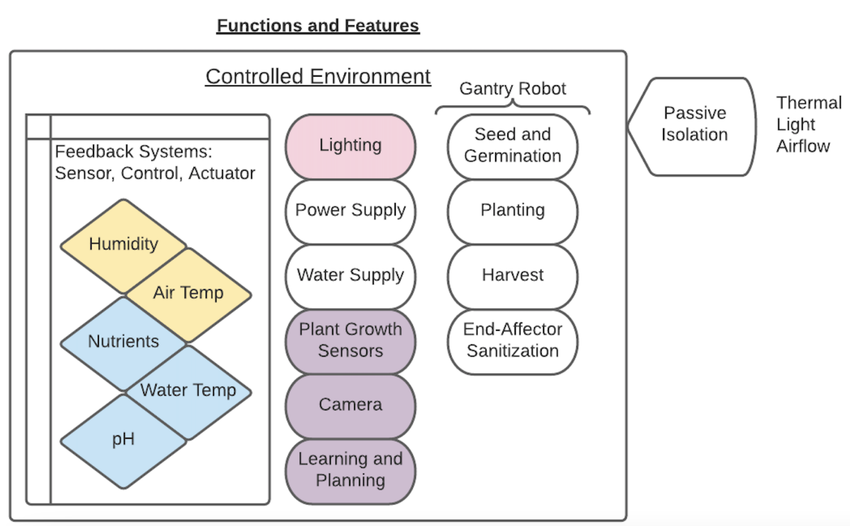

Figure 2: Features and feature types of PeaPod.

2.1 Automation

What: Performing growth-, maintenance-, and data-related tasks autonomously on the basis of both schedule and necessity.

How:

- Schedule:
  - User inputs time/action pairs;
  - E.g. Water at 08:00, Turn light to setting X at 14:00;
  - *Bonus:* Can notify user if action's resource is missing (i.e. water tank low)
- Necessity:
  - "Sense, Plan, Act" robotics/control model:
    1. *Senses* current conditions;
    2. *Plans* a path to desired condition;
    3. *Acts* to change current condition to desired condition;

Why: Increased accuracy/precision over human interference, minimize human hours spent.

2.2 Isolation/Insulation and Housing

What: Isolates growth environment from exterior environment, provides structural integrity and mounting points.

How: Cube exoskeleton (aluminum extrusion) holds solid (acrylic/foam/corrugated board), internally-reflective (mylar) panels in place and aids in mounting plant growth platforms, lights, etc.

- Isolation:
  - Heat - Held in by mylar, blocked out by solid insulation via panels;
  - Light - Blocked out by panels, reflected in by mylar;

  - Moisture - Retained by caulking/other sealing around panels;
- Mounting:
  - Growth trays - Mounted to rails fastened to aluminum extrusion channels;
  - Lights - Many boards mounted to sheet fastened to aluminum extrusion channels;
  - Nozzles - Mounted to inside-bottom face of growth tray;
  - Sensors - Mounted to various points (per-sensor), often fastened to aluminum extrusion channels;

Why: Increases thermal and light efficiency. Isolation increases safety against cross-contamination, pathogens, harmful substances. Simple and strong construction with dedicated mounting channels.

2.3 Aeroponics

What: Medium-free growing method that uses nutrients dissolved within atomized water.

How: High-pressure nozzles deliver atomized nutrient solution to plant roots. Uses parallel distribution topology.

- Pump fills tank with water that has nutrients dissolved within
- Tank uses an air bladder to hold water at desired PSI
- Switch checks line pressure and activates/deactivates pump to maintain PSI
- Solenoid ball valve feeds water to nozzle
- Nozzle atomizes water to ≈50 micron droplets
- T-quick connects with solenoid ball valves at every unit height feed individual trays

Why: No water parameter feedback, 98% more water efficient, minimizes pathogens and waste water.

2.4 Environment Control

The environment control feature can be broken up into **control systems** (2.4.1-2.4.3; sometimes in two parts) and **set systems** (2.4.4-2.4.7).

2.4.1 Air Temperature

What: Maintaining desired air temperature within the enclosure.

How: Thermoelectric heating/cooling system (peltier tiles w/ polarity switch, 'dimming' current control, PID) on a heat sink w/ fan, feedback from distributed temp sensors

Why: TECs have better space and energy efficiency, less complexity (no liquids, pressurized fluids, etc.), better control vs other methods. PID provides best control.

2.4.2 Air Humidification

What: Adding water vapour to air.

How: Ultrasonic nebulizer (piezo disc w/ custom driver circuit), RO water

Why: Piezo for droplet size, commonly used; RO for purity of water vapour

2.4.3 Air Dehumidification

What: Absorbs water vapour from the air.

How: Silica gel bead cartridges with fans/valves to control airflow across.

Why: Non-toxic, safe, cheap, effective. Color-changing indication at saturation, easily reset by baking and recapturing water.

2.4.4 Solution Temperature

What: Maintaining desired water temperature within the water store.

How: Same as 2.4.1; on a water block

Why: Same as 2.4.1

2.4.5 Solution Nutrients

What: Precisely dosing the correct amount of various nutrients (K^+, NO_3^-, etc.) to the water system at setup/water addition.

How: Syringe-like dosage via servo motor to set ppm based on fill volume.

Why: Syringe dosage is precise, easy to refill.

2.4.6 Solution pH

What: Precisely adds pH up/down solutions to set the solution pH at setup/water addition.

How: Same as 2.4.5.

Why: Same as 2.4.5.

2.4.7 Lighting

What: Wide spectrum precision LED lighting targeting PAR.

How: N LED series/colors, N controlled-current PWM drivers, M LEDs per series = NxM LEDs. Custom LED boards wired in series, one power board per tray, w/ diffusion.

Why: LED > every other type in every way, PWM easy protocol, CC because they're LEDs.