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October 8, 2012

Dr. Andrew Rawicz
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Re: ENSC 440 Functional Specification for QuickScan Mapping Device

Dear Dr. Rawicz,

Enclosed is our *functional specification document for a QuickScan Mapping Device*, which further describes our company's product. We are designing a portable scanning device that will quickly measure the area of a given room in 3D space. This device will eliminate the need of manually measuring the dimensions using measuring tape or similar tools.

The functional specification outlines a set of high-level requirements for the system's functionality for both the proof-of-concept and production phases of development. We will use this document to be a guide for research and development activities. As well, we will use it for unit and integration testing as the minimum standard of requirement.

Dimension Technologies consists of five senior engineering students, Chris Kwong, Oliver Huang, William Chiang, Rahul Thomas, and Jack Zhang. We have a wide range of abilities with systems, electrical, and computing background.

If there are any questions or concerns regarding our document or device, please contact me by phone at 604-807-0486 or by e-mail at rmt3@sfu.ca..

Sincerely,

Rahul Thomas
CEO
Dimension Technologies

Enclosure: *Functional Specification for a QuickScan Mapping Device*

FUNCTIONAL SPECIFICATION:
QUICKSCAN MAPPING DEVICE

dimension technologies

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Executive Summary

The QuickScan Mapping Device is a product that Dimension Technologies is developing to assist building professionals in the industrial & residential sectors. The present rapid growth that the world is experiencing has led to an increase in the demand for facilities and houses. Typically, one main consideration in each of these cases is the size and dimensions of different property areas. Dimension Technologies' product will solve these questions through a relatively low cost product. While other solutions have been developed in the past, QuickScan is a standalone device that measures room dimensions in a very short time.

The QuickScan module consists of a high precision distance center that sends data through various signal processing hardware and tools in order to create a 3D render of a given room or area onto the controlling laptop. There are many features and functions that we would like to support in order to best meet our customers' needs. However, in order maintain a tight schedule and budget; we have sorted out these desired features into different levels of priority.

Some of the critical features that we will support are:

- The distance and colour sensor will be able to rotate 360° horizontally and 20° vertically
- The device will be able to sense objects within a 25 ft distance
- The platform supporting the sensor should be adjustable in height
- The user will be able to control rotation angle through a GUI
- The QuickScan device will be completely battery powered

Additionally, some other features that are of lower priority are:

- Laptop to QuickScan connectivity will be wireless
- The device will be able to measure rotation angles with an accuracy of 0.2°
- Device will contain an ON and OFF switch
- The device will be able to operate for 5 straight hours of normal operation

Please note that the features mentioned above are only a few. The following pages contain more specific details regarding the various features and specifications.

In addition to the various design features, Dimension Technologies is fully committed to meet various safety and design standards such as CSA, FCC, etc. Quality & safety are two values that are at the core of our team. Thus we will ensure to develop a high quality, safe and secure product.

Our proposed design features will be implemented in the final QuickScan module. The targeted completion date is the first weeks of December 2012.

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Glossary

3D – Three Dimensional

CAD – Computer Aided Design

CPU – Central Processing Unit

CSA – Canadian Standards Association

dB – Decibels

EM - Electromagnetic

FCC – Federal Communications Commission

GUI – Graphical User Interface

IR – Infrared

kHz - Kilohertz

LED – Light Emitting Diode

MTBF – Mean Time Before Failure

MTTF – Mean Time to Failure

PCB – Printed Circuit Board

USB – Universal Serial Bus

Wi-Fi – Synonym for WLAN – Wireless Local Area Network

1. Introduction

The QuickScan mapping device is relatively low cost device that can be used by drafters and realtors for various dimensioning applications. It provides a quick and accurate method for creating a 3D render of a given room and extracting the desired dimensions. It is compatible with industry standard CAD tools such as AutoCAD and MeshLab. This document contains an extensive list of requirements and specifications that Dimension Technologies will implement in the QuickScan prototype. Each requirement has been categorized based on applicable subcomponents and prioritized based on feature priority.

1.1 Scope

This document contains detailed requirements for QuickScan. Each requirement has been classified based on priority. All brought together, the high priority requirements makeup a functioning proof of concept model. These requirements will act as a baseline in our development process. Lower priority requirements will be added to the working model as enhancements (if time permits).

1.2 Intended Audience

This functional specification has been written as a guide throughout the design process. Members of Dimension Technologies will use these requirements when planning and implementing the various features. The progress of the project can also be measured by comparing implemented features to the required features. These features will serve a benchmark in the testing stage.

1.3 Requirement Classification

Due to the nature of this document, there are many features and requirements that have been listed throughout. In order to aid reviewers, we will use a classification system when listing each requirement. The labeling system is as follows:

[R#-n P]

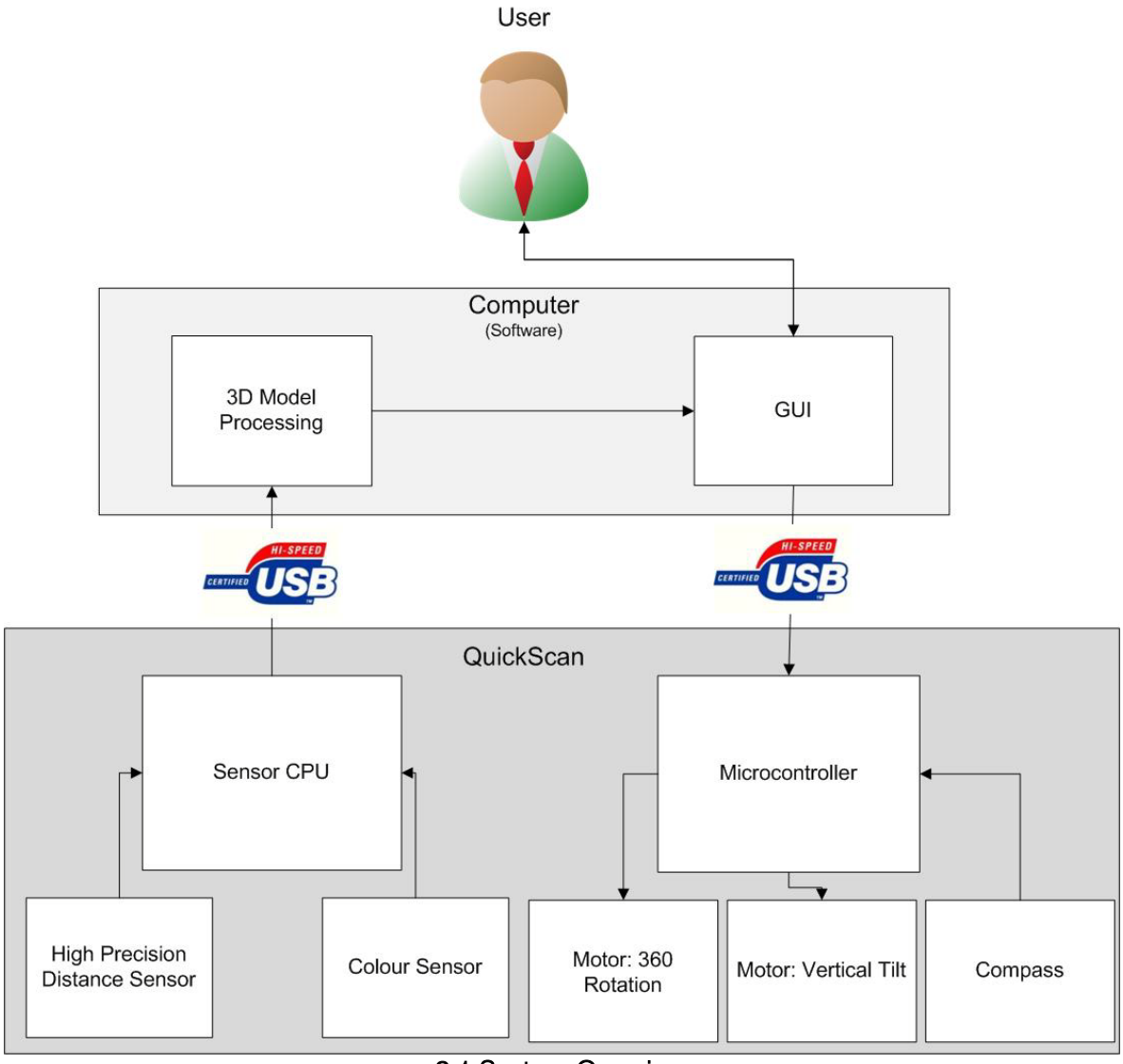
- Requirement section number
n - Requirement number
P - Requirement priority:

- PA - Critical Requirement - A high priority requirement that must be implemented in final module
- PB - Enhancement Requirement - A medium priority requirement that will be implemented if time permits. These requirements will greatly increase effectiveness of working model.
- PC - Minor Requirement - A low priority requirement that will only be implemented if time permits. Such a requirement will not affect final product drastically.

2. System Requirements

2.1 System Overview

The QuickScan block diagram overview, from a high level, can be seen in Figure 2.1:

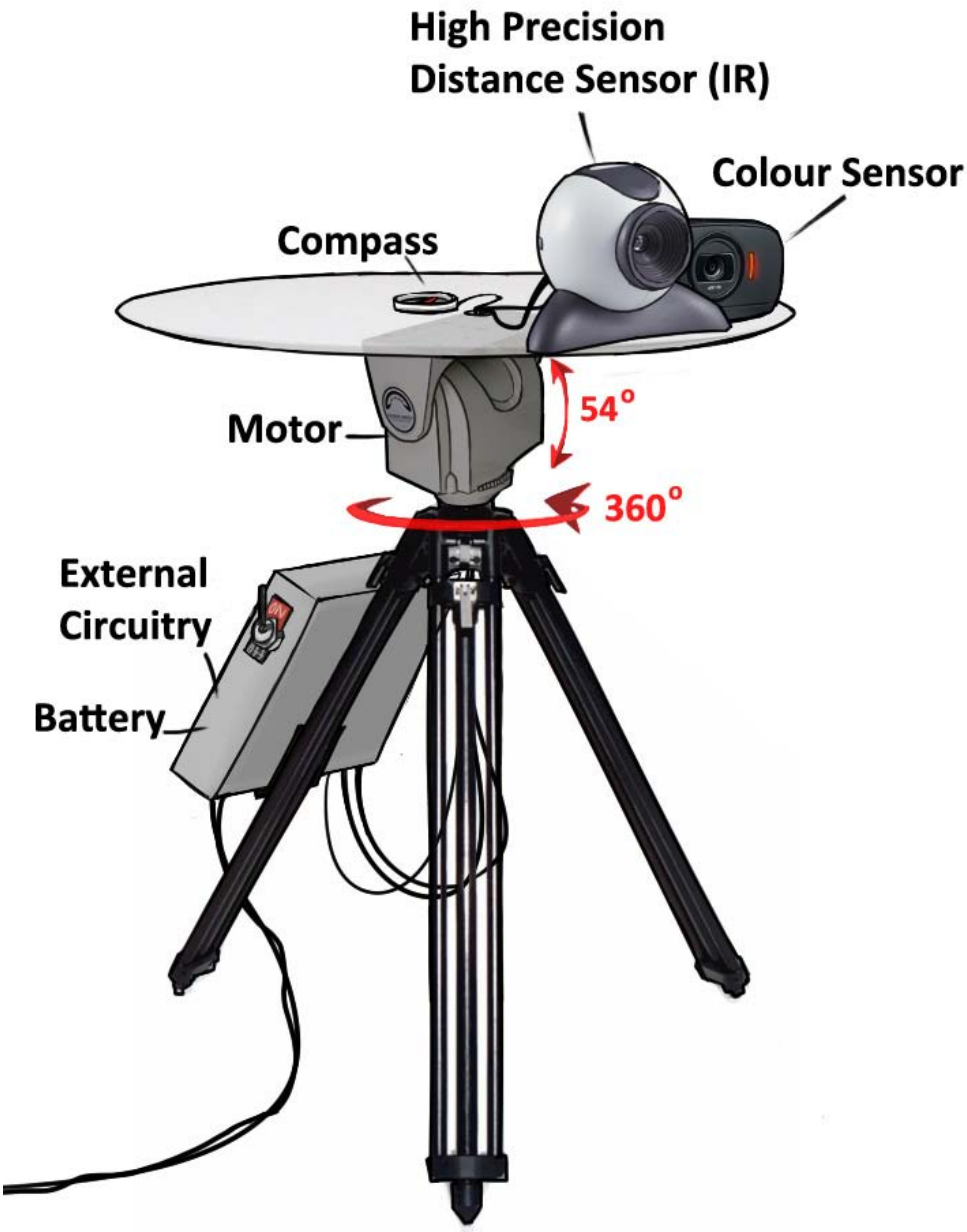


2.1 System Overview

QuickScan can be broken up into two modular subcomponents

1. QuickScan Distance Sensing Module
2. Processing software

Figure 2.2 displays a 3D model of the QuickScan Distance Sensing Module. The major components and subsystems have been identified.



2.2 QuickScan Model

The distance sensing module consists of the following subsystems:

- High precision distance & colour sensor used for 3D reconstruction of various rooms
- Development boards (w. microcontroller) to aid in digital & analog signal processing
- Motor subsystem (motor & driver) to enable 360 degree rotation of sensor and vertical panning for increased spatial coverage
- Compass sensor that will be used to indicate cardinal directions and degree of rotation
- Battery Module will be used to increase portability and remove the need for external electrical power cables

The second major subcomponent is the software interface that will be executed on the user's laptop. This software will be the central hub of control and communication between the user and the sensing module. It will contain a GUI which will allow the user to initiate the spatial scan process and output the data to a viewable design file. Further enhancements such as custom rotation angle selection and real time mesh mapping may be supported if there is adequate time.

A variety of development platforms exist for the software interface. However, for the purposes of this prototype, Dimension Technologies will develop the software component to execute on a Microsoft Windows operating laptop.

The following sections will provide a variety of system and subsystem level requirements using the classification system mentioned in section 1.3.

2.2 General Requirements

[R2.2-1 PA] The final device must cost less than $500.00 CAD

[R2.2-2 PA] The device must not have loose wires and all cables must be safely routed

[R2.2-3 PA] The device must not have a cable to connect to an external power source - device is battery powered

[R2.2-4 PA] The device will meet physical requirements outlined in section 2.3

[R2.2-5 PB] The prototype should be aesthetically pleasing to the user

[R2.2-6 PC] The device will have a power switch to easily turn ON or OFF

2.3 Performance Requirements

[R2.3-1 PA] Device must be able to detect objects from 20 ft away

[R2.3-2 PA] Device must be able to scan 360° radially

[R2.3-3 PA] Device must be able to tilt sensor vertically to improve coverage performance

[R2.3-4 PA] Sensor height must be adjustable (see [R2.4-1 PA])

[R2.3-5 PA] Scan process will take no longer than 2 minutes per room

[R2.3-6 PB] The compass device must be able to measure rotated angle with an accuracy of at least 0.2°

2.4 Physical Requirements

[R2.4-1 PA] The device's scanning platform must be adjustable in height in order to decrease coverage limitations

[R2.4-2 PA] The device must be able to fit through regular sized doorways

- [R2.4-2a PA] Device height must be able to retract to less than 5 ft. in height
- [R2.4-2b PA] Device width must not exceed 75 cm
- [R2.4-2c PA] The device's radial distance must not exceed 37 cm

[R2.4-3 PB] The device must be easily transportable by the user, thus is should not weigh more than 70 lbs

[R2.4-4 PB] The device will not be physically harmful to users - sharp edges and points will not be present

[R2.4-5 PC] The device will operate with relatively low noise and will not be a nuisance to others

2.5 Mechanical Requirements

[R2.5-1 PA] Stepper Motor must be able to rotate sensor 360°

[R2.5-2 PA] Stepper Motor must have a step angle accuracy of at least 0.2°

[R2.5-3 PA] Motor and motor driver must operate from a 12V supply battery

[R2.5-4 PA] Mechanical components will not be visually obstructive in the scanning process

[R2.5-5 PC] Mechanical components will not be physically obstructive

2.6 Electrical Requirements

[R2.6-1 PA] All electronic components including external sensors must be securely fastened onto device

[R2.6-2 PA] Device will be battery powered

[R2.6-4 PA] Electrical cables will be insulated

[R2.6-3 PB] No electrical cables will be exposed to the user (other than USB connection)

[R2.6-5 PC] All components and chips will be incorporated into a PCB module

[R2.6-6 PC] The device battery will be able to last for at least 5 hours of continuous operation

2.7 Environmental Requirements

[R2.7-1 PA] The device will be built to operate indoors

[R2.7-2 PA] The device will only operate in dry conditions

[R2.7-3 PA] The device will operate normally in humidity conditions between 30 to 60% [1]

[R2.7-4 PA] The device will operate under conservative room temperatures: 5-35 ℃ [1]

[R2.7-5 PC] The noise generated from device operation will be no more than 30 dB [2]

2.8 Safety Requirements

[R2.8-1 PA] Device must be well grounded and cannot be easily tipped onto its side

[R2.8-2 PA] No electrical cables will be exposed

[R2.8-3 PB] Internal components will not be exposed but will be easily accessible to qualified technicians

[R2.8-4 PC] An LED light will be incorporated to identify if the device is ON or OFF

[R2.8-5 PC] Device will contain a quick power shut off switch

2.9 Reliability Requirements

[R2.9-1 PA] The device can be easily disassembled for debugging and upgrades

[R2.9-2 PA] The device will be easily serviceable by trained technicians

[R2.9-3 PB] Software components will be easily upgradeable

[R2.9-4 PC] The device will meet the following reliability benchmarks: [3] [4]

- [R2.9-4a PC] MTTF = 100,000 hours [5]
- [R2.9-4b PC] MTBF = 80,000 hours [6]

3. User & Device Interaction

This section will discuss the various functional specifications that are required in the interaction between the user and the QuickScan device. The software GUI interface that Dimension Technologies is developing will serve as the sole method of communication and interaction between the user and QuickScan. The GUI can be interfaced through a laptop operating Windows. The user will be able to control the angle of horizontal rotation and initiate the scan process through this GUI. Additionally, the GUI will export the meshed dimension data to a file that can be viewed in industry standard CAD tools. The dimensions of the room will also be exported in this process.

The following is a list of requirements that are specific to the user and device interaction (i.e. software GUI):

3.1 General Requirements

[R3.1-1 PA] Software will be executable on a Windows based machine

[R3.1-2 PA] Software will be built up from Microsoft .NET Framework 4.5

[R3.1-3 PA] Software will be upgraded periodically

[R3.1-4 PA] GUI interface will be aesthetically appealing and easy to use

[R3.1-5 PA] GUI interface will allow user to control angle of sensor rotation and start scan process

[R3.1-6 PA] The user can connect laptop to QuickScan via USB connection

[R3.1-7 PA] Software must be able to terminate without damaging hardware

[R3.1-8 PA] Software will not interfere with normal operation of user's laptop

[R3.1-9 PC] The user can connect laptop to QuickScan via Wi-Fi & Bluetooth

[R3.1-10 PC] Software processing will take less than 2 minutes

3.2 Data Processing

[R3.2-1 PA] Software will collect data from development boards via USB

[R3.2-2 PA] Software will be able to control angle rotation to a high degree of precision

[R3.2-3 PA] Software will process the collected data into a viewable CAD drawing:

- [R3.2-3a PA] CAD drawing will be viewable in major CAD tools (AutoCAD, MeshLab)
- [R3.2-3b PA] Cardinal directions will be indicated
- [R3.2-3c PB] Dimension of room will be indicated in standard metrics

4. Electrical Subsystem

This section lists the various requirements and standards that will be met for the various electrical components including sensors, batteries, components, and interconnects.

4.1 General Requirements

[R4.1-1 PA] Electrical interconnect paths will be as short as possible to avoid additive noise in system

[R4.1-2 PA] Electrical interconnects paths will be a right angles between each other to avoid cross talk between paths

[R4.1-3 PA] Electrical interconnects will lay flat on breadboard and/or PCB to avoid EM interference issues

[R4.1-4 PA] Electrical wires will be insulated

[R4.1-5 PB] Device will be powered using standard, readily available batteries

[R4.1-6 PC] All electrical sensors and components will be securely mounted on device with acceptable wire management

4.2 Standards

[R4.2-1 PB] All electrical components and sensors will comply with the following CSA electrical codes: [7]

- CSA-C22.2-0.12-M1985: Wire spacing and wire bending regulations [8]
- CSA-C22.2-0.2-93: Wire insulation regulations [9]
- CSA-C22.2-0.8-12: Electronic Safety [10]

[R4.2-2 PB] All microcontrollers and sensors operating above 3 kHz will comply with EMC standards and ICES-003 Information Technology Equipment standards [11] [12]

5. User Documentation

[R5-1 PB] User documentation will be written for a non-technical audience but will also include an appendix with extensive technical details

[R5-2 PB] User documentation will contain text, figures, graphics and tables to enable the user to easily understand device operation

[R5-3 PB] User documentation will be written in English

[R5-4 PB] This documentation will cover the scope of the software interface and the hardware components on the physical device

6. System Test Plan

Dimension Technologies will perform many rigorous tests in order to make sure that our device meets the functional specifications. Tests will be split into subcategories based on the specific components involved; this includes: sensors, motor, software, and batteries. As the subsystem tests are completed, we will verify the device as a whole in order to make sure that it has adhered to its functional requirements. Finally, physical tests will be conducted to make sure our device can handle stress and to ensure that our device will not be harmful to our consumers.

6.1 Sensor Tests

The sensor subsystem of our device involves the high precision distance sensor, the colour sensor, and the CPU that controls these sensors and interacts with external systems. Various tests will be performed to make sure that this subsystem can accurately measure the distance and colour of all objects in its view. These tests include, but are not limited to:

- Measuring the accuracy of the distance sensor by placing an object at a predetermined distance, and comparing it to the sensor's given value.
- Repeating the accuracy measurements by placing objects at the both extremes of the sensor's practical range limits.
- Measuring the accuracy of the colour sensor using an object with a predetermined colour, and comparing it to the sensor's given colour value.

6.2 Motor Tests

The motor subsystem of our device involves two motors (one for 360° rotations and one for vertical tilts) as well as a microcontroller that will be responsible for controlling the motors. The motors will be tested to turn or to tilt at the specified angles. As well we will verify that the microcontroller will be able to control these motors independently as well as simultaneously. These tests include, but are not limited to:

- Commanding the microcontroller to move the rotational motor by a predetermined angle, and then measure the angle of movement.
- Rotating the motor after placing a load of equal or heavier weight of our device.
- Commanding the microcontroller to tilt the motorized pivot by a predetermined angle, and then measure the angle of movement.
- Rotating and tilting the two motors simultaneously

6.3 Software Tests

The software subsystem consists of the user GUI as well as the necessary 3D processing required in order to create a 3D model. Since this is a higher level subsystem, these tests will not be conducted until the sensor and motor tests are completed. In this test suite, the 3D processing software will be tested to make sure it's capable of performing all the necessary functions. These tests include, but are not limited to:

- Using the 3D modeling process to read inputs from the sensors, making sure that the inputs are valid
- Placing the device in a room and scanning the entire room, making sure the 3D modeling process can stitch multiple 3D images together in order to create a 3D model of the room.

As well, several GUI options and manual controls will be verified. These tests include, but are not limited to:

- Using the GUI to manually rotate the motor at a specified angle
- Using the GUI to manually pivot the vertical motor at a specified angle
- Using the GUI to manually take sensor readings
- Using the GUI to initialize the entire scanning process (this includes automatically controlling the motors, taking the inputs, creating and viewing the 3D model)

6.4 Battery Tests

Our device will be powered by an external battery. As specified in the electrical requirements prior, the device battery should last for five hours of continuous operation. To verify this requirement, we will:

- Repeat the entire scanning process over a five hour period, verifying that the device has enough power to operate over this period.

6.5 Physical Tests

Lastly, in order to ensure the safety of our device, a variety of physical tests will be performed on the overall system. These tests will consist of:

- Drop tests to check for device characteristics upon fall and tipping
- Stress tests – apply a reasonable amount of force and observe device's response

We will perform all of the above tests both individually as well as in various combinations with each other. These tests will also be repeated multiple times while we are assembling our device. This will ensure that problems that arise during the design process are dealt with as efficiently as possible. These tests will be repeated again once we have completed our prototype. This will ensure that our final prototype will meet all aforementioned requirements in terms of functionality, performance, and reliability.

7. Conclusion

This document has outlined all the functional and design requirements for the QuickScan device. Dimension Technologies is fully committed to implementing the critical features that were previously listed. We will ensure to maintain a high level of safety and reliability. Lower priority features will be implemented if time permits and all the critical requirements have been successfully implemented. A final prototype is expected to be completed by the first week of December 2012.

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