ENSC 305W/440W Grading Rubric for Functional Specification

Criteria	Details	Marks
Introduction/Background	Introduces basic purpose of the project.	**/05%**
Content	Document explains the functionality of the proposed product without excessive design content (i.e., outlines the "what" rather than the "how").	**/10%**
Technical Correctness	Ideas presented represent valid functional specifications that must be considered for a marketed product. Specifications are presented using tables, graphs, and figures where possible (rather than over-reliance upon text).	**/15%**
Process Details	Complete analysis of problem. Justification for chosen functionalities. Sources of ideas referenced. Specification distinguishes between functions for present project version and later stages of project (i.e., proof-of-concept, prototype, and production versions). Comprehensively details current constraints.	**/20%**
Engineering Standards	Outlines specific engineering standards that apply to the device or system and lists them in the references.	**/10%**
Sustainability/Safety	Issues related to sustainability issues and safety of the device are carefully analyzed. This analysis must cover the "cradle-to-cradle" cycle for the current version of the device and should outline major considerations for a device at the production stage.	**/10%**
Conclusion/References	Summarizes functionality. Includes references for information from other sources.	**/05%**
Presentation/Organization	Document looks like a professional specification. Ideas follow in a logical manner.	**/05%**
Format Issues	Includes letter of transmittal, title page, executive summary, table of contents, list of figures and tables, glossary, and references. Pages are numbered, figures and tables are introduced, headings are numbered, etc. References and citations are properly formatted.	**/10%**
Correctness/Style	Correct spelling, grammar, and punctuation. Style is clear concise, and coherent. Uses passive voice judiciously.	**/10%**
Comments		

SIGNATUS INC.

School of Engineering Science
Simon Fraser University
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Burnaby, BC Canada

October 17th, 2013

Professor Lakshman One
School of Engineering Science
Simon Fraser University
Burnaby, BC V5A 1S6

RE: ENSC 440 Functional Specification for a Wireless Leak Detector and Inhibitor System

Dear Professor Lakshman One,

The attached document contains the functional specification for Signatus Inc's Wireless Leak Detector and Inhibitor System. The end goal is to develop a dependable, scalable system that detects water leakage around the property and is able to automatically shut off the main water source to the property in order to prevent water damage to the property. The purpose of this document is to outline the set of functionalities that our system requires such that the system is operational and marketable. The sections below will provide specific functional requirements for the various components of the system. During the product design procedure and at the end of the finished prototype, this list of functional specifications will be reviewed to ensure a quality product that meets all of the required criterion. A test plan is also attached to explain the methodologies that will be applied to verify the functional requirements laid out in this document.

Signatus Inc. consists of four motivated and talented senior engineering students: Petar Arnaut, Olivier Thomas J, Chris Fontaine, and Barry Zou. If you have any questions or concerns about our functional specification, please contact me by phone at (604) 328-4996 or by email at paa9@sfu.ca.

Sincerely,

Petar Arnaut

Petar Arnaut
Chief Executive Officer
Signatus Inc.

Enclosure: Functional Specification for a Wireless Leak Detector and Inhibitor

Functional Specification

Wireless Leak Detector and Inhibitor

SIGNATUS INC.

Petar Arnaut
Chief Executive Officer

Olivier Thomas
Chief Operating Officer

Chris Fontaine
Chief Technical Officer

Barry Zou
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Submitted to: Lakshman One (ENSC 440)
Mike Sjoerdsma (ENSC 305)

Issue date: October 17th, 2013

Executive Summary

Most owners of condominiums or houses are considered inexperienced in successfully safeguarding their homes against property damage. Purchasing property insurance can be expensive and overwhelming as insurance plans can vary greatly between the degrees of coverage each company provides. Therefore, homeowners decide to purchase policies based on recommendations, or perhaps none at all. When it comes to property water damage, this can result in the loss of items that cannot be replaced, extensive restoration to the home and in extreme cases, relocation of tenants during the renovation. It is common for most home owners to notice a leak when it is already too late, as water can cause excessive damage in a short period of time. If homeowners do have insurance, the claims can often be tricky and take a lengthy duration before homeowners can collect their funds. Most insurance plans do not provide coverage for all water damage accidents, resulting in a more expensive insurance plan. For large scale water leaks, the damage amount can exceed the homeowner's coverage and result in incurring costs even with an insurance plan.

Signatus Inc. has created a solution to assist homeowners in taking matters into their own hands. Our proposed Wireless Leak Detector and Inhibitor system will achieve this goal of preventing water damage to homeowners. The proof-of-concept model will provide the following key functionality to allow homeowners control over protecting their homes to water damage:

- Easily movable sensor mats to detect water leakage.
- An electronic valve capable of turning the water main off to prevent water flow.
- Management software to allow for ease of monitoring and customizability.
- Battery operated devices and wireless connectivity, for ease of use and installation.
- All devices to be safe to use and environmentally friendly, within the systems capabilities and budget constraints.

Safety is critical for all modules of the system since the project is dealing with electrical components that are in close proximity to water and this will be taken into consideration during the design. The proof of concept prototype and production model will meet the safety standards outlined in this document. The standards from CSA, ATSM, IEEE, and other official associations regarding property, plumbing, electrical and safety regulations will be met.

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List of Figures

Glossary

ISR - Interrupt service routine

IEEE - Institute of Electrical and Electronics Engineers standards

IEC - International Electrotechnical Commission

ISO - International Organization for Standardization

ASTM - American Society for Testing and Materials

CSA - Canadian Standards Association

ANSI - American National Standards Institute

LED - Light Emitting Diode

OSHA - Occupational Safety and Health Administration

IP - Ingress Protection Rating

FCC - Federal Communications Commission

PC - Personal Computer

1 Introduction

The Wireless Leak Detector and Inhibitor System will consist of 3 main components: a leakage detector, water source inhibitor and a management software suite. The detection unit shall be created using multiple water sensors spread over an area to prevent false positives. Multiple water sensors on a single mat must provide positive water readings to ensure that false positives do not trigger a response from the system. When a genuine leak is detected, the inhibitor and management software will be notified. The inhibitor and management software shall then choose an appropriate solution depending on the user's customization settings. Multiple preconfigured settings will be available for the user to choose between, such as an automatic setting to shut off the water valve without user involvement in the case where the user is either not at the property location or does not wish to have to manually disable the valve. Another preconfigured setting will allow for the user to be notified of a possible leak and the location of the device without automatically turning off the water valve. This could be potentially useful for apartment buildings or other areas with multiple tenants. These device settings are changed through the user management software, which will also display the battery status of devices and leakage information in an easy to use and intuitive user interface for ease of use and customizability.

1.1 Scope

This document lists the functional specifications and requirements that Signatus Inc. will follow when designing the Wireless Leak Detector and Inhibitor system. This document describes the features of this system, what this system will perform and what such a system will provide to the end user. This document will not be used to describe low level details about specific implementation methods that will be applied to meet the technical requirements of creating such a system.

1.2 Stakeholders and Audiences

This functional specification document will be utilized by the members of the Signatus Inc. team. The engineers at Signatus Inc. will use this document as a strict guideline when developing each feature. The team will use the document in the final testing stages to ensure initial design requirements were met.The upper level managers will be able to use this document to assess the progress and success of the final product.

1.3 Requirement Convention

The following convention will be followed for all requirements

[Requirement Number - Priority] Functional requirement

The priority of the requirements will be defined as followed

1 - Critical to the overall design of the prototype and must be implemented for the prototype.
2 - Will be implemented in the prototype, if time permits.
3 - Implementation not planned for prototype, but will be implemented for the future production version.

2 System Overview

The Wireless Leak Detector and Inhibitor System is comprised of a detector unit, inhibitor unit and software management unit. Users can position detector units wherever a leak may occur. When a leak is detected by the detector unit, a signal is sent to the inhibitor which will shut off the electronic valve attached to the main. In addition, the system will allow for an auditory alarm on the detector unit to further notify the user of a leak location. Moreover, the inhibitor sends a signal to the software management unit to further notify the user and take further action preconfigured by the user.

A high level design diagram of the Wireless Leak Detector and Inhibitor System is shown in Figure 1 below.

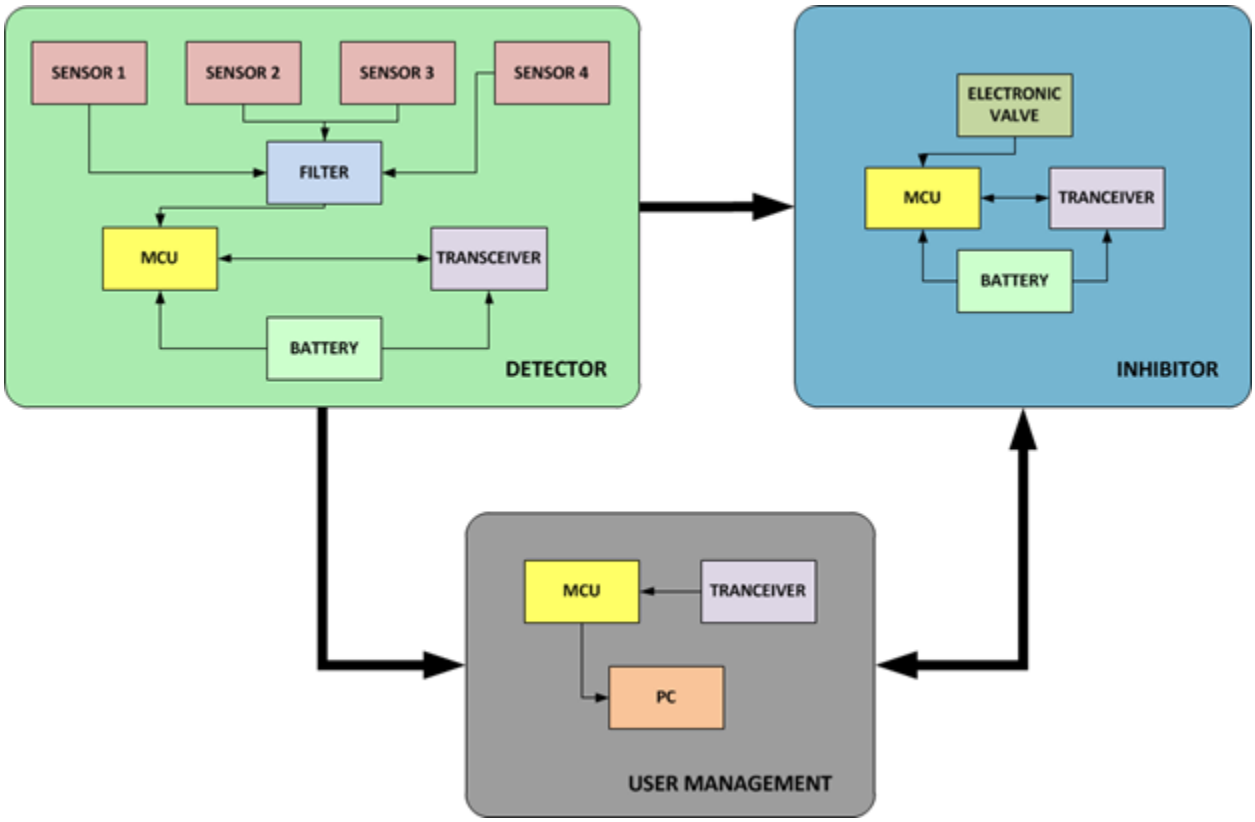

Figure 1: System Overview

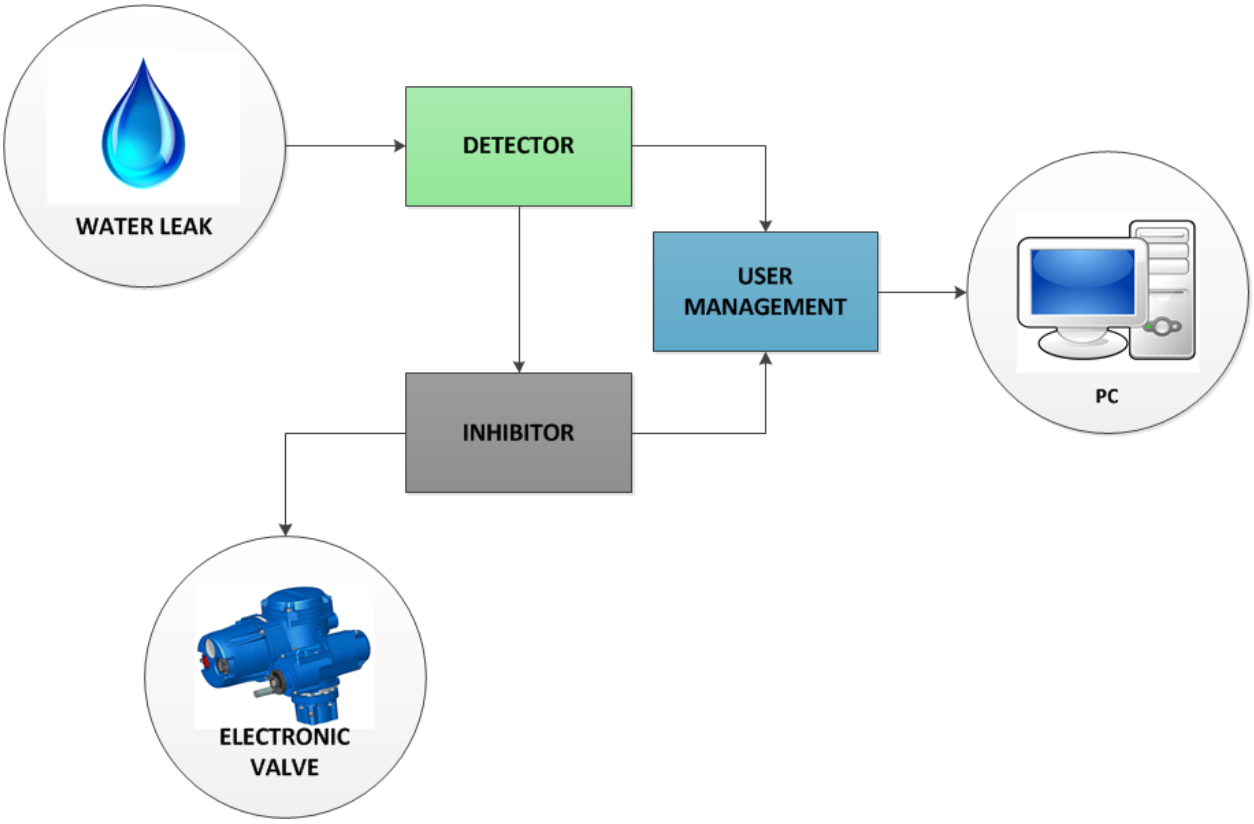

Figure 2: Conceptual Diagram

The system requirements are separated into three major groups: general requirements, hardware requirements, and software requirements.

2.1 Safety Analysis

Safety is a critical matter taken into consideration when developing this system. Although the system is relatively low key in terms of the number of possibilities of causing harm to the user, because of the presence of such electronic devices being placed in close proximity to water, applicable safety standards such as OSHA and CSA will be applied to the design of our system. The standards to be met are listed below underneath the various components they are associated with. Once installed correctly and the user management software configured, the detector is the only module that will have regular interaction with the user, which is why it will be enclosed with a rubber mat for functional and safety purposes. The specific requirements are listed below.

2.2 Sustainability Analysis

For the production model, a big design concern involves the sustainability of the device which includes cradle to cradle design. It is key to have a reusable and scalable system. The majority of the system is composed of electronic parts that are easily separated and salvaged, which can then be reused for other purposes and/or devices. Since Arduino microcontrollers will be utilized and since they are emerging as a very versatile microcontroller that can be used for a multitude of different uses, if a water detection system is no longer needed, then these microcontrollers can easily be reused for other projects. The electronic valve will be able to have the electronics removed and be reused as a normal mechanical valve. Recyclable metal shall be chosen for the electronic valve and the plastics involved will be able to be melted down and reused, in the case whereby the electronic valve is no longer needed. The detector module is easily portable and scalable, to allow for easy removal or addition to the system. A user can purchase as many detectors as they desire and they can be added to an existing system without any changes being made to the existing system. If a user has extra detectors that they no longer need, they will be easily removed from the system and a buy back system for these unused detectors is planned for the future as well. Another future addition to the company is to offer a lease system on the detectors, whereby if a user knows ahead of time that they will only need a detector for a limited amount of time, they will be able to return the product without the detector going to waste. The rubber mat material shall be made from biodegradable materials in the case that a user does throw away the detector. As the production process becomes more refined, we believe the design materials can be reduced from using microcontrollers to smaller, separable electronic circuits to further enable the reusability of the electronics. The standards complied are listed with their associated requirements below.

2.3 General Requirements

[R1-2] The system is installable on any property with a water main
[R2-2] The system is user friendly to 80% of users
[R3-2] The retail price of the system should not exceed $200
[R4-3] 80% of users shall find the mat aesthetically pleasing
[R5-1] User must provide constant internet connection in order to receive notifications

2.4 Physical Requirements

[R6-1] The detector must be able to fit within a confined space, the width/length should not exceed 1m, the height should not exceed 5 cm
[R7-3] The inhibitor should be attachable onto any pipe that adhere to ASME standards
[R8-1] Each module should be movable by the average user

2.5 Mechanical Requirements

[R9-2] An average person's weight of 185 pounds [3] can be put on a detector and not damage the circuitry located in the interior of the detector

[R10-1] Battery compartment will be easily accessible to users

2.6 Electrical Requirements

[R11-1] Detector and Inhibitor modules are battery powered, for ease of installation

[R12-1] Detector mats cannot conduct and will remain safe in proximity to water

[R13-1] The system shall remain active as long as sufficient power is sustained

2.7 Performance Requirements

[R14-1] Detector must send a signal to the inhibitor within 1 second of leak detection

[R15-1] Management software data should be updated within 1 minute of previous data reception

[R16-1] User notification must be sent within 5 minutes of leak detection

[R17-2] The battery in the detector and inhibitor should last at least 4 weeks

2.8 Environmental Requirements

[R18-1] The device will operate under average room temperatures (10-25 degrees celsius)

[R19-1] The device will operate normally in humidity conditions between 30 to 60%

[R20-1] The device will operate with relatively low noise

2.9 Reliability Requirements

[R21-1] Software components will be easily upgradeable

[R22-2] The transceiver shall not interfere with any other devices

[R23-1] The detector shall continue to perform while submerged under water

2.10 Safety Requirements

[R24-1] The device will not harm the users - sharp edges and points are not present

[R25-1] The internal components of the detector shall be enclosed by a mat and not be exposed

[R26-3] The detector mat enclosure material shall adhere to CSA standards C22.2 outlining safety requirements for safe toy materials for kids

[R27-1] The detector mat enclosure material shall be able to grip the ground and shall not be slippery if stepped on

2.11 Standards

[R28-1] All electronic components will comply with the Institute of Electrical and Electronics Engineers standards (IEEE)

[R29-1] All software development will follow ISO/IEC 12207 standards for software development cycle [1]

[R30-3] The rubber mat material to enclose the electronic circuit in the detector shall be biodegradable following the ASTM D5526 standards [3]

[R31-1] Wireless transceivers should comply with FCC standards for unintended radiation [5]

[R32-1] The detector's alarm should comply with OSHA occupational noise standards

2.12 Sustainability

[R33-3] The batteries used by the electronic valve and detector shall be rechargeable

[R34-3] The mat material used to enclose the detector shall be biodegradable according to ASTM D5526 standards [3]

[R35-3] The electronic valve used in the inhibitor shall comply to metal scrap recycle standards OSHA 3348 [4]

[R36-3] Electronic components will be able to be dismantled and reused in other applications

[R37-3] The electronic valve will be able to be disconnected and reused as a regular mechanical valve

[R38-3] The system will allow for modularity (the addition or removal of detection units without affecting the remainder of the system)

3 Hardware

3.1 General Requirements

[R39-1] The detector and inhibitor are battery powered, for ease of use

[R40-1] Radio frequency between 2.405-2.48 GHz ISM Band will be used for wireless communication to inhibit interference with other devices

3.2 Detector Requirements

[R41-1] Must have an auditory alarm that users can enable/disable manually

[R42-1] The device is easily transportable and should weigh less than 25 lbs

[R43-1] The device will have a switch to easily turn ON/OFF the audible alarm

3.3 Inhibitor Requirements

[R44-1] The device must be easily transportable by the user, thus should not weigh more than 15 lbs

[R45-1] The device will have a switch to easily turn ON/OFF or AUTO

[R46-1] Inhibitor enclosure shall adhere to IP-66 standards for dust and water resistance

[R47-3] Inhibitor will have water flow detection to prevent shutting down the main water source falsely when a leak has been detected not associated with the main

3.4 Manager Requirements

[R48-1] PC communication is attained using USB connection

4 Software

4.1 General Requirements

[R49-1] Management software will be executable on a Window XP, Windows Vista, and Windows 7 based machine
[R50-3] Management software will be upgraded when bugs are found
[R51-1] Software must be terminated without damaging hardware
[R52-1] Management software will not interfere with normal operation of user's PC
[R53-1] Management software will collect data from detector/inhibitor via wireless communication

4.2 Detector Requirements

[R54-1] Microcontroller must trigger an alarm when water leak is detected
[R55-3] Management software must have enable/disable alarm functionality
[R56-2] Minimal liquid spillage on detector will not trigger leak detection
[R57-2] Power reset must retain previous connection settings
[R58-2] Must receive and transmit data reliably
[R59-2] Must be connected to manager before normal operations

4.3 Inhibitor Requirements

[R60-1] Must be able to receive and transmit data wirelessly.
[R61-1] Must be able to take appropriate action when a signal is received from the detector

4.4 Manager Requirements

[R62-1] Must oversee detector to inhibitor transmission to insure reliability
[R63-2] Must provide feedback on battery status levels of devices
[R64-2] Must notify user if connection with any device is lost

4.5 User Interface Requirements

[R65-1] The management software interface shall display the current inhibitor operation mode of “On”, “Off”, and “Automatic

[R66-1] The management software interface shall provide the user the option to change the inhibitor’s operation mode of “On”, “Off”, and “Automatic” through the user interface

[R67-2] The management software interface shall display the battery status of each detector and the inhibitor on the user interface

[R68-2] The battery status will be updated periodically at a set amount of intervals

[R69-1] The management software interface shall display the current leak status of of the leak detectors on the user interface

[R70-1] The management software interface will prompt a warning window with a warning message when a leak has been detected

[R71-2] The management software interface will prompt a warning window with a warning message when the battery status of the inhibitor and/or detector is below 20%

[R72-2] The management software will allow the user to provide location labels for each detector

[R73-3] The management software interface shall provide a scalable interface size depending on the total number of detectors within the antenna range

[R74-1] The management software interface will be implemented using C++, for maintainability.

[R75-3] 70% of users shall find the user interface intuitive and easy to use

5 User Documentation

The user documentation will be supported in the fully functional production model only. The user documentation will include details about the features and functionality of the device for the average user and a guide on how to customize the system. A user guide on proper device installation and operation along with example uses and customizations will be provided. Technical specifications of the individual modules of the overall system will also be provided as an appendix at the end of the user documentation.

[R76-3] The user documentation shall include a user installation guide, user manual with example use cases, technical documents including datasheets and contact information

[R77-3] The user manual shall provide step by step instructions on installation of the system, written in non-technical language

[R78-3] The user manual shall provide typical use case examples with detailed figures as well as video demonstration provided on a compact disc

[R79-3] The user manual shall provide information about the limits and boundaries of the devices

[R80-3] There shall be warranty and contact information provided including terms of use and details about any procedures that void the warranty

[R81-3] The technical specification for individual modules will be provided written in technical language with individual datasheet information for parts

[R82-3] The user documentation will support multiple languages to satisfy product language requirements in international markets

6 Test Plan

The general system test plan can be decomposed into three main stages. First is the unit testing stage where individual modules such as the inhibitor, detector, and management software are verified individually. Second the integration testing stage where modules are successfully integrated with each other. Third is user acceptance testing, in this phase the system will be tested by an independent user not associated with the development team. User acceptance testing is important to find any unforeseen issues that may arise due to assumptions that may have made by the development team. During each of the testing phases, other than functionality we will also take into consideration testing of the reliability and physical properties of the system. Examples include duration of the battery life before replacement, environmental conditions that may affect the system and typical use from a homeowner's perspective.

6.1 Unit Testing

Inhibitor:

To verify each component of the inhibitor, which consists of a microcontroller with a transceiver and an electronic valve, the individual unit tests listed, but not limited to, will be performed. The inhibitor needs to be able to receive the leak status of detectors and shut off the electronic valve along with passing that information to the PC.

- The electronic valve is able to close and open depending on the excitation sent to the valve.
- Have a stable wireless connection and moving it behind obstacles to ensure the transceiver is able to maintain signal connection while behind possible obstacles simulating real application environments.
- The microcontroller is able to interface with the electronic valve and receive current mode of operation and pass that data off (checked by a lighting of an LED on the microcontroller if it received the signal).
- The microcontroller is able to transmit and receive signals wirelessly which can be checked by writing a test that lights up an LED on the microcontroller with a signal sent wirelessly.
- The total battery duration will be tested.

Detector:

The detector will consist of multiple sensors, an electronic circuit and a microcontroller. The detector needs to be able to detect genuine leaks with minimal false positives and pass that information wirelessly to the inhibitor. The following tests will be done to ensure its proper function.

- A leak will be created on 3 of the 4 sensors, the electronic circuit should detect this as a genuine leak as per our criteria.
- The battery duration will be tested.
- After a leak is detected the microcontroller should be able to respond by sending a signal to the inhibitor, this can be first tested by lightning up a LED on the microcontroller if a leak is detected.
- The detector should be able to send a wireless signal to the inhibitor .

Software (Management software/Microcontroller software):

All software will have multiple features that will be tested to ensure proper functionality, ease of use, intuitive design, and performance. Testing of the software includes the following but not limited to.

- The user management software will be able to parse the incoming serial and handle multiple ISR for individual messages. Initially the events will be simulated instead of real signals from the detector to test that the GUI is able to display specific events such as leak detection or inhibitor operation mode.
- Intuitiveness and ease of use of the GUI in a stand-alone mode.
- Regression testing.
- Platform testing.

6.2 System Integration

After successful unit testing, integration testing will be done between the three main modules (inhibitor, detector, management software) to verify and validate the functionality of the Wireless Leak Detector and Inhibitor System. First, the integration testing will be performed between the inhibitor and detector. The inhibitor's multiple settings of ON, OFF would have have been checked during unit testing, the automatic setting will be tested now that it is combined with the detector. To test that the inhibitor is able to operate on any automatic setting based on the leak detection status, a water leak will be simulated by pouring water onto the detector unit. The detector unit's microcontroller should take action and send a signal to the inhibitor unit's receiver and appropriate response expected will be the water valve shutting off. Once this step is working as expected, the inhibitor and detector will be successfully integrated. The next step of integration will now be the additional management software module. Key inhibitor and detector information such as leak status, inhibitor operation mode, and battery status need to be sent and received through the transceivers and displayed on the user management software. To verify, the simple operation mode of the inhibitor will be set as off. This information shall be sent through the transceiver to the microcontroller connected to the PC through serial communication which is displayed on the user interface. The software will have ISR to handle the information. It will parse through any data and be able to generate the correct events based on that data (leak detected, operation mode, battery warning) and display the data correctly on the user

interface. After this is working as expected, the complete system will be performed. The complete system will be checked for each requirement along with performance and reliability. Once design requirements are validated, the system is ready for user acceptance testing.

6.3 User Acceptance Testing

When the system has been integrated successfully and deemed safe. User acceptance testing will begin. The purpose of the user acceptance testing is to verify the system can be easily operated without prior technical knowledge. A user without development knowledge will be instructed to install the whole system as well as the management software. The user's feedback will be taken into consideration to improve the prototype and production model further.

The typical usage scenario are instructed to the user

- User installs the inhibitor at the property's main water source
- User places leak detectors at locations desired
- User installs the management software at their own PC

User will create a spill and verify the inhibitor is able to shut off the water main if it was set on automatic mode. The management software should be able to display the water electronic valve's current mode as well as the leak location.

7 Conclusion

The functional specification detailed in this document are the functions, standards, and safety requirements adhered by the Wireless Leak Detector & Inhibitor System. This product will be able to accurately detect a leak via a detector mat and an electronic valve will turn the water main off when this leak is detected. User management software will be included to allow for customization and monitoring of the system. The user documentation and testing plan have been described and will be executed as well. A working prototype with primary requirements marked by 1 or 2 will be completed by December 2nd 2013.

8 References

[1] ISO/IEC 12207:2008. (Oct 2011). *International Standards*.[Online]. Available: http://webstore.iec.ch/preview/info_isoiec12207%7Bed2.0%7Den.pdf [Accessed October 13, 2013]

[2] *Average Human Weight. [Online].Available: http://www.nytimes.com/2012/01/02/us/coast-guard-raises-assumed-average-weight-per-person.html?_r=0 [Accessed October 13, 2013]*

[3] *ASTM D5526 (2011)Standard Test Method for Determining Anaerobic Biodegradation of Plastic Materials Under Accelerated Landfill Condition[Online] Available: http://www.astm.org/Standards/D5526.htm [Accessed October 13, 2013]*

[4] OSHA 3348. (2008). *Metal Scrap Recycling*. [Online]. Available: https://www.osha.gov/Publications/OSHA3348-metal-scrap-recycling.pdf [Accessed October 14, 2013]

[5] FCC Compliance Guides. [Online]. Available: http://www.fcc.gov/ocbo/complianceguides.html [Accessed October 14, 2013]