

Software Requirements Specification for The Nursery Project: The Pot-Pulator

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Contents

1	Reference Material	iv
1.1	Table of Units	iv
1.2	Table of Symbols	iv
1.3	Abbreviations and Acronyms	v
1.4	Mathematical Notation	v
2	Introduction	1
2.1	Purpose of Document	1
2.2	Scope of Requirements	1
2.3	Behavioural Overview	2
2.4	Characteristics of Intended Reader	2
2.5	Organization of Document	3
3	Project Constraints	3
3.1	System Context	3
3.2	User Responsibilities & Characteristics	3
3.3	System Constraints	3
4	Functional Requirements	4
4.1	Tray Dispensing Functional Requirements	4
4.2	Pot Dispensing Functional Requirements	4
4.3	Conveyor Requirements	5
4.4	Verification Requirements	5
5	Nonfunctional Requirements	5
5.1	Appearance Requirements	5
5.2	Usability Requirements	6
5.3	Learning Requirments	6
5.4	Accessibility Requirements	6
5.5	Speed Requirements	6
5.6	Safety Critical Requirements	6
5.7	Precision Requirements	6
5.8	Capacity Requirements	7
5.9	Reliability Requirements	7
5.10	Robustness and Fault Tolerance Requirements	7
5.11	Scalability or Extensibility Requirements	7
5.12	Expected Physical Environement Requirements	7
5.13	Maitenance Requirements	7
5.14	Requirements for Interacting with Adjacent Systems	7
5.15	Supportability Requirements	8
5.16	Compliance Requirements	8

6	Functional Requirements Likelihood of Change	8
6.1	Tray Dispensing Functional Requirements	8
6.2	Pot Dispensing Functional Requirements	8
6.3	Conveyor Functional Requirements	9
6.4	Verification Requirements	9

Revision History

Date	Version	Notes
Date 1	1.0	Notes
Date 2	1.1	Notes

1 Reference Material

This section records information for easy reference.

1.1 Table of Units

Throughout this document SI (Système International d'Unités) is employed as the unit system. In addition to the basic units, several derived units are used as described below. For each unit, the symbol is given followed by a description of the unit and the SI name.

symbol	unit	SI
m	length	metre
kg	mass	kilogram
s	time	second
°C	temperature	centigrade
J	energy	joule
W	power	watt ($W = J s^{-1}$)

1.2 Table of Symbols

The table that follows summarizes the symbols used in this document along with their units. The choice of symbols was made to be consistent with the heat transfer literature and with existing documentation for solar water heating systems. The symbols are listed in alphabetical order.

symbol	unit	description
A_C	m^2	coil surface area
A_{in}	m^2	surface area over which heat is transferred in

1.3 Abbreviations and Acronyms

symbol	description
A	Assumption
DD	Data Definition
GD	General Definition
GS	Goal Statement
IM	Instance Model
LC	Likely Change
PS	Physical System Description
R	Requirement
SRS	Software Requirements Specification
ProgName	
T	Theoretical Model

1.4 Mathematical Notation

[This SRS template is based on [Smith and Lai \(2005\)](#); [Smith et al. \(2007\)](#). It will get you started. You should not modify the section headings, without first discussing the change with the course instructor. Modification means you are not following the template, which loses some of the advantage of a template, especially standardization. Although the bits shown below do not include type information, you may need to add this information for your problem. If you are unsure, please can ask the instructor. —TPLT]

[This template document assumes that a single program is being documented. If you are documenting a family of models, you should start with a commonality analysis. A separate template is provided for this. For program families you should look at [Smith \(2006\)](#); [Smith et al. \(2017\)](#). Single family member programs are often programs based on a single physical model. General purpose tools are usually documented as a family. Families of physical models also come up. —TPLT]

2 Introduction

The current method of preparing pots and trays to be filled with soil and populated with seeds at Sheridan Nurseries is a process with little to no automation, requiring many manual labour hours. Each year, 250,000 pots need to be placed in trays, each one being placed by hand. Recently, the owners of these farms have been finding it increasingly more difficult to fill these roles with enough workers to run the operation smoothly and meet production demands.

We aim to aid in this process by designing and implementing a machine that is able to fill trays with pots and prepare them for populating with soil and seeds. This will alleviate the reliance on manual labour and improve the overall efficiency of the farm.

This introduction will outline the document's purpose, the scope of requirements, characteristics of the intended reader, and the organization of document.

2.1 Purpose of Document

This Software Requirements Specification (SRS) document is to define the purpose of the Pot-Pulator. It will describe how the software will interact with the hardware, and how it is expected to perform, defining the executable requirements leading to the creation of a final product. This document should lay the important groundwork needed for every team member to understand the in-depth technical details of the product to be developed, in preparation for the design stage.

2.2 Scope of Requirements

The branches of the Pot-Pulator include a conveyer belt, tray allocation, pot dropping and verification. These four systems will be implemented to work together to create an efficient product. It will be reliable, easily configurable, affordable, and will greatly reduce the need for hands-on labour in relation to seed population.

The system implemented will be designed exclusively for Sheridan Nurseries, and for the pots and trays at their locations in a three-dimensional workspace. It is limited to usage on their round, 4-inch diameter pots and their respective trays. Considering the conditions of the greenhouses this machine will be used in, material degradation, water resistance, and pressure will all be negligible.

In order to maintain speed of the pots being placed in trays in a timely manor, one of the goals of the machine is to fill each tray with 10 pots every 30 seconds. This is the time it will take for the trays to be populated and move down the conveyer belt. With this goal in place, the machine will only need to be refilled with pots and trays every 15 minutes, greatly reducing the amount of hands-on labour from the workers at Sheridan Nurseries.

After the initial completion of the goal associated with the 4-inch pots, larger pots and trays may be considered as a future goal. There will always be the limitation of the requirement of a rim on the top of the pot, for the machine to easily grasp onto when lifting and dropping.

2.3 Behavioural Overview

The Pot-Pulator will have 4 branches working together to accomplish the task. First, the trays and pots will be manually filled into a section of the machine, ideally 30 trays and 300 pots. The first section of the machine will drop a tray, and the conveyer belt will move it to the pot dropping section.

The conveyer belt will stop once it senses the tray is in the correct position. The machine will drop pots until all 10 spots are filled. The conveyer belt will move the tray according to the needed positions for pot dropping, dispensing 2 pots into the allocated positions, moving forward 4 inches at a time until the process is completed.

The tray filled with pots will then move into a verification system, to verify the pots have been placed in the correct positions. The conveyer belt will then move it to another conveyer system, which will lead to the collection of completed trays. The only maintenance this machine needs is the refill of pots and trays every 15 minutes, and the collection of completed trays at the end of the final conveyer belt.

2.4 Characteristics of Intended Reader

This SRS document is written for the directly individuals involved with the development of the Pot-Pulator. This includes every member of the team; all being involved with the development of the project. It is useful as reference to the functionality of in-depth details regarding the project, and will be read, reviewed, and maintained as the project progresses by all team members.

In general, any users of this document should have an undergraduate level understanding of software and hardware system functionality, physics, and mathematics.

2.5 Organization of Document

The format of this document follows the standard IEEE template divided into multiple sections. The first two sections describe the system descriptions. First a general system description defining the system context, user characteristics and system constraints. It follows with a more specific system description, where the project is looked at more closely, outlining terminology, goal statements, models and constraints.

The next section is dedicated to Requirements. This section will define functional requirements and non-functional requirements with respect to the system features. Finally, the following sections review the likely and unlikely changes of the project. It will reference any specifications that may be subject to change when further advancing with the software and hardware requirements.

3 Project Constraints

This section identifies the interfaces between the system and its environment, describes the user characteristics, lists the system constraints, and provides assumptions relating to the system/environment.

3.1 System Context

The system will consist of a stack of pots, stack of trays, and the mechanism that will autonomously populate the trays with the pots. The trays will move along a conveyor system that operates at approximately 3 feet and will act as the operating workspace for the device. Once the trays are populated with pots, they are fed into a soil potting machine in preparation for planting.

3.2 User Responsibilities & Characteristics

The user will be responsible for refilling the stacks of trays and pots when the supply is depleted. The user will also be responsible for knowing how the entire system will operate within each state. For example, if a tray fails the validation step, the user must be capable of removing the defect and resume the operation of the machine.

The characteristics of the user will ensure smooth operation and workplace safety. The user should be able to lift a sufficient weight and have a good understanding of basic functionality of the system.

3.3 System Constraints

[System constraints differ from other type of requirements because they limit the developers' options in the system design and they identify how the eventual system must fit into the world. This is the only place in the SRS where design decisions can be specified. That is,

the quality requirement for abstraction is relaxed here. However, system constraints should only be included if they are truly required. —TPLT]

4 Functional Requirements

This section provides the functional requirements of the Pot-Pulator, separated into tray dispensing, pot dispensing, conveyor, and verification requirements.

4.1 Tray Dispensing Functional Requirements

- TDR1: The tray dispenser must start when the Pot-Pulator start is pressed.
- TDR2: The tray dispenser must be able to place a standard tray from the loaded stack onto the conveyor belt.
- TDR3: The tray dispenser must be able to store multiple trays at a time.
- TDR4: The tray dispenser must stop operating once it has run out of trays.
- TDR5: The tray dispenser must be able to recognize when trays need to be reloaded and notify an operator.
- TDR6: The tray dispenser must stop when an error arises (verification failed, pot dispenser malfunction/empty, conveyor malfunction).
- TDR7: The tray dispenser must be able to reset after it has been stopped due to error or needs to reload

4.2 Pot Dispensing Functional Requirements

- PDR1: The pot dispenser must start when the Pot-Pulator start is pressed.
- PDR2: The pot dispenser must be able to place a pot into an empty place in a tray.
- PDR3: The pot dispenser must be able to dispense a 4" diameter pot.
- PDR4: The pot dispenser must be able to store multiple pots at a time.
- PDR5: The pot dispenser must stop operating once it has run out of pots.
- PDR6: The pot dispenser must be able to recognize when pots need to be reloaded and notify an operator.
- PDR7: The pot dispenser must stop when an error arises (verification failed, tray dispenser malfunction/empty, conveyor malfunction).

PDR8: The pot dispenser must be able to reset after it has been stopped due to an error or needs to reload.

4.3 Conveyor Requirements

- CR1: The conveyor must start when the Pot-Pulator start is pressed.
- CR2: The conveyor must be able to move a tray from the tray dispensing station to the verification station.
- CR3: The conveyor must be able to stop when a tray is being placed on the conveyor, or when a pot is being placed in a tray.
- CR4: The conveyor material must have a high enough friction such that the trays do not slide while in contact with the belt.
- CR5: The conveyor must stop when an error arises (verification failed, pot dispenser malfunction/empty, tray dispenser malfunction/empty).
- CR6: The conveyor must be able to reset after it has been stopped due to an error or pots/trays need to be reloaded.

4.4 Verification Requirements

- VR1: The verification must check that only one tray is being output by the conveyer belt, and the tray is filled with exactly 10 pots, such that $n_{traysout} = 1$ & $n_{potsout} = 10$
- VR2: The verification must notify all other systems if verification failes, such that $n_{traysout} \neq 1$ or $n_{potsout} \neq 10$

5 Nonfunctional Requirements

the systems nonfunctional requirements will be divided by categories for which the requirements fit into. The mention of subsystems throughout this section is a reference to the four subsystems that the project can be devided into; conveyor, tray dispenser, pot dispenser and verification.

5.1 Appearance Requirements

- NFR1: All electrical equipment and electronics must be well covered and protected. The User must not have access to equipment.
- NFR2: All wiring must be tucked away and not accessible to avoid potential woring failure.

NFR3: All moving part must be covered and protected. moving parts should be covered to protect both the mechanism and the safety of the operator.

5.2 Usability Requirements

NFR4: System must have tray and pot refill locations visible and accessible in order to provide visual verification of capacity status.

NFR5: System output (end of conveyor) must be clear and visible in order to provide visual verification and access to failed outputs.

5.3 Learning Requirements

NFR6: System must be simple to operate, requiring minimal training to operate effectively ($< 1h$).

5.4 Accessibility Requirements

NFR7: System must have both audible and visible signal outputs for each system status.

5.5 Speed Requirements

NFR8: Conveyor system must not accelerate in a manner that would shift the position of the tray. a shift in the position of the tray could result in a misalignment and potential error.

NFR9: The pot dispenser must dispense pots at a rate of 10 pots every 30 seconds, such that $t_{cycle} = 30 \text{ seconds}$ & $n_{pots}(t) = 300 - t/3$; $t \in \{30, 60, 90, \dots, 900\}$ This will allow the machine to meet the output goal required.

5.6 Safety Critical Requirements

NFR10: System must have emergency cut off. in case of any emergency this will trip off all power to system.

NFR11: System must be able to locate and identify failures within each independent subsystem.

5.7 Precision Requirements

NFR12: Conveyor must center trays before potting dispenser within 1 cm of centered position, this allows the tray to enter the pot dispensing system within tolerance for a pot to be dropped in.

5.8 Capacity Requirements

NFR13: The pot dispenser must be able to take a maximum of 30 pots from the user, such that $n_{pots}(t) \leq 300$ This will allow the machine to meet the output goal required.

NFR14: Pot dispenser should dispense pots within a 0.5 cm radius of centered position.

5.9 Reliability Requirements

NFR15: System must be able to operate under constant low and high frequency vibration (small amplitude).

5.10 Robustness and Fault Tolerance Requirements

NFR16: Components must withstand 250,000 cycles system should call for replacement parts after a full season of operation.

5.11 Scalability or Extensibility Requirements

NFR17: System must fit into the existing assembly line and should take minimal effort to implement ($< 1d$).

5.12 Expected Physical Environment Requirements

NFR18: System must withstand operating in a room with high arial polution including dust, dirt and small amounts of water.

5.13 Maitenance Requirements

NFR19: System must be built for ease of maitenance. high wear parts should be easily accessible.

5.14 Requirements for Interacting with Adjacent Systems

NFR20: system must operate at same speed as adjacent systems.

NFR21: System must operate at the same conveyor height as the current system to maintain continuity between systems.

5.15 Supportability Requirements

NFR22: System documentation must be available to troubleshoot, diagnose and fix common issues and replace high wear parts.

5.16 Compliance Requirements

NFR23: System must follow electronics system safety requirements.

6 Functional Requirements Likelihood of Change

6.1 Tray Dispensing Functional Requirements

TDR1: Very unlikely to change, key implementation of system.

TDR2: Very unlikely to change, key implementation of system.

TDR3: Very unlikely to change, key implementation of system.

TDR4: Very unlikely to change, ensures safety of operator reloading trays.

TDR5: Very unlikely to change, key implementation of system.

TDR6: Very unlikely to change, ensures safety of operator and prevents machine from dispensing trays while conveyor and/or pot dispenser are not operational.

TDR7: Unlikely to change, ensures safety of operator and robustness of Pot-Pulator. May change to be integrated with start command or resume command.

6.2 Pot Dispensing Functional Requirements

PDR1: Very unlikely to change, key implementation of system.

PDR2: Very unlikely to change, key implementation of system.

PDR3: Unlikely to change, pot size is standard across the nursery. New pots may be introduced at a future time.

PDR4: Very unlikely to change, key implementation of system.

PDR5: Very unlikely to change, ensures safety of operator reloading pots.

PDR6: Very unlikely to change, key implementation of system.

PDR7: Very unlikely to change, ensures safety of operator and prevents machine from dispensing pots while conveyor and/or tray dispenser are not operational.

PDR8: Unlikely to change, ensures safety of operator and robustness of Pot-Pulator. May change to be integrated with start command or resume command.

6.3 Conveyor Functional Requirements

CR1: Very unlikely to change, key implementation of system.

CR2: Unlikely to change, ensures accuracy of placement of trays and pots. May change to place trays on conveyor as conveyor is moving.

CR3: Very unlikely to change, key implementation of system.

CR4: Very unlikely to change, ensures safety of operator and prevents machine from dispensing pots while conveyor and/or tray dispenser are not operational.

CR5: Unlikely to change, ensures safety of operator and robustness of Pot-Pulator. May change to be integrated with start command or resume command.

6.4 Verification Requirements

VR1: Very unlikely to change, key implementation of system.

VR2: Very unlikely to change, key implementation of system.

References

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- W. Spencer Smith, Lei Lai, and Ridha Khedri. Requirements analysis for engineering computation: A systematic approach for improving software reliability. *Reliable Computing, Special Issue on Reliable Engineering Computation*, 13(1):83–107, February 2007.
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Appendix — Reflection

The information in this section will be used to evaluate the team members on the graduate attribute of Lifelong Learning. Please answer the following questions:

1. What knowledge and skills will the team collectively need to acquire to successfully complete this capstone project? Examples of possible knowledge to acquire include domain specific knowledge from the domain of your application, or software engineering knowledge, mechatronics knowledge or computer science knowledge. Skills may be related to technology, or writing, or presentation, or team management, etc. You should look to identify at least one item for each team member.
2. For each of the knowledge areas and skills identified in the previous question, what are at least two approaches to acquiring the knowledge or mastering the skill? Of the identified approaches, which will each team member pursue, and why did they make this choice?