Portland State UNIVERSITY

Erebus Labs

STEM SENSORS

PROJECT PROPOSAL

Version 1.2

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SCOTT LAWSON

BRYAN BUTTON

CHRIS CLARY

MAX COPE

VERSION HISTORY

Version #	Implemented By	Revision Date	Approved By	Approval Date	Reason
1.2	Scott Lawson	1/14/2014			Updated Objective
1.1	Maxwell Cope	1/13/2014			Updated Objective, Removed extra signature blocks
1.0	Maxwell Cope	1/12/2014			Initial Merger of Individual Sections

NOTE TO READER

This is a template obtained from:
http://www2.cdc.gov/cdcup/library/templates/default.htm

Template Name: Product Design

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1 INTRODUCTION

1.1 PURPOSE OF THE DOCUMENT

This document is the initial project proposal for the STEM (Science, Technology, Engineering, Math) Sensor system. Both signal diagrams and timeline will be extrapolated on depending initial approval.

1.2 BACKGROUND

Current educational curriculum in the US lacks a focus on Science, Technology, Engineering, and Mathematics (commonly referred to as STEM). According to the United States department of education, only %16 of American high school seniors are proficient in mathematics and interested in a STEM career[1]. With a growing demand for STEM related jobs and declining interest in such fields, it is important to get high school graduates into a STEM focused degree program in college. Doing so, however, requires an early start in younger students. In studies referenced by the Business Education Compact, a non-profit focused on bringing STEM education to younger and underserved classrooms, negative interest begins in elementary classrooms where %33 of fourth grade students' attitudes are already hostile towards science and math; that number goes to %50 by 8th grade[2].

Unfortunately, many student oriented projects currently available are not as practical or affordable as would be desired to get students encouraged. Many projects that students get their hands on involve simple data analysis which is not necessarily the best way to get young energetic kids involved the sciences. Other types of projects are available which are fairly cheap to start out, but require the use of chemicals which are usually required to be kept in the classroom and are harder to collect actual data from. Lastly, there are data acquisition modules which are great for collecting actual data but generally require more advanced setup (such as programming) and usually cost more than $100 per unit. An example of one such device is the LabJack data acquisition device.

Another issue facing the proliferation of STEM subjects in schools is teacher education and resources. Unfortunately many teachers do not have the time or resources to put together detailed lesson plans or learn complicated material with the small amount of time available. The department of education states that one issue with STEM proliferation is limited teacher resources and education.

In order to drive interest in STEM, students need access to a means of not only collecting data but analyzing it as well. Collection and analysis needs to be both educational and interesting, while remaining simple and easy to use. This simplicity needs to extend to the teachers as well, with example plans and experiments available to ensure a smooth teaching and learning experience.

[1] www.ed.gov/stem
[2] http://becpdx.org/nem/stemconnect.aspx

1.3 OBJECTIVE

Encourage an interest in STEM in K-12 students delivering a working prototype of an affordable, simple and flexible device to collect environmental data.

2 GUIDELINES

2.1 MARKETING REQUIREMENTS

2.1.1 The system must be modular, allowing multiple sensor types to be employed by one base unit.

2.1.2 The system must be low cost.

2.1.3 The system must be simple enough to operate that K-12 teachers and students can effectively utilize the device in the classroom

2.1.4 The user interface must accommodate both novice and advanced users.

2.1.5 Base unit with sensors attached must be able to operate outside of a classroom.

2.1.6 The system must provide a method for users to specify the data collection interval.

2.1.7 Hardware and software designs should be open-source.

2.1.8 The base unit should be able to collect data for an extended period without user interaction.

2.1.9 The base unit should require minimal changes or adjustments for the use of different sensors.

2.1.10 The user interface should provide a method for organizing and comparing data from multiple base units employed simultaneously.

2.1.11 The base unit should employ a wireless method of exporting data for analysis.

2.1.12 The system should be durable.

2.1.13 The base unit may also be modular and require user assembly.

2.1.14 The base unit may support simultaneous multiple sensor attachments.

2.2 ENGINEERING REQUIREMENTS

Marketing Requirements	Engineering Requirement	Justification
1, 2, 3, 4	All sensors must use the same interface to connect to the base unit	Minimizes cost and complexity for users while increasing versatility
4	The user interface must provide a method for the user to access the raw data collected	Allows advanced users to perform their own data analysis
2	BOM for base unit should not exceed $20.00 each	Necessary for adoption by K-12 classrooms with limited budgets
2	BOM for sensors should not exceed $5.00 each	Necessary for adoption by K-12 classrooms with limited budgets
3, 13	The base unit may use sockets and connectors to attach the controller, power, and communications devices to the PCB	Further modularity provides hardware interactivity and learning opportunities for younger users
3, 4, 9	The base unit should identify the sensor(s) attached and configure itself appropriately	Simplifies operation for younger users
1, 4, 6	The system should be able to collect data points at rates between 1 Hz and 1 per day	Accommodates a wide variety of data collection applications
4, 10	The system should be able to coordinate data collection between 6 base units simultaneously	Accommodates a wide variety of data collection applications
5, 12	The base units and sensors should be operational after a 1.5m drop-test	The system needs to survive daily use by K-12 students
5, 12	The base and sensors may be constructed with a water-resistant case	The system needs to survive daily use by K-12 students
5, 12	The base unit with sensors attached should operate when exposed to temperatures between -20°C and +80°C	Temperature range required for outdoor operation
7	A publicly-accessible repository will be used for code and documentation hosting	Encourages exploration and experimentation by students
2, 7	If third-party software is used, it will be open-source	Encourages exploration and experimentation by students, minimizes cost
3, 8	The base unit should be able to collect data points for 90 days without user interaction	Simplifies operation for all users
2, 3	If the system is does not use a rechargeable power source, it must not use proprietary battery types	Using widely available batteries minimizes cost
11	A wireless data dump interface should be utilized by the base unit	Provides a convenient method for users to retrieve data
11	If a wireless data dump interface is utilized by the base unit, it should not require the user to be closer to the base unit than 3 meters	Provides a convenient method for users to retrieve data
2, 4, 14	The base unit may contain multiple attachment points to enable multiple sensors to be used simultaneously	Enhances versatility for advanced data collection

3 ARCHITECTURE

3.1 GENERAL SYSTEM OVERVIEW

3.2 SENSOR INTERFACING

To reduce interfacing complexity, it is proposed that the sensors be modularized and all interfacing be done through one standard connection. This allows the capability to use a variety of sensors and sensor topologies yet still interface with the base unit for data collection.

4 TIMELINE

4.1 OVERVIEW

The Timeline is currently only populated with milestones. These milestones are designed to dictate the general sequence of the project. Pending approval of the project as well as these milestones, the team will create a more robust timeline.

The main direction taken with these milestones is the functional prototype (3) at the end of the first term. This will be the half-way point of the project, and a functional prototype by then allots us the time to revise our approach to produce a more robust final product.

4.2 MILESTONES

	Task Name	Finish	Predecessors
1	Proposal	Sun 1/12/14	
2	Design Review One/ Begin Prototype	Fri 1/31/14	**1**
3	Functional Prototype	Sun 3/23/14	**2**
4	Design Review Two and Revision	Sun 4/6/14	**3**
5	Begin Final Project Assembly	Sun 4/20/14	**4**
6	Final Unit Completion	Sun 5/18/14	**5**
7	Present/Wrap Up	Fri 6/6/14	**5**

5 BUDGET

5.1 DEVELOPMENT COSTS

All costs are given in U.S. dollars. Development costs assume low enough quantities that there is no volume discount. Quantities assume two breadboard prototypes and two assembled PCB-based prototypes.

Item	Cost (Ea)	Quantity	Ext. Cost	Cost Factors
Sensor	1.00 – 25.00	5 – 8	5.00 – 50.00[1]	Type, Quantity of each type
µController	1.00 – 5.00	5 – 8	5.00 – 40.00	Onboard features[2]
Batteries	0.75 – 12.00	5 – 16[3]	12.00 – 60.00[3]	Rechargeable, composition, form factor
Passives[4]	0.05 – 2.00	50 – 100	20.00 – 30.00[1]	Values and tolerances required
Interfaces[5]	0.50 – 8.00	16 - 25	8.00 – 50.00	Wireless vs. Wired
PCBs[6]	4.00 – 18.00	4 - 6	24.00 – 48.00	PCB Area, sensor requirements
Other SI[7]	0.50 – 2.00	16 – 30	8.00 – 50.00[1]	Battery selection, sensor output
Packaging	3.00 – 75.00	2 – 3	9.00 – 225.00	Materials: laser-cut acrylic vs. 3D-printer
Total:				100.00 – 500.00

1. Extended cost does not scale linearly with quantity because it is assumed that the maximum quantity would not be entirely comprised of the most expensive components.
2. Onboard features include ADC, power conditioning, amount of memory, etc
3. Quantity and extended cost assume either a small amount of expensive rechargeable proprietary batteries, or a larger amount of cheap (AA or 9V) batteries.
4. Resistors, capacitors, inductors, LEDs
5. Antennas, transceivers, receivers, cable jacks
6. Assumes a PCB for the base unit as well as separate PCBs for the interchangeable sensors.

Example: Minimum extended cost is based on a 2in x 2in base unit PCB with two 1in x 1in sensor PCBs at $2.00 per square inch, x2 prototypes.

7. Other semiconductors: op-amps, voltage regulators, discrete transistors

5.2 BOM COSTS

Low Price-point Example: one base unit with two external interchangeable sensors. Single unit cost assuming volume is low enough that there are no quantity discounts.

Item	Cost (Ea)	Quantity	Ext. Cost	Notes
Sensor	0.19, 5.99	2	6.18	Temperature Sensor, CO sensor
µController	1.36	1	1.36	ATTiny84 – onboard ADC, 8KB flash
Batteries	2.14	1	2.14	Standard 9v Battery
Passives[4]	0.05 – 0.50	10	3.00	Misc resistors, capacitors, LEDs
Interfaces[5]	0.50	4	2.00	Generic jack for sensors, USB for base
PCBs[6]	4.00 – 8.00	3	16.00	2”x2” base PCB, 1”x2” PCB per sensor
Other SI[7]	0.50	0	0.00	Assuming µC ADC can handle sensor output
Packaging	3.00	1	3.00	Laser-cut acrylic from EPL, hand assembled
Total:				$33.68

6 PROPOSAL APPROVAL

Signature: ______________________________ Date: ____________

Print Name: ______________________________

Title: ______________________________

Role: ______________________________

Signature: ______________________________ Date: ____________

Print Name: ______________________________

Title: ______________________________

Role: ______________________________

Signature: ______________________________ Date: ____________

Print Name: ______________________________

Title: ______________________________

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