Budget Proposal

for Autonomous Panda System

Sponsor: The Department of Electrical, Computer, Software & Systems Engineering at Embry Riddle Aeronautical University

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Funky Town Fancy Pandas Development Team

**Abstract:** The budget proposal and functional design is contained in this document in conjunction with the preliminary budget, justifications, and decisions for each of the major components.

# Revision History

|  |  |  |
| --- | --- | --- |
| **Version** | **Date** | **Description** |
| 0.1.0 | Sept. 28, 2014 | Initial draft of the document |
| 0.2.0 | Sept. 30, 2014 | Continuation of budget proposal |

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# Introduction

The introduction of this document defines the purpose, scope, and team information for the project.

## Purpose

The purpose of this document is to identify the preliminary budget for the Autonomous Panda System (APS). It is intended to provide the customers of the APS with justifications for major item decisions. These justifications include decision matrices, risk analysis and fulfillment of requirements.

## Scope

This document is intended to provide the customers of APS with a list of parts with justification and pricing information. In this list of parts, only major components have been considered. These major components are those with price above $20 [**citation**] and are essential to the early prototyping of the APS. This document also contains a high-level break down of the APS that provides an overview of the initial design of the system.

## Team Information

|  |  |
| --- | --- |
| **Name** | **Role** |
| Kurt Pedrosa | Team Leader/Scrum Master |
| Merissa Roth | Software Leader |
| Mary Luongo | Hardware Leader/Product Owner |
| Luis Bogran | Development Leader |
| Kok Peng Tan | Developer |

# Functional Decomposition System

## High-Level Architecture of System

## Decomposition of Vehicle Hardware Layer

## Decomposition of Communication Hardware Layer

# Requirements Traceability

## Microcontroller

|  |  |  |
| --- | --- | --- |
| **ID** | **Requirement Text** | **Fulfillment** |
|  |  |  |

## Sensors

|  |  |  |
| --- | --- | --- |
| **ID** | **Requirement Text** | **Fulfillment** |
| 4.1.3 | The APS shall monitor the red LED on the floor. |  |
| 4.1.5 | The APS shall follow the line on the floor. |  |
| 4.1.6 | The APS shall remain within the playing board. |  |
| 4.1.7.1 | The APS shall identify the game station. |  |
| 4.1.8 | The APS shall stop moving once the finish line is crossed. |  |
| 4.2.2 | The APS shall play with the Simon Carabiner for 15 seconds. |  |
| 4.2.3 | The APS shall rotate one (1) row of the Rubik’s Cube 180 degrees. |  |
| 4.2.8 | The APS shall pick up one (1) playing card from the stack of cards. |  |

## Motors

|  |  |  |
| --- | --- | --- |
| **ID** | **Requirement Text** | **Fulfillment** |
| 4.1.4 | The APS shall start moving when the red LED powers off. |  |
| 4.1.6 | The APS shall remain within the playing board. |  |
| 4.1.8 | The APS shall stop moving once the finish line is crossed. |  |

## Arm

|  |  |  |
| --- | --- | --- |
| **ID** | **Requirement Text** | **Fulfillment** |
| 4.2.1 | The APS shall press the middle button on the Simon Carabiner to start playing. |  |
| 4.2.2 | The APS shall play with the Simon Carabiner for 15 seconds. |  |
| 4.2.3 | The APS shall rotate one (1) row of the Rubik’s Cube 180 degrees. |  |
| 4.2.6 | The APS shall draw “IEEE” on the Etch-a-Sketch using the knobs located on the Etch-a-Sketch. |  |
| 4.2.8 | The APS shall pick up one (1) playing card from the stack of cards. |  |

## Frame

|  |  |  |
| --- | --- | --- |
| **ID** | **Requirement Text** | **Fulfillment** |
|  |  |  |

## Batteries

|  |  |  |
| --- | --- | --- |
| **ID** | **Requirement Text** | **Fulfillment** |
| 4.1.1 | The APS shall receive power from an independent, on-board, battery. |  |

# Budget Decision Matrices and Justifications

This section of the document contains the reasoning used during the selection of the major components. The use of decision matrices is main method for selecting all components to be used for the APS. These matrices show the important characteristic of the component and indexed each of them with a weighted score. The development team scored each characteristic of each component and the average score is then calculated. The total score is gathered and the item with the highest total score is then selected as the most desirable component for the system.

## Microcontroller

The microcontrollers considered and descriptions of the decision process are described in the following content. The process was tailored to provide the APS with the optimal microcontroller to control all the subsystems.

### Items Under Consideration

The following items were considered as the microcontroller used to operate the subsystems of the APS. All of the items have been characterized on **table x** by item identification name (Item ID), vendor, and a description.

|  |  |  |
| --- | --- | --- |
| Item ID | Vendor | Description |
| Arduino Uno | Amazon | A microcontroller board based on the ATmega328. It contains 14 digital I/O pins, with 6 of them providing pulse width modulation (PWM) output. It has a 5V operating voltage with input voltage recommendation between 7V and 12V. |
| Raspberry Pi Modle B+ | Amazon |  |
| UDOO Quad | Udoo |  |
| BeagleBone Black | Amazon |  |

### Decision Matrix

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Name** | **Price** | **Speed** | **RAM** | **Memory** | **GPIO** | **OS/IDE** | **Ease of use** |  |  |
| Arduino Uno | $40.22 | 84 MHz | 96 kB | 512 kB | 54 (12 PWM) | Arduino IDE |  |  |  |
| Raspberry Pi Modle B+ | $38.89 | 700 MHz | 512 MB | SD Card | 40 | Linux |  |  |  |
| UDOO Quad | $135 | 1 GHz | 1 GB | SD Card/SATA | 76 | Linux/Aduino IDE |  |  |  |
| BeagleBone Black | $65.90 | 1 GHz | 512 MB | 4 GB | 65 | Linux |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Arduino Uno | 8 | 2 | 2 | 5 | 8 | 6 | 9 |  |  |
| Raspberry Pi Modle B+ | 9 | 5 | 5 | 9 | 7 | 8 | 9 |  |  |
| UDOO Quad | 3 | 8 | 8 | 10 | 9 | 10 | 5 |  |  |
| BeagleBone Black | 5 | 8 | 5 | 7 | 8 | 8 | 7 |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Weight | 0.2 | 0.2 | 0.1 | 0.25 | 0.1 | 0.1 | 0.05 | 1 |  |
|  |  |  |  |  |  |  |  |  |  |
| Arduino Uno | 1.6 | 0.4 | 0.2 | 1.25 | 0.8 | 0.6 | 0.45 |  | 5.3 |
| Raspberry Pi Modle B+ | 1.8 | 1 | 0.5 | 2.25 | 0.7 | 0.8 | 0.45 |  | 7.5 |
| UDOO Quad | 0.6 | 1.6 | 0.8 | 2.5 | 0.9 | 1 | 0.25 |  | 7.65 |
| BeagleBone Black | 1 | 1.6 | 0.5 | 1.75 | 0.8 | 0.8 | 0.35 |  | 6.8 |

### Justification

## Sensors

### Items Under Consideration

### Decision Matrix

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Categories with Weight** | |  |  |  |  |
| **Availability** | **Price** | **OS/IDE** | **FPS** | **Resolution** |  |  |
| 0.1 | 0.2 | 0.2 | 0.25 | 0.25 |  |  |
|  |  |  |  |  |  |  |
| **Product** | **Availability** | **Price** | **OS/IDE** | **FPS** | **Resolution** |  |
| Pixy Cam | Available | $0 | Arduino/C | 50 | (640 x 400) |  |
| CMUcam4 Robot Vision | Buy it | $116.24 | Arduino/C | 30 | VGA (640 x 840) |  |
| Raspberry Pi | Buy it | $29.95 | Raspberry Pi | 30 | 1080 p HD |  |
| Minoru 3D webcam | Buy it | $37.99 | openCV | 30 | 320 x 240 |  |
|  |  |  |  |  |  |  |
|  | **Availability Weight** | **Price Weight** | **OS Weight** | **FPS Weight** | **Resolution Weight** |  |
| Pixy Cam | 10 | 10 | 9 | 8 | 6 |  |
| CMucam4 Robot Vision | 5 | 5 | 9 | 6 | 7 |  |
| Raspberry Pi | 5 | 8 | 6 | 6 | 9 |  |
| Minoru 3D webcam | 5 | 7 | 6 | 6 | 4 |  |
|  |  |  |  |  |  |  |
|  | **Availability** | **Price** | **OS/IDE** | **FPS** | **Resolution** | **Total** |
| Pixy Cam | 1 | 2.00 | 1.8 | 2 | 1.5 | 8.30 |
| CMucam4 Robot Vision | 0.5 | 1 | 1.8 | 1.5 | 1.75 | 6.55 |
| Raspberry Pi | 0.5 | 1.6 | 1.2 | 1.5 | 2.25 | 7.05 |
| Minoru 3D webcam | 0.5 | 1.4 | 1.2 | 1.5 | 1 | 5.60 |

### Justification

## Motors

### Items Under Consideration

### Decision Matrix

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Motors | Price | Voltage-Max | RPM | Stall Torque | Stall Current | Weight |
| Standard Gearmotor | $24.95 | 12V | 101 | 32.2 N-cm | 0.5 A | 119.07 g |
| Preicision Gearmotor | $34.95 | 12V | 90 | 98.01 N-cm | 1 A | 240.97 g |
| 154:1 Metal Gearmotor 20Dx44Lmm | $19.95 | 6V | 90 | 84.73 N-cm | 3.3 A | 32.6 g |
| 100:1 Metal Gearmotor 37Dx57L mm | $24.95 | 12V | 100 | 155.35 N-cm | 5 A | 201.28 g |
|  |  |  |  |  |  |  |
| Motors | Price | Voltage-Max | RPM | Stall Torque | Stall Current | Weight |
| Standard Gearmotor | 4 | 4 | 5.61 | 2.9 | 9.1 | 5.6 |
| Preicision Gearmotor | 1 | 4 | 5.00 | 6.7 | 8.2 | 1.0 |
| 154:1 Metal Gearmotor 20Dx44Lmm | 5 | 8 | 5.00 | 5.9 | 4.1 | 8.8 |
| 100:1 Metal Gearmotor 37Dx57L mm | 4 | 4 | 5.56 | 10.0 | 1.0 | 2.5 |
|  |  |  |  |  |  |  |
| Weights | 0.15 | 0.1 | 0.05 | 0.35 | 0.3 | 0.05 |
|  |  |  |  |  |  |  |
| Motors | Price | Voltage-Max | RPM | Stall Torque | Stall Current | Weight | Total |
| Standard Gearmotor | 0.60 | 0.40 | 0.30 | 1.05 | 2.70 | 0.30 | 5.35 |
| Preicision Gearmotor | 0.15 | 0.40 | 0.25 | 2.45 | 2.40 | 0.05 | 5.70 |
| 154:1 Metal Gearmotor 20Dx44Lmm | 0.75 | 0.80 | 0.25 | 2.10 | 1.20 | 0.45 | 5.55 |
| 100:1 Metal Gearmotor 37Dx57L mm | 0.60 | 0.40 | 0.30 | 3.50 | 0.30 | 0.10 | 5.20 |

### Justification

## Arm

### Items Under Consideration

### Decision Matrix

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Product** | **Claw Size** | **Weight** | **Price** | **DOF** | **Controlled** |  |
| OWI-535 Robotic Arm Edge | 2-3 in. | 1.45 lbs. | $44.29 | 5 | RC |  |
| Stacker 2WD Mobile Robot | 4.25 in. | 3 lbs. | $142.78 | 2 | RC or autonomous |  |
| AX-12 Dual Robotic Gripper | 9 in. | 2 lbs. | $69.00 | 6 | Autonomous |  |
| AL5D Arm Hardware Only - Kit | 1.3 in. | .6 lbs. | $143.88 | 4 | Autonomous |  |
| Weights | 0.25 | 0.15 | 0.15 | 0.25 | 0.2 |  |
|  |  |  |  |  |  |  |
| **Weights** |  |  |  |  |  |  |
| OWI-535 Robotic Arm Edge | 4 | 9 | 10 | 8 | 1 |  |
| Stacker 2WD Mobile Robot | 7 | 5 | 4 | 3 | 7 |  |
| AX-12 Dual Robotic Gripper | 10 | 6 | 9 | 9 | 9 |  |
| AL5D Arm Hardware Only - Kit | 2 | 9 | 4 | 6 | 9 |  |
|  |  |  |  |  |  |  |
| **Weighted Total** |  |  |  |  |  | **Total** |
| OWI-535 Robotic Arm Edge | 1 | 1.35 | 1.5 | 2 | 0.2 | 6.05 |
| Stacker 2WD Mobile Robot | 1.75 | 0.75 | 0.6 | 0.75 | 1.4 | 5.25 |
| AX-12 Dual Robotic Gripper | 2.5 | 0.9 | 1.35 | 2.25 | 1.8 | 8.8 |
| AL5D Arm Hardware Only - Kit | 0.5 | 1.35 | 0.6 | 1.5 | 1.8 | 5.75 |

### Justification

## Wheels

### Items Under Consideration

### Decision Matrix

### Justification

## Frame

### Items Under Consideration

### Decision Matrix

### Justification

## Batteries

### Items Under Consideration

### Decision Matrix

### Justification

# Risk Analysis

## Microcontroller

## Sensors

## Motors

## Arm

## Wheels

## Frame

## Batteries

# Total System Budget

# Glossary

# Acronyms & Abbreviations

|  |  |
| --- | --- |
| **Entry** | **Expanded Phrase** |
| FTFP | Funky Town Fancy Pandas |
| DOF | Degrees of Freedom |
| APS | Autonomous Panda System |
| LED | Light-emitted Diode |
| IEEE |  |
|  |  |

# References