AirTack

School of Engineering Science • Simon Fraser University
Burnaby, BC • V5A 1S6

January 27, 2013
Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Functional Specification for the Real Time Gas Monitoring System

Dear Dr. Rawicz:

Attached is a document from AirTack Industries. describing the functional specification for the AirTack Real Time Gas Monitoring System (RTGMS). We are designingand implementing a real-time home monitoring system capable of detecting levels of various gases and other important environmental factors. The RTGMS willrespond to sensed conditions via text message notification, electrical shutoff and ventilation management, thereby protecting families and property from dangerous levels of airborne pollutants and hazardous home conditions.

Our functional specification provides a set of high-level requirements for system functionality, including proof-of-concept and production phases of the development cycle. This document will be used by AirTack's project manager and design engineers as a requirements guide throughout the research and development process.

AirTack Industriesconsists of four creative, motivated and disciplined fourth and fifth-year engineering students: Rouzbeh Roshanravan, Samuel To, Tessa Ryan, and Marvin Lee. If you have any questions or concerns about our proposal, please feel free tocontact me by phone at (604) 710-5476 or by e-mail at rra19@sfu.ca.

Sincerely,

Rouzbeh Roshanravan

Rouzbeh Roshanravan
President and CEO
AirTack Industries

AirTack

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Functional Specification for a

Real-time Air Monitoring System

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Issued date:

February 11, 2013

Revision:

1.4

1 Executive Summary

"All of us face a variety of risks to our health as we go about our day-to-day lives.... Indoor air pollution is one risk that you can do something about." — US EPA.

Canadians spend 90% of their time indoors, on average, making indoor air quality a critical health concern. Poor indoor air quality can cause a host of unpleasant symptoms, including headaches, fatigue, shortness of breath, nausea, dizziness, and eye, nose, throat and skin irritation. There are two main sources of air pollutants – biological and chemical. Biological irritants like bacteria require moisture to multiply, while chemical pollutants include gases (carbon monoxide, natural gas) and particulates (soot and ash) and within the home can typically be sourced to appliances. Both types of air pollutants are addressed by the AirTack Real-Time Air Monitoring System, which is capable of sensing a variety of gases (CO, CO2, natural gas), particulate, humidity and temperature. The system informs and empowers the user, providing statistical data to help make correlations to pinpoint the problem and responding to serious issues by initiating ventilation management and electrical shutoff.

Development of the Monitoring System will occur according to the Waterfall development methodology, with each phase split into hardware and software modules. Sensing functionality will be established in phase one, followed by response functionality in phase two.

Upon completion of the first phase, the system will have the following functionality:

- Sensing
    - Natural gas, carbon monoxide, carbon dioxide sensing
    - Particulate sensing
    - Temperature monitoring
    - Humidity sensing
- Establishment of threshold levels for each sensed factor, calibration with basic feedback to ensure correct detection and comparison with threshold level. (Software)
- Integration of sensing module to server via implementation of power line communication
- USB communication between server and computer
- Consideration of compliance with industry standards

Upon completion of the second phase, the system will have the following functionality:

- SMS response once levels have surpassed programmed thresholds, specific to each factor
- Completion of basic data analysis and graphing software on computer to connect to server
- Electrical shutoff (circuit break) proof of concept
- Ventilation management proof of concept
- Compliance with industry standards within an acceptable threshold.

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3 Glossary

GSM - Acronym for **G**lobal **S**ystem for **M**obile Communications, originally **Groupe Spécial Mobile.** It identifies a standard set by the European Telecommunications Standards Institute (ETSI) to describe protocols for digital cellular networks.

SMS - Acronym for **S**hort **M**essage **S**ervice. It is a text only messaging service component of communication systems under a standardized protocol.

1 Introduction

The Real-Time Air Monitoring System (RTAMS) is a sensing and response system that will detect hazardous levels of various gases and other environmental factors and respond in one or several ways to protect people and property. Once a threshold level of a detected substance is reached, the system will alert the user with an SMS, initiate a ventilation system and/or initiate an electrical circuit break to turn off the suspected source. The requirements for the Air Monitoring System, as proposed by AirTack Industries, are described in this functional specification.

1.1 Scope

This document describes the functional requirements that must be met by the Real-Time Air Monitoring System product. The feature set proposed in this document is a work in progress, though the requirements fully describe the proof-of-concept device. The listed requirements will drive the design of the device, while expansion of functionality on the proof-of-concept system is expected to evolve with further development.

1.2 Intended Audience

The functional specification is intended for use by all members of AirTack Industries. It will be used to guide development and measure progress throughout the design and implementation period. Each member will refer to the requirements as overall design goals, and testing shall also be guided by the required functionality of the finished proof-of-concept system.

1.3 Classification

Throughout this document, the following convention will be used to describe functional requirements:

R[n - p] Functional requirements

where **n** is the functional requirement number and **p** is the development phase in which the requirement will be addressed. **p** may be A or B, depending on whether the requirement is attributable to sensing (phase I) or response (phase II) functionality.

2 System Requirements

2.1 System Overview

The Air Monitoring System is a network of devices that monitors the air for environmental hazards and sounds an alarm when a hazard is detected. The system can be modeled as shown in Figure.

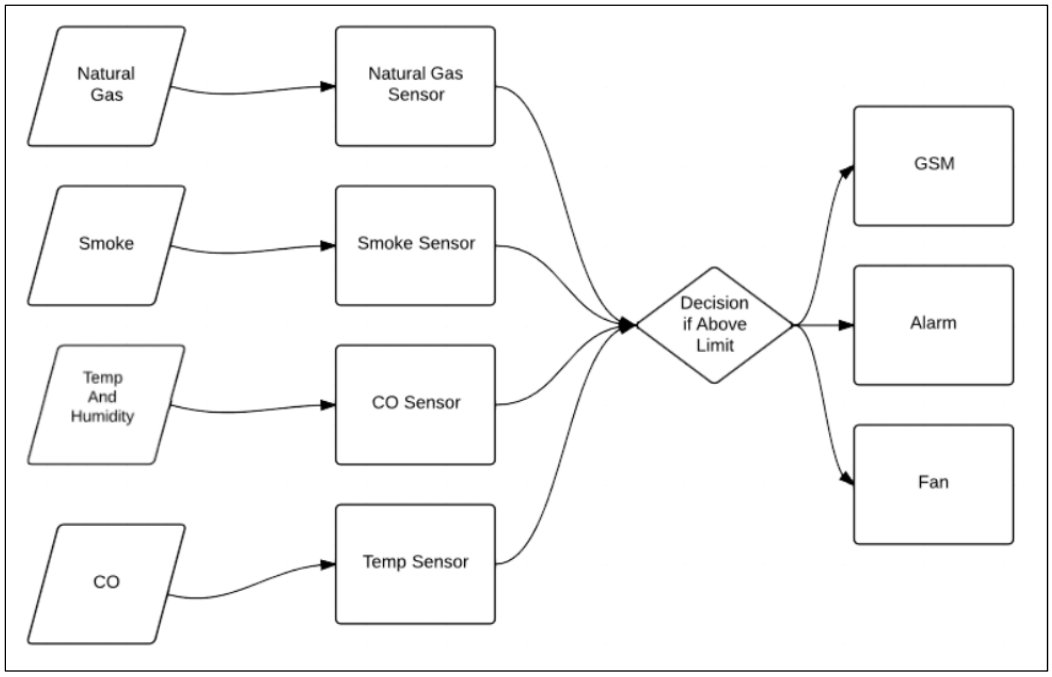

Figure 1: System Overview Diagram

The system will have three types of modules: the sensor module, the server module, and the active module. All the modules will be able to communicate to each other without installing additional wires. The sensor module will monitor the air for environmental hazards such as temperature, humidity, natural gas, carbon monoxide, and smoke. All sensor modules are able to function as stand-alone devices. The server module will be able to control the system as a whole by reading data from the sensor modules and sending commands to the active modules. Active modules will react to the hazards accordingly, for example: venting a room when smoke is detected, or shut off the gas line when natural gas is detected.

Once powered the modules should automatically configure themselves to do basic functionalities. Sensor modules will begin monitoring and sever modules will start communicating with the other modules. With this automatic setup, adding additional modules is simple. For more configuration

options, the user may be able to connect to the system using a PC or phone. The user can then configure the system to their preference.

2.2 General Requirements

[R1-A] The modules shall be easy to install in a residential building.

[R2-B] The modules must be cheap to manufacture.

2.3 Physical Requirements

[R3-A] The modules shall not have a mass more than 100g each.

[R4-A] The module unit shall not have any moving parts.

[R5-A] The maximum dimension of a module is 15 x 15 x 5 cm.

2.4 Electrical Requirements

[R6-A] The power supply should be able to power all the components of the module.

[R7-A] The module shall be usable with a wall supply of 110V at 60 Hz.

[R8-A] The module should only require a single plug to the wall.

[R9-A] A backup battery shall be installed in the module in case of a power outage.

[R10-A] The modules shall be able to run at 220V at 50Hz in future updates.

2.5 Environmental Requirements

[R11-A] The system shall monitor the environment for possible hazards.

[R12-A] The modules shall be silent under normal conditions.

[R13-A] The modules must be used indoors.

[R14-B] The modules shall operate in a large temperature range (0 - 60°C).

2.6 Standards

[R15-B] The system shall conform to C22.2 NO. 208-03 standards. [1]

[R16-B] The module shall conform to CAN/CSA-C22.2 NO. 60079-29-1:12 standards. [2]

[R17-B] The module shall conform to CAN/CSA-6.19-01 standards. [3]

2.7 Reliability and Durability

[R18-A] The module shall be able to operate individually when the mains electricity is off.

[R19-B] The modules shall not malfunction under normal operating temperatures.

[R20-B] The Modules shall be able to communicate in the event of a power failure.

2.8 Safety Requirements

[R21-A] The system shall detect and alarm the user of possible hazards.

[R22-A] The system shall turn on all alarms if only one device detects a hazard.

[R23-A] The system shall respond to a hazard within 5 seconds.

[R24-B] The modules shall not be the cause of a hazard.

[R25-B] Electronic components and power connections shall be enclosed.

2.9 Usability Requirements

[R26-A] The modules shall be able to work as a standalone system.

[R27-A] The modules shall be able to configure itself automatically to the network once powered.

[R28-A] The system shall be able to communicate to a PC via the sensor module.

[R29-A] The user shall be able to configure the system through a PC.

2.10 Luxury Requirements

[R30-B] The modules shall support monitoring other environmental parameters.

[R31-B] The modules shall support home break-in alarms.

3 Sensing Module

Sensing Module of our project consists of five individual sensors; however, the system is designed such that additional sensors can be easily added by the users as needed. These sensors are natural gas sensor, smoke sensor, carbon monoxide sensor, temperature and finally humidity sensor. Each sensor provides real time data of the environment and will trigger the system to proceed accordingly if necessary. In this section we will examine each sensor's requirements in details.

3.1 General Requirements

[R32-B] - The sensor should not be blocked by other component.

[R33-B] - The casing of the sensing module needs to have proper opening for each sensor.

3.2 Physical Requirements

MQ4 (Methane Sensor)

[R34-A] - Using temperature of this sensor is between -10 C to 50 C.

[R35-A] - Storage temperature of this sensor is between -20 C to 70 C.

[R36-A] - The related humidity must be less than 95%.

[R37-B] - Oxygen concentration must be at most 21% which is the standard oxygen concentration and at least 2%. Oxygen concentration has direct impact on the sensors sensitivity.

[R38-B] - Needs a minimum space of 17mm by 17mm and height of 23mm.

MQ7 (CO/CO_2 Sensor)

[R39-A] - Using temperature of this sensor is between -20 C to 50 C.

[R40-A] - Storage temperature of this sensor is between -20 C to 50 C.

[R41-A] - The related humidity must be less than 95%.

[R42-B] - Oxygen concentration must be at most 21% which is the standard oxygen concentration and at least 2%. Oxygen concentration has direct impact on the sensors sensitivity.

[R43-B] - Needs a minimum space of 1.7cm x 1.7cm x 2.3cm (L x W x H).

Smoke Sensor (B008MSQO0W)

[R44-A] - Using temperature of this sensor is between -5 C to 50 C.

[R45-A] - Minimum space required for this module is 7cm x 5cm x 1.8 cm (L x W x H).

Humidity and Temperature Sensor (RHTO3)

[R46-A] - Using temperature of this sensor is between -40 C to 80C.

[R47-A] - The humidity of the environment needs to be 0-100%.

[R48-A] - Minimum space required for this module is 1.51 cm x 0.77cm x 2.51cm (L x W x H).

3.3 Electrical Requirements

MQ4 (Methane Sensor)

[R49-A] - This module requires a DC or AC circuit voltage of 5V ± 0.1.

[R50-A] - The heating voltage should be 5V ± 0.1.

[R51-A] - Load resistance needs to be 20kΩ.

[R52-A] - The heater resistance is 33kΩ ± 5% at room temperature.

[R53-B] - The heating consumption is 750mW or less.

MQ7 (CO/CO_2 Sensor)

[R54-A] - This module requires a DC or AC circuit voltage of 5V ± 0.1.

[R55-A] - The heating voltage can be DC or AC of at most 5V ± 0.1 with a minimum of 1.4V ± 0.1.

[R56-A] - The heating time for this sensor is 60 - 90 seconds.

[R57-A] - Load resistance can be adjusted as necessary.

[R58-A] - The heater resistance is 33kΩ ± 5% at room temperature.

[R59-A] - The heating consumption is 350mW.

Smoke Sensor (B008MSQO0W)

[R60-A] - The Voltage for the smoke sensor needs to be a DC voltage of 9V.

[R61-A] - The Standby Current: needs to be 10mA.

[R62-A] - The Induced Current: must be less than 30mA.

Humidity and Temperature Sensor (RHTO3)

[R63-A] - The Voltage for the humidity/temperature sensor needs to be a DC voltage of 3.3 to 6V.

[R64-A] - When power is supplied to sensor, don't send any instruction to the sensor within one second to pass unstable status.

[R65-B] - For wave filtering a capacitor of 100nF can be added between VDD and GND.

[R66-A] - The current must be between 1 - 1.5mA.

[R67-A] - The standby current can be between 40 to 50 uA.

[R68-B] - The collecting period is 2 seconds.

4 Central Server Module

The central server module consists of an Arduino microcontroller, a power line communication module, an LCD, a GSM shield and a buzzer and a micro SD shield for storage purposes.

4.1 Physical Requirements

Arduino Microcontroller

[R69-A] - This item Weighs 1.4 ounces and this needs to be considered when mounting it.

[R70-A] - Using operating temperature of this module is between -40C to 85C.

[R71-BI] - Minimum space required for this module is 7.62 cm x 6.35cm x 1.91cm (L x W x H).

Basic 16x2 Character LCD (LCD-00255)

[R72-BI] - Minimum space required for this module is 8cm x 3.63cm

[R73-A] - The operating temperature of this device is between 0C to 50C.

Buzzer (CEM-1203)

[R74-BI] - Minimum space required for this module is 1.2cm x 1.4cm ± 0.05cm

[R75-A] - The operating temperature of this device is between -20C to 60C.

[R76-A] - The storage temperature of this device is between -20C to 60C.

microSD Shield (DEV 09802)

[R77-A] - Minimum space required for this module is 7.62 cm x 6.35cm x 1.91cm (L x W x H).

GSM Shield (CEL-09607)

[R78-B] – The module shall have a SIM card inserted

[R79-B] - The module must be in an area that has cellular reception

[R80-B] – The module must be mounted correctly into the micro controller

4.2 Electrical Requirements

Arduino Microcontroller

[R81-A] - The Arduino's software is to be installed on one of the following operating systems: Windows, Mac OS X or Linux.

[R82-A] - This module requires an Input voltage of between 7-12V.

Basic 16x2 Character LCD (LCD-00255)

[R83-A] - This module requires an input voltage of 4.7 - 5.5V.

[R84-A] - The supply current for this device at 5V is to be set between 1.5 - 4 mA.

[R85-A] - Recommended LCD riling voltage for is between 4.1 - 5.5V depending on the surrounding temperature.

Buzzer (CEM-1203)

[R86-A] - The required operating voltage for this module is 3-5V.

[R87-A] - Mean current for this module is 35mA.

microSD shield (DEV 09802)

[R88-A] – This shield is to be installed on top of an Arduino microcontroller.

[R89-A] – It needs an input voltage of 5V which will be supplied by the Arduino controller. The onboard voltage converter chip will then convert the signals to 3.3V signals in accordance with SD specifications.

GSM Shield (CEL-09607)

[R90-B] – The module must be able to send an SMS as an alarm to the programmed user

[R91-A] – The module should be capable of receiving an SMS from a specified user and apply the appropriate response

[R92-B] – The module must have a response to notify the user of the inserted SIM card is not compatible

5 User Interface

The user interface shall consist of a minimal set of inputs to the unit. There will be multiple methods of output on both the unit itself as well as the graphical user interface on the computer.

5.1 General Requirements

[R93-A] – The unit will be powered by 2 sets of electrical plugs

[R94-B] – There will be LEDs for power on/off, hazard indicator

[R95-A] – There will be an LCD screen for status and configuration messages as well as displaying the telephone number that has been programmed

[R96-A] – Receive text message to program the phone number that will be used in the future for notifications

5.2 Physical Requirements

[R97-B] – The unit will be in a visible area and be near a computer when necessary

[R98-B] – The sensors will be in an appropriate location so that the sensors will function properly

5.3 Software Requirements

[R99-B] – The unit will be able to take in CSV data

[R100-B] – The user will be able to see an output which has trending data information

[R101-B] – The user will be able to control the time period as well as select which data they want to see

6 System Test Plan

6.1 Module Testing

In this segment we will be testing the performance and reliability of every module. Each module will be connected to the mains electricity in different rooms. There are three modules that we will be targeting in this test: sensor testing, server testing and finally testing of the active module.

6.1.1 Sensor Testing

This test is targeted to see if each sensor works properly. In every test case sensors will be connected to an Arduino microcontroller which will display the out of each sensor on the screen. We can use the sensors output value to trigger different LEDs for a more visual test. This will show us that each sensor can detect different levels of the substance it is intended to detect.

Procedure:

Smoke Sensor (B008MSQO0W)

The smoke sensor will be placed in a closed environment such as a glass box. We will produce a reasonable amount of smoke by burning a piece of paper and will monitor the results.

Humidity and Temperature Sensor (RHTO3)

The Humidity and Temperature Sensor will be placed in a closed environment such as a glass box. We will place the glass box on a heater and will monitor the results. As for the humidity a vaporizer will be used to trigger and monitor the sensor.

MQ4 (Methane Sensor)

The MQ4 Sensor will be placed in a closed environment such as a glass box. We will produce a reasonable amount of smoke methane using a small lighter and then monitor the results.

MQ7 (CO/CO_2 Sensor)

The MQ7 will be placed in a closed environment such as a glass box. We will produce a reasonable amount of smoke CO To confirm that CO detector is detecting the carbon monoxide, we can produce CO by for example using a lit cigarette. We will then monitor the results.

Pass Condition

- The output from each sensor varies as the amount of each specific substance changes.

6.1.2 Testing the Server and Active Module

In this test we will be testing the active module which consists of an Arduino controller, a fan along with a mamba shield. We need to make sure that the fan will start to run once an input is received.

Procedure:

We will program the server's arduino controller such that at a certain time an input is sent to the active module. We then monitor the active module.

Pass Condition:

- Fan needs to start running.

6.2 Integration Testing

To test the system for performance and reliability, we will require one of each type of module. Each module will be connected to the mains electricity in different rooms. There are three test cases for integration: basic setup and communication, alarm handling, and network disconnections.

6.2.1 Setup and Communication

The modules will be tested to see if they are able to configure themselves and be able to communicate with each other. The server module is powered on first followed by other modules. The server module will be monitored to see if it detects the other modules and if data can be transfered. Once communication is established, the server module will be tested to see if it receives data from the sensor module and can send commands to the reactive module.

Pass Conditions:

- Modules configure itself correctly.
- Communication is established between server module and other modules.

6.2.2 Alarm Handling

Once the basic communication functionalities are tested, we will test the system for sending alarm signals and handling the alarms. The sensor module will be simulated to raise an alarm. Examples of simulation include raising the temperature or releasing a controlled amount of natural gas near the sensor module. All other modules will be checked if it receives the alarm signal. The server module will be monitored to see if it will react to the alarm signal and issue the proper commands to the active module.

Pass Conditions:

- An alarm signal is received by all connected modules.

- The server module is able to correctly handle the alarm.

6.2.3 Network Disconnections

The modules should be able to handle and recover from network failures. The test will monitor how the system will react when subjected to the following events: removing a module, power failure, and signal integrity.

Pass Conditions:

- The server module can detect when a module has been disconnected.
- The modules can work as a stand-alone device during a power failure.
- The modules can rebuild the network when power is restored after a blackout.
- The server can detect errors in the signal and correctly handle the event.

7 User Documentation

This product is designed for use in the home by individuals and families who do not necessarily have technical backgrounds or prowess. As such, user-friendly documentation will be prepared to ensure ease of use for the average person.

7.1 General Requirements

[R102-B] – User documentation shall include graphics, text, and step by step instructions to guide users through each critical process of system operation and maintenance.

[R103-B] – A quick-start guide will be produced and included with the final product to describe the initial set up process to the user.

[R104-B] – A troubleshooting section will be included to help users address common issues involving both software and hardware components of the product.

7.2 Usability Requirements

[R105-B]- User documentation shall include a section that specifically describes how to interpret data trending information seen in the product's software.

8 Conclusion

The functional specification clearly specifies the design objectives of the AirTack Monitoring System and how the design team intends to meet these requirements. The feature set proposed is a work in progress, though the requirements fully describe the proof-of-concept device. The listed requirements will drive the design of the device, while expansion of functionality on the proof-of-concept system is expected to evolve with further development. AirTack will develop details in the design requirements based on the functional specifications contained in this document.

9 References

[1] CSA. (2003) *C22.2 NO. 208-03 (R2008)* [Online] Available: http://shop.csa.ca/en/canada/wire-and-cable/c222-no-208-03-r2008/invt/27020102003/

[2] CSA. (2012) *CAN/CSA-C22.2 NO. 60079-29-1:12* [Online] Available: http://shop.csa.ca/en/canada/hazardous-location-equipment/cancsa-c222-no-60079-29-112/invt/27033792012/

[3] CSA. (2001) *CAN/CSA-6.19-01 (R2006)* [Online] Available: http://shop.csa.ca/en/canada/accessories/cancsa-619-01-r2006/invt/27013442001/