Erebus Labs

# *STEM Sensors*

# Design Specification

Version 1*.*1

*1/30/2014*

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# VERSION HISTORY

|  |  |  |  |
| --- | --- | --- | --- |
| **Version #** | **Implemented**  **By** | **Revision**  **Date** | **Reason** |
| 1.2 | Scott Lawson | 1/31/2014 | Added development boards cost to section 2.2  Fixed type in BOM costs |
| 1.1 | Scott Lawson | 1/30/2014 | Changed to Standardized Format  Added microcontroller costs |
| 1.0 | Scott Lawson | 1/28/2014 | Initial Release |

**NOTE TO READER**

This is a template obtained from:

<http://www2.cdc.gov/cdcup/library/templates/default.htm>

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# TABLE OF CONTENTS

1 Introduction 5

1.1 Purpose of The Document 5

1.2 Objective Statement 5

1.3 Overview 5

2 Development Costs 6

2.1 Ledger 6

2.2 Anticipated Costs 7

3 BOM Costs 8

Appendix A: Glossary 9

A.1 Acronyms 9

A.2 System Architecture 9

# Introduction

## Purpose of The Document

This document describes the budget allotted and cost estimations for the Erebus Labs STEM Sensor. This document is intended to be a living document. As such, it should be updated whenever new budget-related information is available. The reader should be aware that information contained in this document may change at any time.

## Objective Statement

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

## Overview

This document is divided into two sections:

1. Development Costs

This section contains estimated costs related to the development of the STEM Sensor. This section is further divided into two sections: a ledger to track purchases that have already been made, and expected future costs.

1. Bill of Materials Costs

These are costs associated with the production of a single sensor unit, excluding amortized development costs. As design/part decisions are made, the BOM will be updated to reflect those decisions, and the ranges will be replaced with known values.

# Development Costs

## Ledger



## Anticipated Costs

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Item** | **Cost (Ea)** | **Quantity** | **Ext. Cost** | **Cost Factors** | |
| **Sensor** | 1.00 – 25.00 | 5 – 8 | 5.00 – 50.001 | Type, Quantity of each type | |
| **μController** | 0 | 5 – 8 | 0 | PSoC3 – CY832 Free samples likely | |
| **Batteries** | 0.75 – 12.00 | 5 – 162 | 12.00 – 60.002 | Rechargeable, composition, form factor | |
| **Passives4** | 0.05 – 2.00 | 50 – 100 | 20.00 – 30.001 | Values and tolerances required | |
| **Interfaces5** | 0.50 – 8.00 | 16 – 25 | 8.00 – 50.00 | Wireless vs. Wired | |
| **PCBs6** | 4.00 – 18.00 | 4 – 6 | 24.00 – 48.00 | PCB Area, sensor requirements | |
| **Other SI7** | 0.50 – 2.00 | 16 – 30 | 8.00 – 50.001 | Battery selection, sensor output | |
| **Packaging** | 3.00 – 75.00 | 2 – 3 | 9.00 – 225.00 | Materials: laser-cut acrylic vs. 3D-printer | |
| **Software** | 0.00 | 0.00 | 0.00 | Only utilizing free development software | |
| **Development Boards** | 99.00 | 2 | 198.00 | Buying two boards, but getting two more free with programmers = ~$400.00 value | |
|  | | | | | | 0.00 | 0.00 | 0.00 | Only utilizing free development software |
| **Total:** | | | | | 300.00 – 700.00 |

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. Quantity and extended cost assume either a small amount of expensive rechargeable proprietary batteries, or a larger amount of cheap (AA or 9V) batteries.
3. Resistors, capacitors, inductors, LEDs
4. Antennas, transceivers, receivers, cable jacks
5. 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.

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

# 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. Excludes amortized development cost.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Item** | **Cost (Ea)** | **Quantity** | **Ext. Cost** | **Notes** |
| **Sensor** | 0.19, 5.99 | 2 | 6.18 | Temperature Sensor, CO sensor |
| **μController** | 5.52 | 1 | 5.52 | PSoC3 CY8C3245PVI-150 |
| **Batteries** | 2.14 | 1 | 2.14 | Standard 9v Battery |
| **Passives** | 0.05 – 0.50 | 10 | 3.00 | Misc resistors, capacitors, LEDs |
| **Interfaces** | 0.50 | 4 | 2.00 | Generic jack for sensors, USB for base |
| **PCBs** | 4.00 – 8.00 | 3 | 16.00 | 2”x2” base PCB, 1”x2” PCB per sensor |
| **Packaging** | 3.00 | 1 | 3.00 | Laser-cut acrylic from EPL, hand assembled |
|  | | | | |
| **Total:** | | | | $37.84 |

Note: This example makes assumptions about future decisions for the purpose of estimating the cost of a single unit, and should only be used as a general reference.

The cost may be reduced in Q3 or Q4 of 2014 by changing the microcontroller to the Cypress PSoC4 when the PSoC4 model with onboard USB support becomes available.

# Appendix A: Glossary

## Acronyms

|  |  |
| --- | --- |
| **Acronym** | **Meaning** |
| ADC | Analog-to-Digital Converter |
| BOM | Bill of Materials |
| CO | Carbon Monoxide |
| CSV | Comma-separated-value formatted file |
| EEPROM | Electrically Erasable Programmable Read-Only Memory |
| EPL | The Portland State University Engineering and Prototyping Lab |
| I2C | The Inter-Integrated Circuit communication protocol |
| ISR | Interrupt Service Routine |
| K-12 | Kindergarten through 12th grade school |
| LED | Light Emanating Diode |
| PCB | Printed Circuit Board |
| PSoC | Programmable System On Chip |
| SI | Silicon |
| SPI | Serial Peripheral Interface Bus |
| STEM | Science, Technology, Engineering and Math |
| TRM | Technical Reference Manual |
| USB | Universal Serial Bus |

## System Architecture

**Base Unit**

The central device that manages power, communication, and data storage, and has one or more sensors attached to it.

**Sensor**

The individual data collection devices such as VOC detectors and thermometers that are attached to the base unit.

**User Interface**

The program that will be run on a laptop or desktop computer that allows the user to view and interact with the data collected.

**System**

The operational product comprised of base units with attached sensors and a user interface.