

PeaPod - Design Report

Primary Written Deliverable for the Deep Space Food Challenge Phase 1

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Revision 0.1

University of Toronto Agritech

June 9th, 2021

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1 Design Abstract

2 Design Report

2.1 Description

An automated and isolated aeroponic crop growth system, able to generate any environment from a combination of independent environment parameters, with both environment and crop growth data collection. The system takes the form of an enclosed cube, with most crew interaction limited to water and nutrient refill. Hardware components can be broken down into 4 primary categories: Feedback Systems, Resource Supply, Support Structures, and Electronic Control. Together, these 4 components create the "Black Box" seen in Figure X.

Operations concept follows Figure 1:

2.2 Innovation

Wide, continuous, precise control Environment optimization for output metrics

2.3 Adherence to Constraints

2.3.1 Palatability of Crop Output

Hydroponic crops have seen commercial success, suggesting that their output is of sufficient hedonic quality to be desired. Additionally, PeaPod is designed to optimize for edible plant mass, nutrient density, and other health indicators—pushing hedonic quality up over time.

2.3.2 Air Temperature Control Range**2.3.3 Air Humidity Control Range****2.3.4 Light Spectrum Wavelength Range****2.3.5 Light Spectrum PAR Match****2.3.6 Light Intensity Control Range****2.3.7 Internal Circulation Airflow Control Range****2.3.8 Nutrient Solution Delivery Control Range****2.3.9 Nutrient Solution Temp. Control Range****2.3.10 Nutrient Concentrations Control Range****2.3.11 Time Requirement - Maintenance****2.3.12 Loss of Functionality Over 3 Years****2.3.13 Input Lifetime while Safe, Useful****2.3.14 Outer Dimensions****2.3.15 Outer Volume****2.3.16 Power Consumption****2.3.17****2.4 Performance Criteria****2.4.1 Acceptability****Process****Food Products****2.4.2 Safety****Process**

Products

2.4.3 Resource Inputs and Outputs

Inputs

Outputs

Optimization

Maximizing output is perhaps the greatest strength of PeaPod. Since it is fully automated, growth cycles have a high degree of certainty that let researches hone in on the perfect conditions—and then repeat them ad infinitum. By collecting data in an isolated environment like this, optimization can be done on any number of parameters, including quantity of inputs. As trials are conducted and PeaPod gathers data, it measures the quantity of inputs taken and a plethora of plant data related to usable quantity, bringing PeaPod to the most efficient conditions over time. In addition, the array of sensors used to collect data double as input for PID control, letting PeaPod react to unpredictable events such as poor seed health and salvage otherwise poor outputs.

2.4.4 Reliability and/or Stability

Process Reliability

By nature of its design, PeaPod will last three years at near 100% functionality on minimal maintenance. This is achieved by self-monitoring component health, using servicable materials, and providing smart notifications to the user when maintenance is needed. For one, PeaPod is designed to be assembled by a single user with readily available tools. This means it can be disassembled, cleaned, and put back together by one person in a non-restrictive amount of time. For another, the sensors used to monitor plant health and growing conditions allow PeaPod to notify the user when a part needs to be fixed or replaced. For example, if humidity readings fall below historical levels for current water output, PeaPod will notify the user to replace the insulating material in the nozzle area. If light intensity begins to drop in a certain sector, PeaPod will tell the user to replace a certain bulb.

This said, every component in PeaPod has an expected lifespan over three years. From the LEDs

(rated for 5 years) to the nozzle (only needs periodic cleaning) to the bonding agents (tested for materials used), replacement monitoring is only needed as a backup.

Scheduled maintenance breaks down to three primary tasks: refilling nutrients, cleaning spray nozzle, and harvesting/replacing plants. Since PeaPod mixes the nutrient solution automatically, the only required maintenance is replenishing stores of water and individual nutrients. By tracking consumption rates and using past trends, PeaPod can schedule the most efficient refill time in advance and notify the user. The spray nozzle, by way of its fine mesh, will build fine amounts of sediment over time. This can be easily cleaned by the user at either pre-determined times or, as mentioned above, when the unit detects an issue. Finally, plant harvesting is a quick task that simply constitutes opening the unit and removing the plant. Replacing it only requires the user to open the unit, place the seed in the grow cup, and digitally set the grow conditions for PeaPod to follow.

Input and Output Stability

2.5 Terrestrial Potential

2.5.1 Customer-facing Food Service

At present, a restaurant requires either a local supplier or a substantial amount of outdoor space (and labour) to serve fresh produce. Both of these are cost-prohibitive, and the latter is entirely impossible in many situations. Local suppliers' high costs are the result of a few things:

- Limited seasonal availability
- Frequent transport need
- High costs with little demand

PeaPod has the potential to reduce these barriers in a cyclic way. Partnerships between local suppliers and restaurants will provide these restaurants with space- and time-efficient PeaPod units with the purpose of generating both produce and data. The increase in produce will reduce the frequency at which suppliers need to make deliveries, while the data produced will let suppliers maximize output. Over time, this can increase efficiency to the point where local suppliers can

provide produce at a lower price.

2.5.2 Crowdsourced Research

Due to PeaPod's automated nature, off-site research is a feasible method of collecting data. As a result, universities and other institutions can save costs related to space and energy usage by subsidizing PeaPods to consumers, schools, or even restaurants. Users would receive sets of parameters within which to grow crops, and the data would be sent back to the institution. The user can use the produce, at the cost of space and energy, while the institution continues to provide parameters with which to grow. The end result is a massive set of data, conducted in identical conditions in different places, verified by comparison with the myriad devices conducting the same tests.

2.5.3 De-centralized Production

Many crops are only feasible in certain climates, making global transport a necessity to sell them worldwide. This reduces freshness, necessitates various preservatives, and increases carbon consumption. By upscaling PeaPod technology to a farm scale, it becomes possible to produce climate-bound crops in any location. This creates region-based farms that can produce a tremendous variety of crops, vastly reducing transport needs and making it easier to have a local food diet.