June 12, 2022

Dr. Craig Scratchley
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

RE: ENSC 405W/440 Requirements Specification for **DIRTS**

Dear Dr. Scratchley,

Please find the attached requirement specification document for our device, Direct Interface for Rapid Testing of Soil (DIRTS) prepared by Everyday Planting Solutions for ENSC 405W/440. The device is designed to gather real-time data about the soil properties followed by a transfer of data using Near Field Communication (NFC) scanner to upload the data over an application in a phone. The results later display the compatible plants in the environment based upon given parameters. The system will be simple and relatively inexpensive for anyone to use, or for beginner gardeners hoping to learn.

The document discusses the requirements of our device based upon different product phases one of which consists of the proof-of-concept demo phase. These phases will be the basis of the projected timeline for our project deliverables. The document will discuss the general requirements relating to the feasibility for the user, as well as low-level hardware/software requirements to be followed in the design of both the phone application and the physical device.

Everyday Planting Solutions consist of five senior engineering students from different branches: Mehar Rehill and Gurparkash Singh (both biomedical), Francis Chui and Shravan Gupta (both computers) and Kyle Granville (systems). All the members are motivated towards utilizing their expertise in making this product possible.

I would like to thank on behalf of our company for taking your time out and consideration in reading the documentation of DIRTS. If you have any concerns and issues, please contact Mehar Rehill via email mrehill@sfu.ca.

Sincerely,

Mehar Rehill

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Mehar Rehill
Chief Executive Officer
Everyday Planting Solutions

School of Engineering Science

ENSC 405W

Everyday Planting Solutions' DIRTS

(Direct Interface for Rapid Testing of Soil)

Requirements Specification

Company 2

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Submitted To:
Dr. Craig Scratchley, ENSC 405W
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Abstract

Direct Interface for Rapid Testing of Soil (DIRTS) is on the verge of changing the gardening industry by providing the data to people about what exactly they need. DIRTS neither requires any extensive setup unlike other large soil testing equipment nor it needs to extract a sample of soil manually from the ground. This functionality is achieved by using sensors like moisture sensor, pH sensor, and Nitrogen-Phosphorus-Potassium measuring sensor and processing the data using a microcontroller enclosed in a waterproof casing and can be left in soil for longer periods of time. The need of DIRTS can be seen at places where people don't know which plants are best suited for different conditions. The system comes with a mobile app to acquire data from the sensor so that the user can be provided with a guide about which plants to grow or not. One of the main features of DIRTS is to set limits on the soil parameters after the user planted a plant so that a warning can be issued if something drops over the time. With the implementation of this device, people won't be clueless while taking care of their plants and less plants will die. This document states a full well detailed set of requirements for DIRTS, covering different areas like software, hardware, electrical, mechanical, safety, sustainability and provide applicable engineering standardization considerations.

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Glossary:

Term	*Definition*
CSA	Canadian Standards Association
NFC	Near-Field Communication
NPK	Nitrogen Phosphorus Potassium
OS	Operating System
pH	Potential of Hydrogen, Acidity
RFID	Radio–Frequency-Identification
UI	User Interface

1. Introduction

1.1 Background

Figure 1: showing different expressions regarding the plants

Soil is one of the essential factors in the growth of a plant. It provides anchorage for the roots, water, temperature modification, and nutrients for the plants [1]. Based on the classification of different types of soil we can deduce the soil properties into four categories: moisture (water retention), pH (potential of hydrogen) levels, NPK (Nitrogen Phosphorus Potassium) levels, and temperature. Every plant has its own specifications in respect to the soil properties in which it grows the best, considering sunlight and weather as constants.
The current market consists of several Humidity, pH, NPK and temperature sensors, but the usage of the data to plan your garden is a luxury available only to the professionals. Our company is presenting device named DIRTS, a one of its kind soil testers which not only provides the user with soil properties but also guides the user with the information about which plant or vegetable is the best for the provided data.

1.2 Intended use of DIRTS

Direct Interface for Rapid Testing of Soil (DIRTS) is a promising technology for testing moisture, pH levels, NPK levels, and temperature of the given sample of soil. The user places the sensor in the soil and the sensor will measure and collect real time data for a certain period of time and then go to sleep. The data is further transferred to user's phone through Bluetooth or RFID. After the successful transfer of the data, an app would provide a summary of the test results and will suggest plant types classified in accordance with sunlight, seasons, flower/shrubs, vegetables, or trees, in summary providing the user with a plant guide based on the soil type.
DIRTS is especially meant for people who would like to grow any kind of plants. It is a good place to start if a person has no prior knowledge about plant growth and development. Our goal with DIRTS is to have a major impact not only in the agricultural industry, but also beneficial in environmental studies.

1.3 Intended Audience

This document is meant to serve as DIRTS' requirements for the potential users, Everyday Planting Solutions (EPS) members, investors, partners, Dr. Craig Scratchley, and teaching assistants of the course ENSC405W and ENSC440.

1.4 Scope

The scope of this document is to provide a detailed and explicit description about DIRTS, including electrical, mechanical, and software components, as well as how the system complies to sustainability and engineering standards.

1.5 Requirement Classification

The understanding of the requirements throughout this paper is made easier by using the following requirement label.

REQ <Req Section>. <Subsection (optional)> - <Product Phase>

The Product Phase mentioned above is categorized as follows:

Notation	*Product Phase*	*Description*
A	Alpha Phase	Focus mainly on the proof of concept and the working/testing of individual parts. Data transfer via cable in this phase
B	Beta Phase	The product should be functional, and fabrication of casing must be in progress. Data transfer wirelessly. App development in progress
GG	Release Phase	Final assembly and testing must begin in accordance with Engineering Standards.

Table 1.5.1

2. System Overview

DIRTS is a small sensor that can be inserted on top of soil that can take measurements of pH, NPK, moisture, and temperature. It is designed to be paired with a phone application that will be able to recommend plants based on the measurements taken. The figure below shows the basic conceptual design of the system and its interaction with the phone.

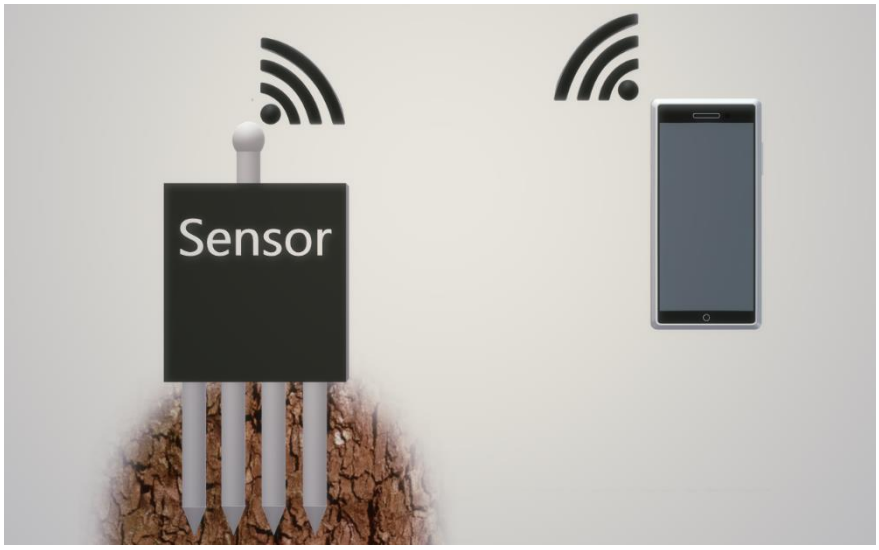

Figure 2: The expected layout of the product

Unlike other sensors available in the market for soil testing, DIRTS will make soil testing much easier by giving all the required information in one test and there wouldn't be any need to manually take any soil samples. A brief description about each sensor is shared below

2.1 NPK Sensor

The NPK sensor here is an optical transducer formed by the integration of light transmission system and light detection system [2]. Diagram below shows the basic working of the sensor.

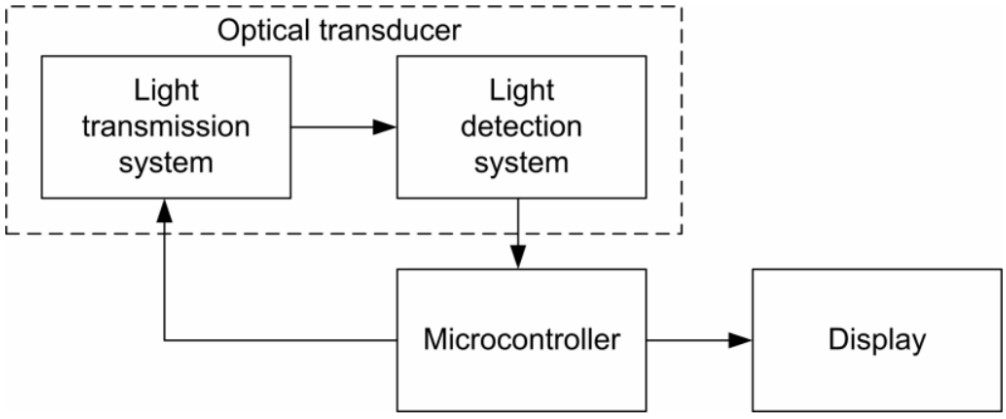

Figure 3: Block diagram of optical NPK sensor [2]

NPK- Nitrogen(N), Phosphorus(P), and Potassium(K) levels are very important to monitor as they promote the growth of plant in

different ways. This detection method is based on optical characteristics of NPK soil absorption where three different color LEDs are used to gather the information.

2.2 pH Sensor

When taking care of the plants, we must know what kind of soil nature is required. Is it acidic or basic? The pH sensor will take care of this and will give the information about biological availability of chemical components in your soil such as nutrients like phosphorus, nitrogen, and heavy metals [3]. The sensor covers the full range of 0-14 pH and have a response time of less than 1 minute. The output of the sensor is fed to Arduino or any other MCU for further processing.

2.3 Moisture Sensor

The soil moisture sensor measures the content of water inside the soil and gives moisture level as output. It can be used in both analog and digital mode and the output is gathered by connecting it to the Arduino. This sensor has two probes that allows the current to pass through the soil and then records the resistance to measure the water level [4]. If there is no water present, the soil will conduct less electricity which means more resistance and hence lower water level.

The basic working of the whole system is described below in the form of a flow chart.

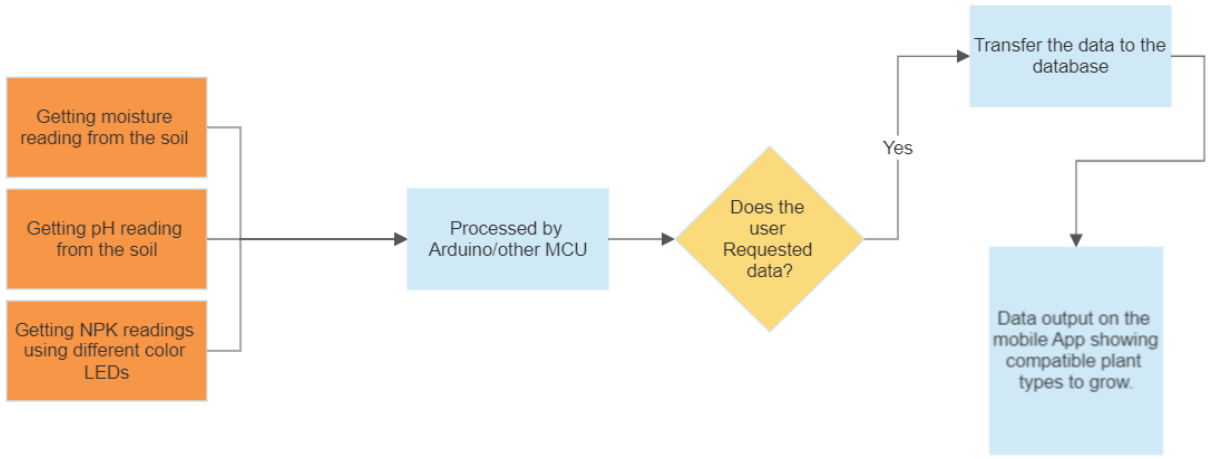

Figure 4: The flow chart for the working of the product DIRTS

3. Basic Requirements

Req. Label	*Requirement Description*
Req 3-A	The system should be allowed to use in both indoor and outdoor environments
Req 3-A	The controller must establish a connection with a wireless device via Bluetooth or Wi-Fi if possible.
Req 3-B	The controller must upload sensor data to the database
Req 3-B	The system must have the capability to be planted in soil for extended periods
Req 3-GG	Product must be simple to use after reading the manual
Req 3-GG	The final price of DIRTS shall be less than CAD 300

Table 3.1

4. Power Supply Requirements

Req. Label	*Requirement Description*
REQ 4-A	The power supply must be able to power all the components in the system.
REQ 4-A	The power supply must be within in a range of 3.3V-5V
REQ 4-B	A manual reset button must be provided to perform a hard reset.
REQ 4-B	The power supply must have the capability of switching to power-saving mode when system goes to sleep.

Table 4.1

5. Hardware Requirements

5.1 Wiring and Enclosure

Req. Label	*Requirement Description*
REQ 5.1-A	The electrical circuit must be protected to reduce risk of damage or shock
REQ 5.1-A	Wiring standards must be followed
REQ 5.1-B	Wiring must be completely contained within the device enclosures.
REQ 5.1-B	The system must be an enclosed device to make it waterproof and dustproof.

Table 5.1.1

5.2 Sensors Requirements

Req. Label	*Requirement Description*
REQ 5.2-A	The sensors must be calibrated according to the common soil type found in the region.
REQ 5.2-A	The sensor probes must be the only thing sticking in the soil.
REQ 5.2-A	Microcontroller and all the sensors must operate between 3.3V to 5V
REQ 5.2-A	The sensor must be able to provide analog signals to the MCU
REQ 5.2-A	The temperature sensor must be calibrated in Celsius with the range going up to 150C
REQ 5.2-B	A low pass filter or notch filter must be added to remove 60Hz environmental noise.

Table 5.2.1

6. Software Requirements

The software will be a simple application that serves as an interface from the hardware to the user. The software will be run on Android, written in C#. We chose android because we believe it is easier to generate a proof of concept writing onto Android first instead of iOS. As well, the team is more experienced in C++, which is easier to transition to C#. I do not believe we should have any major performance issues, as there is no hefty data processing. Storage capacity should not be an issue, as there aren't enough data columns to make the database too large.

6.1 General Requirements

Req. Label	*Requirement Description*
REQ 6.1-A	Software must be able to run on a mobile device/tablet
REQ 6.1-A	Able to retrieve data about plants from database via name
REQ 6.1-B	Must be a user-friendly UI
REQ 6.1-B	Able to establish a connection to sensor remotely
REQ 6.1-B	Run on Android OS version 7.0 (API 24, Nougat) and newer.
REQ 6.1-GG	App will be able to advise user of plants that are suitable for the soil sensor is on
REQ 6.1-GG	App must be able to retrieve data only when user presses a button to retrieve it at that time

Table 6.1.1

6.2 Database Requirements

Req. Label	*Requirement Description*
REQ 6.2-B	Storage data of at least 100 plants
REQ 6.2-B	Each plant will have tolerances specifying pH, NPK and humidity
REQ 6.2-B	Database can exist within the application

Table 6.2.1

6.3 Performance

Our performance requirements are based on any phone that has a processing power of 2.3 GHz or better. (Example: Samsung Galaxy S8)

Req. Label	*Requirement Description*
REQ 6.3-B	Should be able to boot in less than 10 seconds
REQ 6.3-B	Connection to sensor via NFC must take less than 5 seconds when less than 10 cm from device
REQ 6.3-B	Software will exit automatically if it crashes
REQ 6.3-B	Searching for a plant in database should take less than 3 seconds

Table 6.3.1

The process of whole software side of the product is described in terms of a flow chart given below:

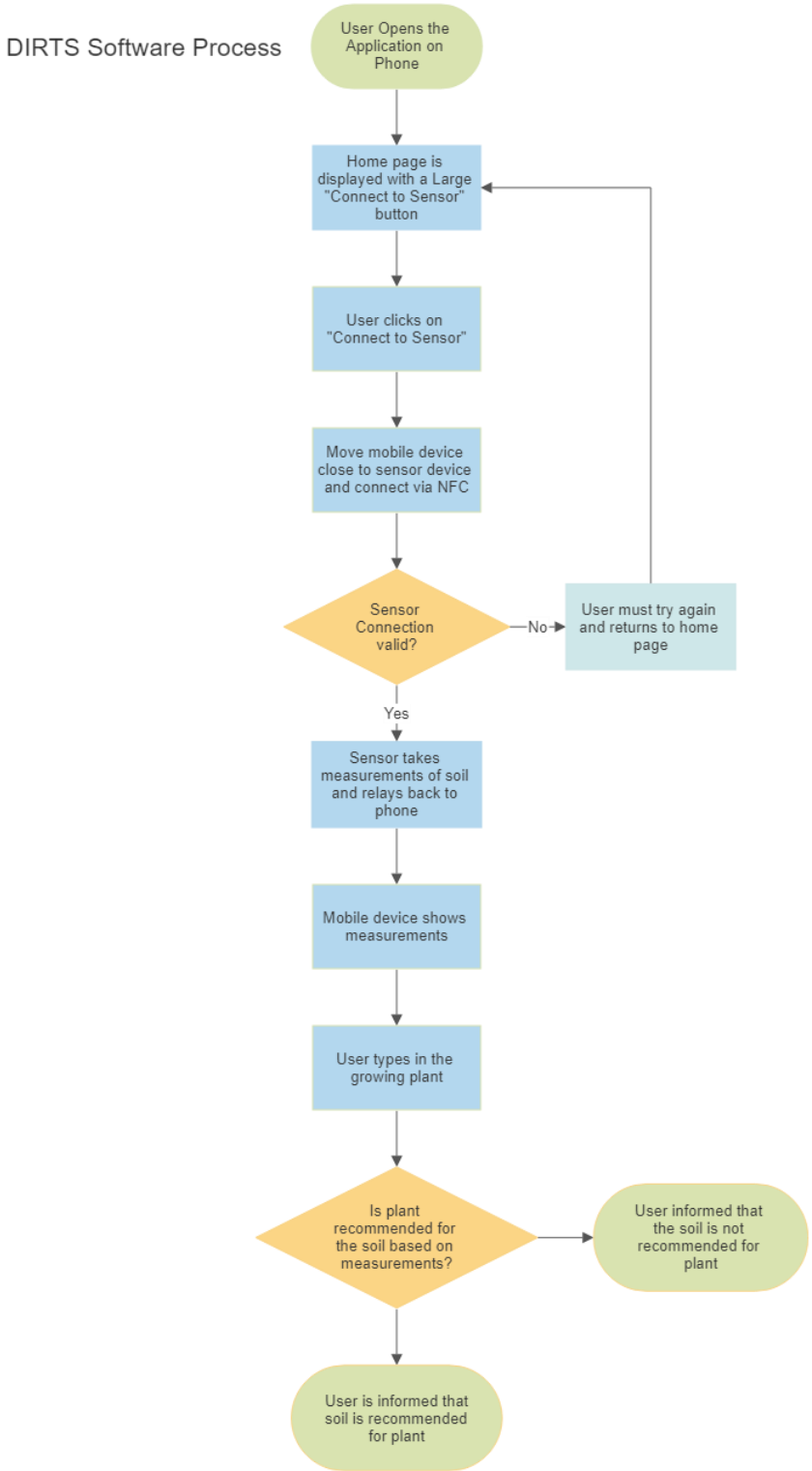

Figure 5: The flow chart showing the software working of the product DIRTS

7. Environmental Standards

The design of DIRTS will be made sure to follow the standards set by CSA group. These standards are developed with the help of various international stakeholders to provide consistency in areas of environmental management, natural resources management, energy efficiency and other important sustainability-related subjects. Our product will attempt to the following standards:

Standard	*Description*
CAN/CSA-ISO 14040-06 (R2011)	Environmental Management - Life Cycle Assessment - Principles and Framework [5]
CAN/CSA-SPE-890-15	A Guideline for accountable management of end-of-life materials [6]
IEC 62133	Requirements for secondary batteries and cells [7]
ISO 18400-104:2018	Soil quality — Sampling [8]

Table 7.1

8. Engineering Standards

Standard	*Description*
CSA C22.2 No. 0-10	General requirements - Canadian electrical code, part II [9]
CSA C22.2 No.0.23:15	General requirements for battery-powered appliances [10]
ISO/IEC TR 24774	Standards for developing a software project lifecycle process [11]
IEEE 829 -2008	IEEE Standard for Software and System Test Documentation [12]
IEEE 802.15.1	WPAN/Bluetooth [13]
C22.2 No. 205-17	Signal Equipment [14]
IEC 60335-1:2020	Safety of electrical appliances for household and similar purposes [15]

Table 8.1

9. Sustainability and Safety

9.1 Sustainability

The goal of EPS is not only to make better and affordable devices, but also committed in creating sustainable devices. Our motive is to make DIRTS feasible in a way that in the end of its life

cycle, the parts must be either recycled or reused. Moreover, we want the product to be robust so that a single battery replacement would be enough to make it work again.

The system will include sensors and a battery along with an enclosure, rest the working will be based on a mobile app. Different soils and plants used in the process of testing the system would be replanted to ensure minimum damage to the environment. Any damaged or unused components would be recycled at the recycling depot. Moreover, electrical components will be chosen in accordance with the standards of recycling processes.

9.2 Safety

Req. Label	*Requirement Description*
REQ 9.2-A	All electrical connections would comply with CSA C22.1 [4]
REQ 9.2-A	All electronic components would be adequately insulated from detrimental conditions to reduce the risk of device damage and fire hazards.
REQ 9.2-A	All interconnects would be electrically insulated to prevent damage
REQ 9.2-B	Warnings shall be posted in appropriate, high visibility locations to notify the user of hazards.
REQ 9.2-GG	The procedure must provide information for secondary batteries and battery installations

Table 9.2.1

10. Conclusion

The document provides a detailed description of the requirement specifications for the successful completion of our capstone project (DIRTS). The device DIRTS is a promising product which is not only restricted to the field of agriculture or household gardening it can also be beneficial in environmental studies. The requirements cover specification regarding electrical, embedded system, app development and data analysis components of DIRTS. Furthermore, the document covers a vivid description of environmental, safety and sustainability requirements which would be needed to make DIRTS a successful project. The requirements also contribute to the engineering standards to validate DIRTS as a planter's best guide. The development of DIRTS is currently divided into 3 phases –alpha, beta and release phase after which DIRTS will be ready to change lives.

11. References

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