CONCEPT OF OPERATIONS

FOR

FRUIT2U

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Revision History and Notes

Change ID or CI #	Date Reviewed	Date Approved	Comment	Signature
-	08/28/21	-	Initial Draft of ConOps	AT, DS, KD, AS
A	9/23/2021	9/24/2021	Updates to ConOps	AT, DS, KD, AS
B	10/10/2021	10/11/2021	ASE6001 Exit	AT, DS, KD, AS

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6. Executive Summary

The mission of Fruit2U is to tackle rampant problems such as food wastage, food shortage and hunger, and global warming. Data from the USDA shows that even as recent as 2019, 10-12% of households in the United States faced food insecurity. [1] The other side of the coin is that grocery stores are major contributors to food wastage. RTS states that retail grocery stores waste ~30% of their produce leading to around 16 billion pounds of food waste annually. [2] Most of this food waste ends up in landfills and decomposes to release greenhouse gases that aggravate global warming. This wasted food is around twice the profit from food sales and thus the concept of Fruit2U was further incentivized for retail grocers. [3] Thus, the primary customer for Fruit2U is retail grocers like Walmart or Kroger.

The objective would be to have a solution to bridge the gap between the existence of surplus food that is disposed of, and areas with widespread hunger. The major distribution challenge here is currently the spoilage time for food with Produce leading the list. Bananas are the leading contenders in produce due to their short spoilage time, volume, and popularity of the product. Moreover, the marketable window where users find the fruit aesthetically pleasing is quite small thus leading to large quantities of bananas being disposed to landfills.

This led to the generation of the Problem statement: “Short spoilage time and perishability lead to bananas being major contributors to produce waste.” The related solution for this was: “To develop an equipment to prepare, dehydrate and package surplus bananas for transport to food banks.” The goal of the project is to develop a system that will be addressed as Fruit2U to process surplus bananas at retail grocery stores. Fruit2U would convert the fresh fruits into dehydrated packs of bananas which have a longer shelf-life, thus alleviating the burden on the supply chain and minimizing food waste. The team would develop this equipment with funding from retail groceries to commission Fruit2U within their facility to process surplus bananas into ready-to-eat packages.

7. Administrative Information

2.1 Identification

This document is controlled by the version control table.

2.2 Document Security

Fruit2U described in this document is the intellectual property of the team. Do not share or reproduce this document without the written consent from the authors. Any documentations surrounding the proprietary design specifications would be securely stored at the Fruit2U facility. Physical access would be limited using locks. Access to confidential product information will be restricted on a need-to-know basis.

8. Meta-model diagram

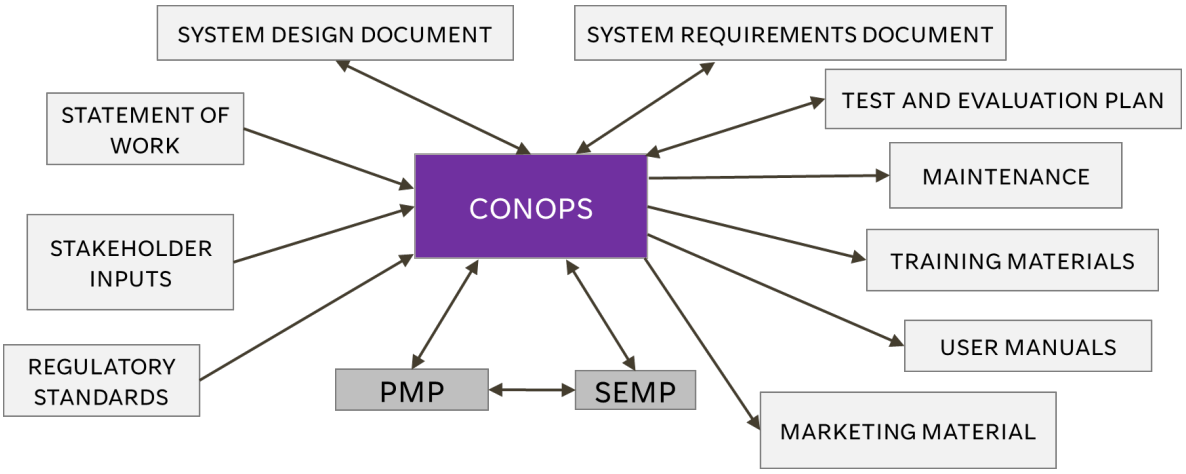

Figure 1 – Meta-model Diagram

Note: All meta-model traces are manually updated.

The meta-model shows the information flow of the project. The ConOps is the center of the information flow. The Statement of Work (SoW), the Stakeholder inputs, and the Regulatory Standards will provide input to the ConOps. The Project Management Plan, the SEMP and the ConOps will work together to control the high-level processes and requirements. The System Design Document, System Requirements Document, and Test and Evaluation documentation will be derived from and provide feedback to the ConOps. The Maintenance, Training Materials, User Manuals, and Marketing materials will all derive from the ConOps information.

9. Current Situation

9.2 Background

- In the battle against global hunger, one of the major challenges faced by food distribution is the gap in logistics i.e., the efficient transport of perishable foods. Without looking at third world countries, one can see the prevalence of (1) food insecurity. In the United States, food insecurity varies considerably by state, ranging from 6.6 percent in New Hampshire to as high as 15.7 percent in Mississippi. 1 in 4 children in Mississippi face hunger or malnourishment as per 'Feeding America'. Excess food produced in areas of surplus does not make it to areas with a deficit due to several factors. Apart from socio-political factors like unequal access, poverty, economic policy, war and conflicts, another key factor is logistics. This is the (2) difficulty in transporting perishable food within the spoilage time in a cost-efficient manner. The Food and Agriculture Organization of the UN estimates that roughly one-third of food produced for global human consumption is lost or wasted, amounting to ~1.3 billion tons of food waste per year globally.
- Inevitably this also equates to the huge waste of water used in food production, and the greenhouse gas emissions caused by the production of food and its disposal in landfills (3) aggravating climate change. "If food waste emissions were a country, it would be the third largest emitting country in the world".
- Paired with extremely high standards for size and grade, and customer preferences with a small non-perishable selling window, produce ends up being a major player in food waste. "About 30 percent of food in American grocery stores is thrown away. US retail stores generate about 16 billion pounds of food waste every year. Wasted food from the retail sector is valued at about twice the amount of profit from food sales." In the produce aisle, bananas are front-runners in wastage when looking at metrics like spoilage time, consumer preference, climate impact and sheer volume of product.
- At the forefront of this initiative are the project management directives. These high-level directives will help the product team to comply with applicable laws and regulations throughout the entire breath of the process. This project will use the most refined management practices that typically increase probability of project success.

9.3 Objective

The objective for this product is three-fold: 1) to combat hunger and 2) reduce food waste in the United States, and 3) the reduction in the pace of global climate change due to food waste bi-products. Fruit2U will alleviate the pressures with food spoilage prior to the distribution of perishable food. This would be done using a lower cost, easy to implement, product working on clean energy.

9.4 Scope

The scope of this project is to create a product that is a solar/electric hybrid dehydrator for bananas that will help with preparing, dehydrating, and packaging for transport prior to complete spoilage. Solar heating would be used during the day while electricity would provide continued dehydration during the night. Current industrial dehydrators are integrated into food processing facilities while this product will be aimed at being implemented through retail grocery stores to mitigate food waste. The Fruit Dehydrator will package dehydrated fruit (e.g., bananas) that will then be transported to regions with food shortages (food deserts).

Out-of-Scope Product Inputs: The process of obtaining bananas is the responsibility of the customer buying this product. The customer will also be required to meet all regulatory requirements while using this equipment.

Out-of-Scope Product Outputs: The process of delivering the dehydrated bananas in its packaging is the responsibility of the customer. (e.g., delivery to a Food Bank). The customer will also be responsible for procuring packaging material that is compatible with the Fruit2U System.

5. Analysis of the Proposed system

5.1 Users or Affected Personnel

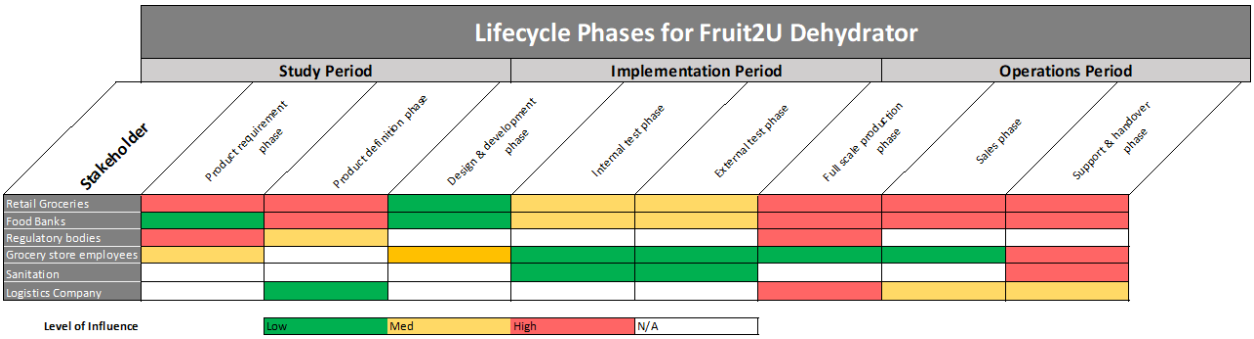

Figure 2 – Stakeholder Analysis

Initial stakeholder analysis illustrates that the Retail Groceries (e.g., Kroger & Walmart) sustain a high level of influence in almost all phases across the product's life cycle. The Maintenance and Sanitation groups were affected the least, as they will need to be trained to handle the system. Once the training occurs there should not be any major system changes and the role will be relatively stable. Their involvement is also limited as they are not a part of design and development. The food banks also command a high-level influence as they are a recipient of the end product.

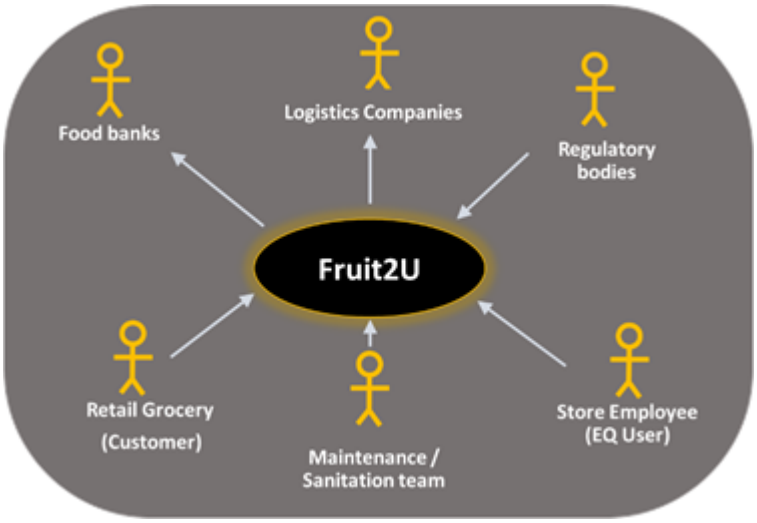

Figure 3 – Context Diagram

The context diagram shown above was used to obtain a preliminary understanding of the customer needs. The various actors interact with the Fruit2U System in different ways:

- The **Retail Groceries** are the customer for the Fruit2U system and will house the Fruit2U system at their site. The Retail Grocery will provide the operational inputs for the Fruit2U system (viable bananas and energy considerations)
- The **Grocery Store Employee** is intended to be the main operator of the Fruit2U system. They will load the Fruit2U with unprocessed bananas and be responsible for moving the packaged banana chips from the packaging area to a temporary storage area.
- The **Logistic Company** is responsible for taking the packaged banana chips from the Retail Grocery Store and delivering it to the Food Banks.
- The **Food Bank** is the end recipient of the packaged banana chips as it relates to the Fruit2U system.
- The **Regulatory Bodies** will be critical to the successful implementation of this system. This system must be approved for production of food fit for Human consumption. Regulatory bodies exist at the local, state and federal levels and each will be considered.

5.2 Affinity Diagram

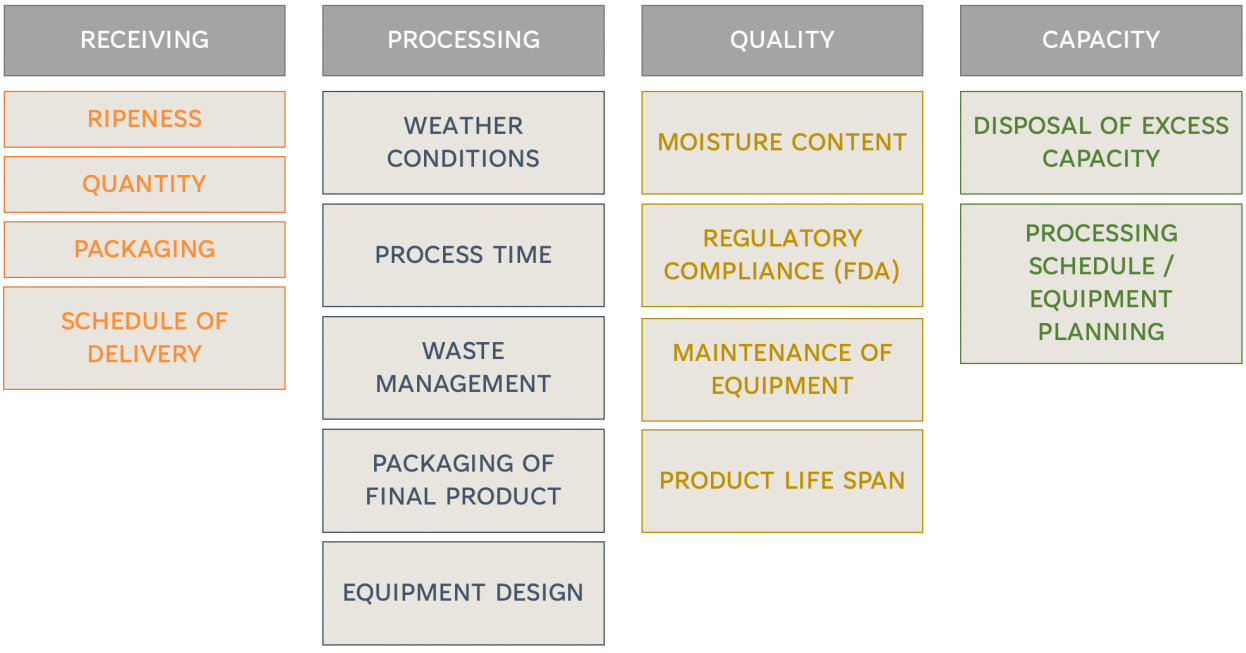

Figure 4- Affinity Diagram

An overview of the product was assessed from four main viewpoints, under which receiving, processing, quality, and capacity were considered. Receiving needs to consider ripeness and quantity of bananas, any packaging and accommodate delivery

schedules. These aspects all interact with each other; quantities and packaging will impact the ripeness rate; Schedule of deliveries also impact quantities and ripeness. The Processing activities must consider weather conditions, processing time, waste management, packaging of the final production, and general equipment design. Weather will impact processing time. Equipment design will impact packaging. The Quality viewpoint must consider the moisture of the content so as to not ruin the dried bananas, must meet regulatory requirements, consider how to perform maintenance activities, and meet product life span. The moisture content could impact regulatory compliance. The maintenance will impact life span. The capacity aspect considers dealing with excess capacity and processing schedules. Each of these impacts each other.

5.3 Tree Diagrams

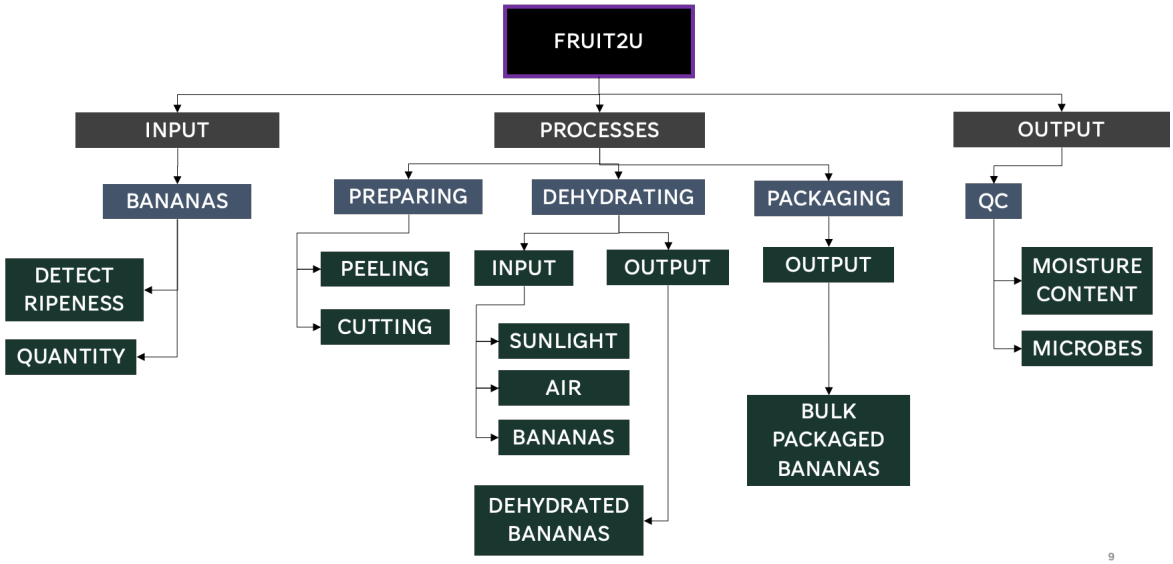

Figure 5- Functional Tree Diagram of the Fruit2U System

The Fruit2U system comprises three functions; these are input, process, and output. The different grades of bananas that are deemed as waste by the retail store are sorted into those suitable for processing, and those that are not. The suitable ones are peeled and fed into the processing area where they undergo dehydration. The dehydrated bananas are packaged and boxed up to be transported to food banks.

5.4 System Advantages

- **Reduces food waste that ends up in landfills**
- Wasted food from the retail sector accounts for roughly twice the amount of profit yield from food sales. Fruit2U will help curtail a fraction of this wastage.
- **Helps curtail the population of hungry people globally**
- With the equipment's capability to remove moisture, increase shelf-life, and protect food products from microbial degradation, fresh food will be fed to the hungry.
- **Environmental-friendly device------a green initiative**
- It will be powered by a hybrid solar system, with solar power serving as a chief source of energy for Fruit2U's heating elements for the majority (~80%) of its operating time. Electricity from the power grid will operate the unit at night.
- **Reduction in the emission levels of Greenhouse Gases**
    - This product uses bananas that would have been sent to a land fill as an input. In effect, this leads to the reduction in Greenhouse gases released.
    - Since the exhaust fumes of trucks that transport waste to landfills contain pollutants that are detrimental to the ozone layer and can contribute to respiratory diseases, a reduction in trips to the landfill using Fruit2U to process food waste can help reduce and control the release of such gases.

5.5 System Limitations

- **Capacity constraints of the Fruit2U system**
    - With the high perishability rate of bananas, it will be beneficial for the dehydrator system to be able to process large volumes of bananas all at once rather than in small batches. Commercially available food dehydrators can only handle small batches at a given time resulting in relatively small volumes of the finished product.
- **Machine operator error**
    - The continuous operation of the system for long hours (~14-16 hours/day) can leave room for mistakes by operators. Negligence on their part could lead to a lower-quality packaged food, which must be discarded leading to unnecessary costs and inefficient use of time.
- **Availability of real-estate space to accommodate unit**
    - Real estate space can be costly and difficulty to acquire. Fruit2U system needs a suitable and sizable building space to accommodate both equipment and heating source (hybrid solar system).

- **High initial investment cost of solar technology**
  - It's quite costly to purchase a solar unit, which serves as a source of clean energy to drive the Fruit2U system; its cost benefit will be achieved after the Fruit2U system has achieved about a year worth of operations.

References: *https://www.solarreviews.com/blog/pros-and-cons-of-solar-energy*

5.6 Areas of Potential Improvement

- The overall system can be evaluated to see areas where automation can boost its efficiency. For example, a consideration can be made to make some processes of the system automated to eliminate or reduce human errors.
- With a more powerful dehydrator, packaged foods can be processed in bigger batches and transported in one bulk to reduce the number of trips between food banks and other food organizations.
- The placement of the heating source on a rooftop location will allow direct sunlight exposure to solar panels, which in turn will boost the efficiency of the solar heating source to Fruit2U. This is also a cost-effective measure that helps eliminate the higher costs associated with the acquisition of enclosed buildings to house the Fruit2U system.

5.7 Alternatives and trade-offs considered

Refer to the SEMP for Alternatives and trade-offs considered.

6. Concept for New or Modified system

6.1 Description of the new or modified system

The Fruit2U System is comprised of three subsystems: 1) A Preparing Subsystem 2) A Dehydrating Subsystem and 3) A Packaging Subsystem. (Figure 1 and 2)

Preparing Subsystem
The Preparing Subsystem will receive bananas, detect and sort based on ripeness, peel and remove the banana peel, then cut the bananas which serve as an input to the Dehydrating Subsystem.

Interfaces to the Dehydrating Subsystem will be defined in later revisions of this document.

Dehydrating Subsystem
The Dehydrating Subsystem will hold the bananas and dehydrate using direct solar heating.

Interfaces to the Packaging Subsystem will be defined in later revisions of this document.

Packaging Subsystem
The Packaging Subsystem will remove the dehydrated bananas from the Dehydrating Subsystem and package them into bulk containers.

6.2 Operational Policies and Constraints

6.2.1 Environmental Constraints

Rationale: The internal Fruit2U environment must be warm and dry enough to dehydrate bananas.

Local Temperature and Humidity: The system will operate in a local temperature and humidity that will allow for the dehydration of the banana.

Sunlight: Fruit2U should be used in areas with at least 8 hours of sunlight to efficiently dehydrate bananas without supplemental heating inputs.

Climate and Seasonal Use: The Fruit2U system is recommended for use in areas that have a climate and season that typically meets the environmental constraints.

6.2.2 Banana Ripeness Constraints

Rationale: The blades of the Fruit2U peeler cannot function with Class VIII-XII ripe bananas.

The Fruit2U System is only recommended for use of Banana Ripeness Class I-VII. Class VIII-XII are overripened and shall not be used with the System.

6.2.3 Capacity Constraints

Rationale: The System requires direct sunlight on bananas to dehydrate. Overpacking the bananas in the Fruit2U system will greatly impair the efficiency of the system.

The mass of bananas to be that can be processed in one cycle is still to be defined.

6.2.4 Electrical Constraints

Rationale: The Systems peeler and packaging subsystems require electrical energy. The electrical sources shall be a common 120V outlet. The System will be design for use in the United States.

The Fruit2U System shall be powered by a 120V GFCI outlet. The power rating will be determined in future revisions of this document. (e.g., rated to 20A)

6.3 Technical Policies and Constraints

6.3.1 FDA Regulations for Food Processing

- The Fruit2U system will involve food processing and must meet all FDA and State regulations.
- The Fruit2U system must be designed to meet FDA and State requirements in-order for use in the United States.

Although the customer owns the scope to obtain FDA Food Facility Registration, the Fruit2U System must be designed with these requirements in-mind.

6.3.2 Packaging and Shipping

Packaging material shall be selected to prevent damage to the Fruit2U System. Specific requirements will be determined in future revisions of this document.

Shipping requirements shall be determined by the selection of the carrier. Selection of the carrier and constraints will be defined in future revisions of this document.

6.3.3 Electrical Constraints

Rationale: The product must meet federal electrical regulations.

Fruit2U shall conform to the electric Code of Federal Regulations (eCFR).

6.4 Users or Affected Personnel

The Fruit2U will impact two major users 1) Retail stores (e.g., Kroger & Walmart) and 2) Food Banks. The product may require a full-time employee (FTE) to be responsible for the process. The Fruit2U System will require personnel to load bananas into the system. The System will require limited monitoring during operations. The equipment will then need to be passed through QC monitoring and then packaging. Packages may be carried by operators and stored in a warehouse prior to shipping.

6.5 Support Concept

6.5.1 Training

Fruit2U training will be addressed by two methods: 1) Hosted Training Sessions and 2) provided Operation Manual.

Hosted Training Sessions: Fruit2U corporations will host training sessions for use and marketing. These sessions will review the general constraints of the System, along with showing users operational use and maintenance of the System. The occurrence of the training sessions shall meet the needs of the demand of the system.

Operations Manual: The Fruit2U System will provide an operation manual for the user. This will include a text- and graphics-based manual (e.g., IKEA graphical instruction manuals) as well as a graphical one-pager summary of operations. The manual will be provided with the System and available on-line.

6.5.2 Equipment and Operations support

Rationale: To minimize operational costs, the Fruit2U System will not provide 24-hour support. Users are not profit-driven and delays in production must be accepted by the user.

The Fruit2U System will provide equipment and operational support through a website email address.

6.5.3 Repair and Replacement Criteria and cycles

Rationale: The replacement cycle shall be delayed until the selection of materials of the Fruit2U System (e.g., blades, storage material, packaging design)

Repair and replacement cycles shall be defined in a later revision of this document.

Storage and distribution methods: A central warehouse for the storage of un-sold units will be defined in a later revision of this document.

Rationale: To reduce the cost of operations, mail services will be selected rather than a dedicated distribution team.

The Fruit2U system shall use mail services and logistics providers to distribute the systems. (e.g., UPS, USPS)

6.5.4 Customer Design and Testing Involvement

Fruit2U will partner with Central Mississippi Food Pantry and Mississippi Food Network during the Design Phase of the Fruit2U. These two locations will be the first users of the System.

7. Operational Scenarios

- Operations will be performed by 2 primary users: 1) The retail store (grocery store) 2) The Food Bank.
- Retail Store: The primary focus will be on the retail stores. The user will divert unsold bananas on-track to the landfill to the Fruit2U processing center located at the user's facility. The user will process the bananas and package. The user will then deliver or outsource delivery of dehydrated bananas to the Food Bank or final customer.
- Food Bank: The food bank will receive bananas from the Grocery store. The food bank will then deliver dehydrated bananas to the people facing food shortage.
- *Farm Producers: This is an example of a 3rd user to whom Fruit2U could act as a tool to process surplus bananas.*

Mission Elements	Scenario Number						
Mission							
Transform ripe bananas into dried banana chips and encase the output chips within sterile packaging	I	II	III	IV	V	VI	VII
Mission Type							
Prepare bananas	✓	✓	✓	✓			✓
Cut Bananas	✓		✓	✓			✓
Dehydrate Bananas	✓	✓	✓			✓	✓
Package dehydrated bananas	✓	✓	✓			✓	
Enable backup power system			✓				
Disinfect system							✓
Abort system					✓		✓
Environmental Factors							
Temperature > 70 ° F	✓	✓					
Rain			✓		✓		
Snow / Sleet / Hail / Ice			✓		✓		
System failures / Malfunctions							
No power in a specific component					✓		
Component experiences a physical blockage				✓			
Threat							
Bad actor contaminating system							✓

Figure 6- Mission Task Analysis

The above figure focuses on Operational Scenarios with an emphasis on human interfaces to the system. Assumptions are that operators interacting with the system

are fully trained and available while the system is in operation. Personnel operating the system will not be required to constantly monitor the system, as they are employees of a grocery store operating and monitoring part-time when available from primary duties, so they must quickly regain situational awareness and identify issues when re-focusing on the Fruit2U operations. Users should understand general system operations, monitor for inclement weather and precipitations, be aware of power outages, and identify when the system has been tampered with by a "bad actor".

Scenario I: A nominal processing day for the user. The user will complete all steps in the processing and have banana chips as the output. The system will run at a warm temperature in which the system can rely on solar heating.

Scenario II: This scenario is like Scenario I but executes the option to dehydrate whole bananas (bypass cutting bananas).

Scenario III: Processing bananas in inclement weather. The scenario addresses when the Fruit2U is used during colder weather and with precipitation. In this case the system cannot operate entirely on solar heating. An operator is needed to ensure the system can still process bananas.

Scenario IV: Unclogging physical blockage. This scenario addresses when there is a blockage in the cutting hardware. The system will be stopped for an operator to safely remove the blockage.

Scenario V: System powers down for user safety. This scenario addresses when there is a power outage due to adverse weather conditions.

Scenario VI: Users could decide to dehydrate fruit other than bananas. In this case, the scanning or cutting (Prepare function) operations will be bypasses and fruit will be loaded manually by the operator into the dehydrator. The system will then move forward to inspect and package the dehydrated fruit.

Scenario VII: Process aborted due to bad actor contaminating the system. This requires identification of a malicious intrusion then disinfecting the System. Fruit2U will not be under constant surveillance and could be vulnerable to attack.

7.1 Use Case Diagram - Top level function

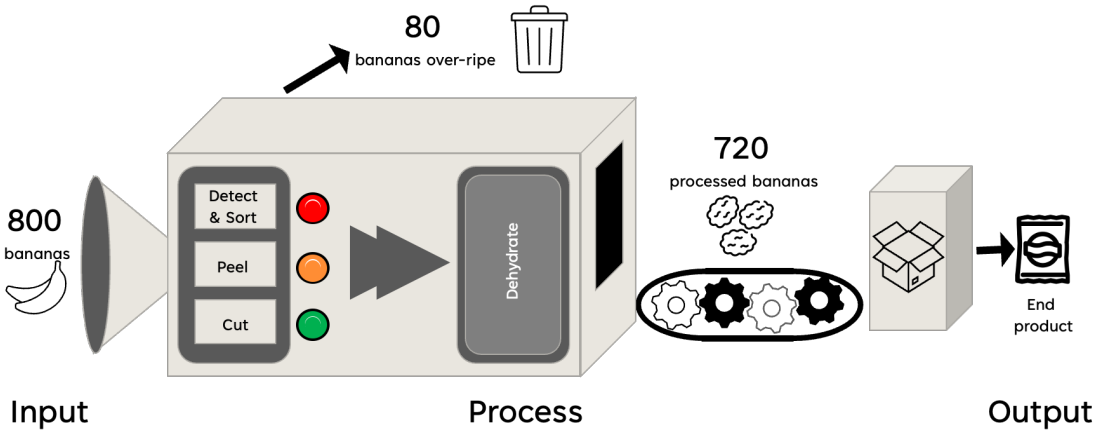

Figure 7- The Fruit2U System

There are 3 main functions / process steps to the Fruit2U system: input, transformation, and output. The different grades of bananas that are assessed as waste by the retail store are fed into the receiving (input) side of Fruit2U. The bananas then go into the transformation phase where the detection unit sorts the over-ripe from ones suitable for dehydration. The over-ripe ones are expelled into a trash area outside the device. The dehydrated bananas are packaged and boxed up to be transported to food banks where they can be further distributed.

7.2 Use Case Diagram

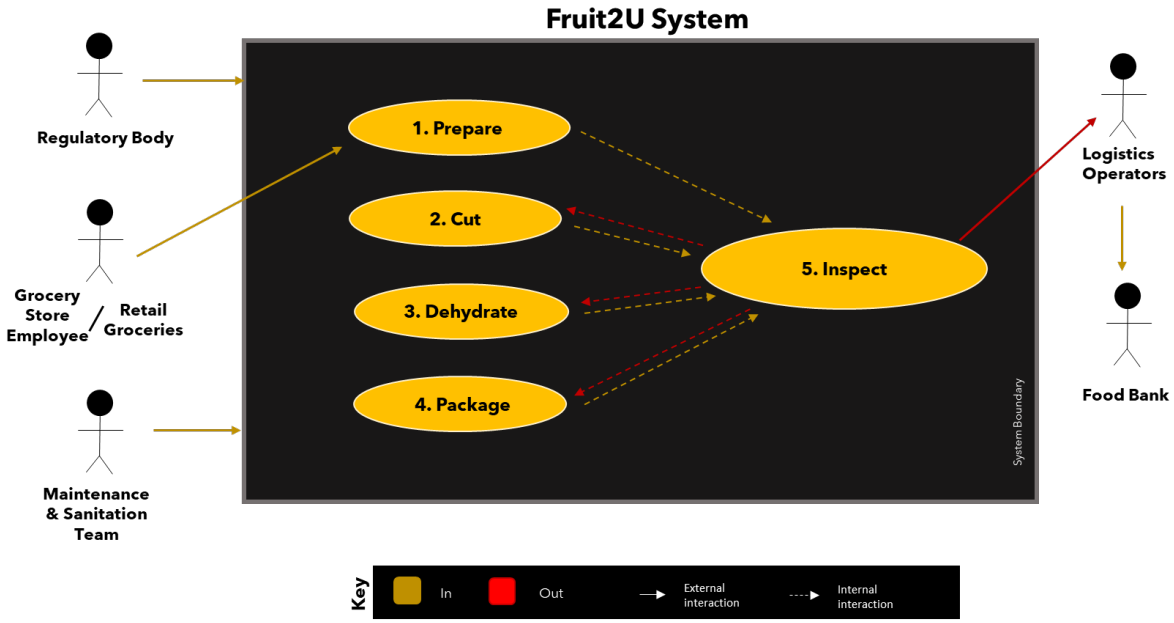

Figure 8- Use Case Diagram for SOI

This diagram shows the relations between Fruit2U and stakeholders. The key players are the retail groceries which utilize the capability of Fruit2U to convert near-waste bananas to packaged bananas with extended shelf life, and food banks who would be the receiver. To successfully execute the high-level goal of the project there would need to be further interaction between food banks, regulatory bodies (FDA), grocery stores, and logistic companies that would help with approvals for this socio-engineering solution being developed.

8. Summary of Impacts

8.1 Operational impacts

In the long term, the impact on the supermarket's operations is minimal. This product is intended to be implemented on the roof tops of the customer's buildings (where property management allows). As such it is not expected to disrupt the existing day-to-day work. The device would ideally be run on a scheduling / batch system rather than a continuous flow allowing for greater flexibility to respond to unexpected operational challenges.

8.2 Organizational impacts

The introduction of the Fruit2U product and incorporation into a supermarkets value stream is expected to have limited organizational impact. Depending on the number of units implemented, the dedication of an FTE may become necessary. It is necessary to craft Standard Operating Procedures for the newly defined responsibilities as well as train the employees in working with the product and the new process.

The training would need to define:

1. How to sort the bananas that are to be used as inputs.

2. How to handle the output of the Fruit2U both before and after it is packaged.

3. Basic trouble shooting and recovery scenarios.

8.2.2 Impacts during development

The impact on the customers during the development and implementation is expected to be minimal. The construction of the product would occur at a separate facility and then be installed on the customers rooftops. There will be little interaction between the customer staff and the Fruit2U team during the physical set up. The testing of the product is to be conducted before the device is installed at the customer site and any associated documentations such as test results and user manuals, would be handed over at the time of final set up.

9. Notes

-FDA: Food and Drug Administration

-FTE: Full-Time Employee.

-Fruit2U: Name given to the System of Interest (SOI) in this project.

-near-waste: [here] refers to items that are about to spoil.

-SEMP: Systems Engineering Management Plan

10. Appendices

To be populated as ConOps document evolves.

11. References

[1] Gustavsson, Jenny. "Global Food Losses and Food Waste - Home | Food and ..." FAO.Org, Food and Agriculture Organization of the United Nations, 2011, http://www.fao.org/3/i2697e/I2697E.pdf.

[2] Mattsson, Lisa, et al. "Waste of Fresh Fruit and Vegetables at Retailers in Sweden – Measuring and Calculation of Mass, Economic Cost and Climate Impact." Resources, Conservation and Recycling, Elsevier, 5 Dec. 2017, https://www.sciencedirect.com/science/article/pii/S0921344917303737.

[3] Hegnsholt, Esben, et al. "Tackling the 1.6-Billion-Ton Food Loss and Waste Crisis." BCG Global, BCG Global, 2 Aug. 2021, https://www.bcg.com/publications/2018/tackling-1.6-billion-ton-food-loss-and-waste-crisis.