**System Requirements Specifications for Roadie**

Sponsor

**Electrical, Computer, Software & Systems Engineering at Embry-Riddle Aeronautical University**

Released 25 November 2014

**Are We There Yet?**

# **Revision History**

|  |  |  |
| --- | --- | --- |
| Date | Reason for Change | Version |
| 18 Nov 2014 | Initial Draft | 0.1.0 |

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# **Introduction**

## **Purpose**

The purpose of this document is to define the system requirements of Roadie, the robot put forth by team Are We There Yet (AWTY) to compete in the 2015 Institute of Electrical and Electronics Engineers (IEEE) SoutheastCon student hardware competition. These requirements include both functional requirements and non-functional requirements. This document is intended for the customer of AWTY, the requirements engineering team for AWTY, the design, testing and quality assurance teams, as well as all other teams involved in the development and construction.

## **Problem Statement**

To create an autonomous robot to compete in the 2015 IEEE SoutheastCon student hardware competition.

## **Scope**

Roadie is intended to compete in the 2015 IEEE Southeast Con student hardware competition. The system is envisioned to complete four unique challenges:

* Correctly play Simon for 15 seconds
* Draw “IEEE” on an Etch-A-Sketch
* Twist one row of a Rubik’s cube 180 degrees
* Pick up and carry one playing card across the finish line

Roadie system is intended to successfully complete the challenges outlined above within a time limit of five minutes.

Roadie is not intended to serve any other functions or fulfill any other purposes other than competing in the 2015 IEEE SoutheastCon competition.

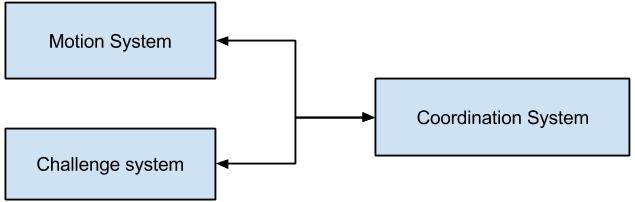
## **Team Information**

|  |  |
| --- | --- |
| Name | Role |
| Brian Powell | Team Leader |
| Michael Philotoff |  |
| Alex Senopoulos |  |
| Brian Sterling |  |

## **Overview**

# **Functional Decomposition of System**

Roadie is broken down three main subsystems: (1) the coordination subsystem, (2) the challenge subsystem and (3) the motion subsystem. The division of these subsystems is illustrated in **Fig. 1**.



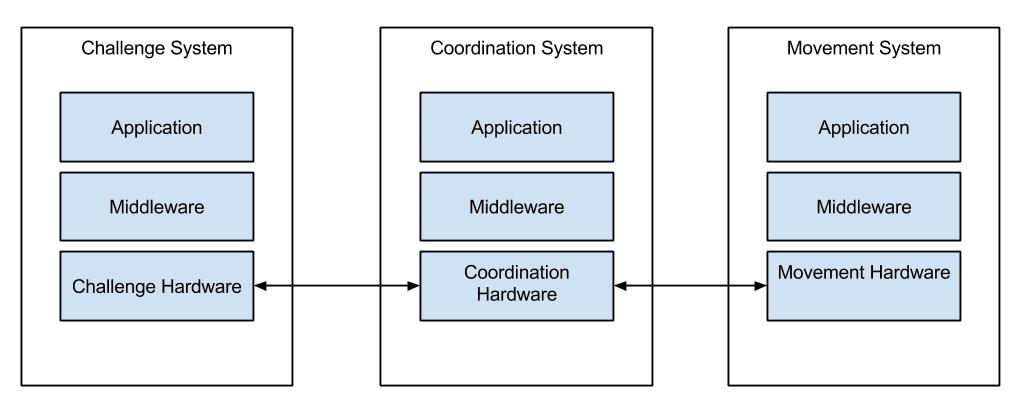
**Fig. 1**: Division of Roadie into three subsystems.

The communication and coordination subsystem relays information to both the arm subsystem and the movement subsystem. The components of Roadie were broken into subsystems based upon what other components they interacted with and what task they set out to perform. For example, all of the interactors for challenges (Simon, Etch-A-Sketch, Rubik’s cube and playing card), were divided into the Challenge System since the interactors represent the means through which Roadie will physically manipulate the challenges. The Coordination System encompasses the microcontrollers as well as the camera and line sensors. The reasoning behind such a decisions is that the camera and line sensors will send correction information that will be interpreted by the microcontroller to navigate the Roadie to the right challenge as well as identify the correct challenge upon arrival. The motion system is comprised of the motors and their associated wheels. This is due to the fact that the motors and wheels are responsible for moving the system to the intended destination.

These subsystems are further divided by functionality to create the high-level architecture as described in Sections 2.1, 2.2 and 2.3.

## **High-Level Architecture of System**

The system architecture of Roadie is designed in a layered approach, depicted in **Fig*.* 2** below, in order to better divide the work being done and to aid in the conceptualization of the system design.

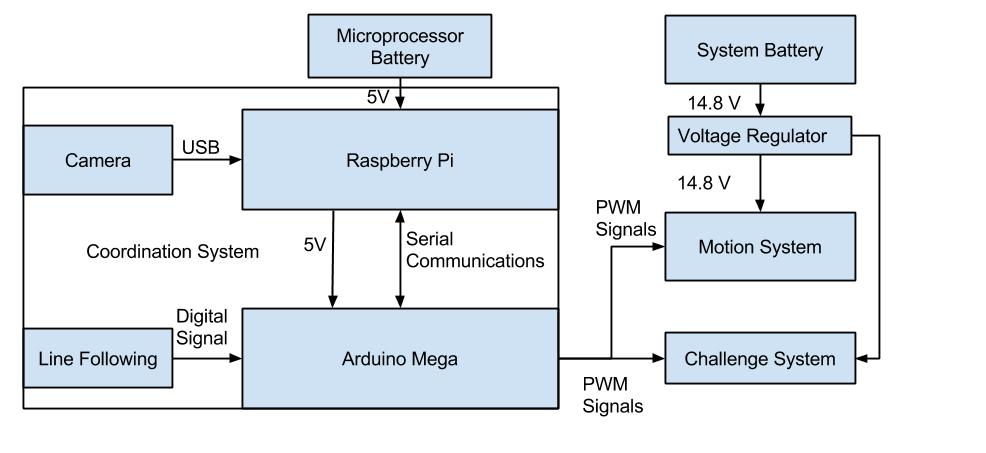


**Fig. 2**: High level description of the systems in Roadie.

The applications in the Coordination System represent feedback from the sensors (reflectance and camera) which is translated by the middleware (software) to the physical communications means. From here, the Challenge System and the Motion System are directed by the Coordination System in order to navigate to challenges (Motion System) and complete the challenges (Challenge System). From there, middleware in the form of software is used to talk to the applications. In this instance, the application in the Challenge System represents the challenges (Simon Carabiner, pocket Etch-A-Sketch, Rubik’s cube, picking up a playing card), with the motion application being moving the whole system along the competition area. As Roadie progresses along, the Communication System constantly sends correction information to the Motion System as well as monitor the Motion System’s behavior to correct any anomalies.

## **Decomposition of Coordination System**

**Fig. 3** below, better illustrates the communications that occur amongst the systems in Roadie.



**Fig. 3**: Decomposition of coordination system for Roadie.

As depicted in **Fig. 3**, the Coordination System is composed of two microcontrollers, both communicating with each other over a serial interface. The Arduino Mega is the primary micro controller, interpreting inputs from the reflectance array (line following) and issuing commands based on values received. For instance, once the Arduino has detected a challenge location based on a pre-defined threshold, it will issue a command to the Raspberry Pi to object detect with the camera. Once an object has been found, the Raspberry Pi will send a signal back to the Arduino identifying what object has been found. The Arduino will then issues commands to the Challenge System based upon what challenge has been found, and to the Motion System to move the system to the corresponding location on the challenge array.

All of the communications originating from the Coordination System are a hard wire connection. That is to say that all of the communications occur over a physical medium. The Arduino issues commands to the Motion System and the Challenge System via pulse width modulation (PWM) signals through wires connected to the Arduino’s PWM ports. Similarly, communications within the Coordination System occur over a physical medium. The Raspberry Pi and the Arduino communicate via a serial communications over a USB cable. The camera is activated by the Raspberry Pi via serial signals over a USB cable as well. The line following array communicates via digital high and low signals over wires connected to the digital pins on the Arduino.

## **Requirements**

### **Navigation**

COR 1. The system shall commence operation from the starting area. (3.2.1).

COR 2. The system shall progress forward along the blue guidance tape until reaching a challenge zone or reaching the finish line.

COR 4 The system shall **some metric about line following**

COR 5 The system shall identify the challenge zone upon arrival.

COR 5.1 The system shall approach the challenge until it is 4.2 cm ± 0.1 cm from the challenge.

COR 5.2 The system shall initiate the challenge detection process once it is 4.2 cm ± 0.1 cm from the challenge

COR 5.3 Upon completing the challenge, the system shall exit the challenge zone, continuing to progress along the blue guidance tape.

* + - 1. **Challenge Detection**

COR 4. The system shall correctly identify the challenge within 10 seconds of arrival in a challenge zone

COR 4.1 The system shall correctly identify the challenge within 5 seconds of initiating the challenge detection process.

COR 4.1 The system shall correctly identify the Simon Carabiner depicted in

COR 4.2 The system shall correctly identify the Rubik’s Cube depicted in

COR 4.3 The system shall correctly identify the pocket Etch-A-Sketch depicted in

COR 4.4 The system shall correctly identify the playing cards depicted in

COR 5 The system shall determine the center of the challenge relative to the center of the leading edge of the chassis.

COR 5.1 The system shall align with the challenge if the challenge is not within 0.1 cm of the center of the leading edge of the chassis

## **Use Cases**

The following use cases demonstrate the intended operations of the Coordination System of Roadie. The use cases outline the intended sequence of events as well as the procedures that will be followed in the event of a system failure.

Note: “\*” indicates at any given time, during the use case.

## **Use Case 1: Line Following**

Scope: Roadie

Level: User goal

Primary Actors: Roadie

**Stakeholders & Interests**

**Team AWTY**  - as the development team for Roadie, Roadie’s performance in the challenge will reflect directly back upon them.

* **Dr. Barott, Dr. Seker and Mr. Jorge Torres –** as customers of Team AWTY, there is an expectation that Roadie will compete successfully in the challenge.
* **ERAU –** the system represents the quality of the education at the University as well as the technical ability of the sponsors and the department.
* **ECSSE Department –** direct sponsor of Team AWTY expects Roadie to compete in and complete the challenge to the best of its abilities.
* **IEEE –** competition sponsor expects Team AWTY to conduct themselves in a manner befitting of a professional organization as well as to demonstrate innovate solutions to technical challenges.

**Preconditions**

* Roadie has been placed in the 1 ft. x 1 ft. starting area on the competition area.
* Roadie has been turned to the on position.

**Postconditions**

* Roadie crosses the finish line.

**Main Success Scenario**

1. Roadie waits for the red LED to turn off before entering into the Line Following State.
2. Roadie enters into the Line Following State and starts line following making turns based on which way the line is turning until reaching the first challenge.
3. After completing the first challenge, Roadie turns around and begins to line follow until reaching the second challenge.
4. After completing the second challenge, Roadie turns around and beings to line follow until reaching the third challenge.
5. After completing the third challenge, Roadie turns around and beings to line follow until reaching the fourth challenge.
6. After completing the fourth challenge, Roadie turns around and beings to line follow until crossing the finish line.

**Extensions (Alternate Flows)**

\*a. Roadie has

**Frequency of Occurrence**

This use case will occur each time the system is placed within the 1 ft. x 1 ft. white square. During the competition this shall occur three times due to there being three rounds for each robot that is entered.

## **Arrival at Challenge Zone**

Scope: Roadie

Level: User goal

Primary Actors: Roadie

**Stakeholders & Interests**

* **Team AWTY**  - as the development team for Roadie, Roadie’s performance in the challenge will reflect directly back upon them.
* **Dr. Barott, Dr. Seker and Mr. Jorge Torres –** as customers of Team AWTY, there is an expectation that Roadie will compete successfully in the challenge.
* **ERAU –** the system represents the quality of the education at the University as well as the technical ability of the sponsors and the department.
* **ECSSE Department –** direct sponsor of Team AWTY expects Roadie to compete in and complete the challenge to the best of its abilities.
* **IEEE –** competition sponsor expects Team AWTY to conduct themselves in a manner befitting of a professional organization as well as to demonstrate innovate solutions to technical challenges.

**Preconditions**

* Roadie has reached a challenge zone.

**Postconditions**

* Roadie has correctly identified what challenge zone it has arrived at.

**Main Success Scenario**

1. Roadie correctly detects it has arrived at a challenge zone.
2. Roadie begins to approaches the object.
3. Roadie halts movement at 4.2 cm ± 0.1 cm from the challenge.
4. Roadie correctly initiates the challenge detection process.
5. Roadie correctly identifies the challenge it has arrived at within 5 seconds of initiating the challenge detection process.
6. Roadie determines the alignment of the challenge relative to the leading edge of the chassis.
   * If the challenge is aligned within 0.1 cm of the leading edge of the chassis, Roadie will proceed to step 9.
   * If challenge is not aligned within 0.1 cm of the leading edge of the chassis, Roadie will proceeded to step 7.
7. Roadie correctly determines the direction and distance to move laterally (left or right) to align with the challenge.
8. Roadie repeats steps 6 and 7 until it is aligned within 0.1 cm of the leading edge of the chassis.
9. Roadie enters a challenge completion state.

**Extensions (Alternate Flows)**

\*a. Roadie fails to correctly detects it has arrived at a challenge zone.

1.

\*b. Roadie fails to halt movement at 4.2 cm ± 0.1 cm from the challenge.

1.

\*c. Roadie fails to correctly initiate the challenge detection process

1.

\*d. Roadie fails to correctly detect the challenge.

1.

\*e. Roadie fails to correctly identify the challenge within 5 seconds of initiating the challenge identification process.

1. Roadie will continue

**Frequency of Occurrence**

This use case will occur every time Roadie reaches a challenge zone. During the competition this shall occur four times due to there being four challenge zones on the competition area.

## **Traceability Matrix**

## **Decomposition of Challenge System**

**Fig. 4** shows the decomposition of the Challenge System into its major components.



**Fig. 4**: Decomposition of Challenge System for Roadie.

Signals into this subsystem originate from the Coordination System via PWM signals from the Arduino’s PWM ports. The signals designate what interactor is to activate and what challenge sequence is to be completed. Power for each interactor is sourced from a 14.8V battery.

## Rubik’s & Card Interactor

## Requirements

## Use Cases

## Traceability Matrix

## Etch-A-Sketch Interactor

## Requirements

## Use Cases

## Traceability Matrix

## Simon Interactor

## Requirements

## Use Cases

## Traceability Matrix

## **Decomposition of Movement System**

**Fig. 5** shows the decomposition of Roadie’s movement System into major components.



**Fig. 5**: Decomposition of Movement System Roadie.

Signals into this subsystem originate from the Coordination System via PWM signals from the Arduino’s PWM ports. The signals are sent to a motor shield, which interprets the signals and activates the correct motor. When the motor receives a signal to activate, it turns a wheel which is connected via bolts. Power to the Movement System is sourced from a 14.8V battery.

## Requirements

## Use Cases

## Traceability Matrix

# **Appendix A**

Appendix A includes all of the requirements presented in the System Requirements Specifications for Roadie, version 1.0.0, dated 2014-09-18. The requirement text is shown, followed by changes, signified by a red strike-through. The resulting revised requirement in shown in the final column. This information is displayed in **Table** 1below:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Previous Requirement Number | Previous Text | Changes | Resulting Requirement Text | New Requirement Number |
| 3.1.1 | The system shall move in the competition area shown in **Fig. 7**. |  |  |  |
| 3.1.2 | The system shall move from the starting area to the Simon Carabiner along the Scotch Blue Painter’s tape (guidance tape). |  |  |  |
| 3.1.3 | The system shall move from the Simon Carabiner to the pocket Etch-a-Sketch along the guidance tape. |  |  |  |
| 3.1.4 | The system shall move from the pocket Etch-a-Sketch to the Rubik’s Cube along the guidance tape. |  |  |  |
| 3.1.5 | The system shall move from the Rubik’s Cube to the deck of playing cards along the guidance tape. |  |  |  |
| 3.1.6 | The system shall move from the deck of playing cards to the finish line along the guidance tape. |  |  |  |
| 3.1.7 | The system shall wait for red [RGB value TBD] LED in starting area to turn off before exiting the starting area. |  |  |  |
| 3.2.1 | The system shall start in the starting area. | The system shall ~~start in the~~ commence operation from the starting area. | The system shall commence operation from the starting area. | COR 1 |
| 3.2.2 | The system shall progress forward along the blue guidance tape until reaching a challenge area or reaching the finish line. |  |  |  |
| 3.2.3 | The system shall identify the challenge zone and stop movement upon arrival. | The system shall identify the challenge zone ~~and stop movement~~ upon arrival. | The system shall identify the challenge zone upon arrival. |  |
| 3.3.1 | The system shall correctly identify the challenge upon arrival. | The system shall correctly identify the challenge within 10 seconds of arrival in a challenge zone. | The system shall correctly identify the challenge within 10 seconds of arrival in a challenge zone. |  |
| 3.3.1.1 | The system correctly identifies the Simon Carabiner depicted in **Fig. 8** | The system shall correctly identify the Simon Carabiner depicted in **Fig. 8** | The system shall correctly identify the Simon Carabiner depicted in **Fig. 8** |  |
| 3.3.1.2 | The system correctly identifies the Rubik’s Cube depicted in **Fig. 9.** | The system shall correctly identify the Rubik’s Cube depicted in **Fig. 9** | The system shall correctly identify the Rubik’s Cube depicted in **Fig. 9** |  |
| 3.3.1.3 | The system correctly identifies the pocket Etch-A-Sketch depicted in **Fig. 10**. | The system shall correctly identify the pocket Etch-A-Sketch depicted in **Fig. 10** | The system shall correctly identify the pocket Etch-A-Sketch depicted in **Fig. 10** |  |
| 3.3.1.4 | The system correctly identifies the playing cards depicted in **Fig.** [TBD]. | The system shall correctly identify the playing cards depicted in **Fig.** [TBD]. | The system shall correctly identify the playing cards depicted in **Fig.** [TBD]. |  |
| 3.3.2 | The system shall align with the challenge before attempting to complete the challenge. | The system shall align with the challenge if the challenge is not within 0.1 cm of the center of the leading edge of the chassis. | The system shall align with the challenge if the challenge is not within 0.1 cm of the center of the leading edge of the chassis. |  |
| 3.3.3 | The system shall play the Simon Carabiner. |  |  |  |
| 3.3.3.1 | The system shall play the Simon Carabiner for 15 seconds. |  |  |  |
| 3.3.3.2 | The system shall initiate the Simon Carabiner by pressing the start button. |  |  |  |
| 3.3.3.3 | The system shall correctly sense color blue [exact RGB values TBD] when illuminated on the Simon Carabiner. |  |  |  |
| 3.3.3.4 | The system shall correctly sense color red [exact RGB values TBD] when illuminated on the Simon Carabiner. |  |  |  |
| 3.3.3.5 | The system shall correctly sense color yellow [exact RGB values TBD] when illuminated on the Simon Carabiner. |  |  |  |
| 3.3.3.6 | The system shall correctly sense color green [exact RGB values TBD] when illuminated on the Simon Carabiner. |  |  |  |
| 3.3.3.7 | The system shall not obstruct the Simon Carabiner during play. |  |  |  |
| 3.3.3.8 | The system shall respond to the last color in the Simon sequence within [TBD] amount of time. |  |  |  |
| 3.3.4 | The system shall twist one row of a Rubik’s Cube 180 degrees. |  |  |  |
| 3.3.4.1 | The system shall not obstruct the Rubik’s Cube during play. |  |  |  |
| 3.3.5 | The system shall draw “IEEE” on the pocket Etch-A-Sketch. |  |  |  |
| 3.3.5.1 | The system shall use [Font and Size TBD] for drawing “IEEE”. |  |  |  |
| 3.3.5.2 | The system shall not obstruct the pocket Etch-A-Sketch during play. |  |  |  |
| 3.3.6 | The system shall collect a single playing card [Exact deck TBD]. |  |  |  |
| 3.3.6.1 | The system shall carry playing card across finish line. |  |  |  |
| 3.3.6.2 | The system shall keep the card in a usable condition. |  |  |  |
| 4.1.1 | The system size shall be no greater than 1ft. x 1ft. x 1ft. within the starting area and the finishing area. |  |  |  |
| 4.2.1 | The system shall operate for a minimum of [TBD] minutes when the power source starts with a full charge. |  |  |  |
| 4.3.1 | The system shall have an easily accessible power switch. |  |  |  |
| 4.3.2 | The system shall be completely autonomous after being powered on. |  |  |  |
| 4.3.3 | The system shall maintain contact with the competition area’s surface at all times. |  |  |  |

Table 1:Requirements imposed upon Roadie in the level one requirements.

# **Glossary**

The glossary contains definitions of words and phrases used throughout this document.

|  |  |  |
| --- | --- | --- |
| Entry | Definition | Aliases |
| Align | The system will position itself so the appendages can properly reach the challenges. |  |
| Autonomous | Undertaken or carried on without outside control [2]. |  |
| Bad state | Any state that is not the line following state or the challenge state. |  |
| Challenge Detection Process |  |  |
| Challenge State | The state in which Roadie is completing one of the four challenges. |  |
| Challenge Zone | The 1ft. x 1ft. areas where each of the challenges will be played along the course. |  |
| Competition Area | The competition area is the plywood board where the competition is being held on. The system must maintain contact with the board at all times. |  |
| Course Round | A span of five minutes during which the system is expected to complete the 4 challenges [1]. |  |
| Pocket Etch-A-Sketch | The pocket Etch-A-Sketch is a popular children’s toy with two knobs to move the cursor up and down as well as left and right. For the competition, the specific version of the pocket Etch-A-Sketch being used is SKU:FD79DD3F from Toys R Us online [7], and can be seen in **Fig. 10.** |  |
| Finish Line | The finish line is the ending point of the competition. It is the point where the Scotch Blue Painter’s Tape comes to the final “T” shape on the course [1]. It is marked as FINISH in **Fig. 7**. |  |
| Good state | Either the line following state or the challenge state. |  |
| Institute of Electrical and Electronics Engineers | “IEEE is the world's largest professional association dedicated to advancing technological innovation and excellence for the benefit of humanity” [4]. That being said, IEEE is not only composed of electronic and electrical engineers as the name might suggest. Other types of members include computer scientists, software developers and even some doctors. | IEEE |
| Line Following State | The state in which Roadie is following the Scotch Blue Painter’s tape located on the competition area. |  |
| Obstruct | SoutheastCon rules state that the system cannot obstruct any obstacle [1]. |  |
| Playing Card | Information on the specific playing cards is still pending, thus, [TBD]. |  |
| Rubik’s Cube | The Rubik’s Cube is a puzzle game that achieved popularity in the 1980’s. For the competition, the specific version of the Rubik’s Cube being used is SKU:DAD09D9E from Toys R Us online [6], and can be seen in **Fig. 9.** |  |
| Scotch Blue Painter’s Tape | Scotch Blue is a brand of painter’s tape produced by the company 3M. For the competition, the specific model of painters tape being used is SKU: 958999 from Home Depot [8], and can be seen in **Fig. 11.** | Guidance Tape |
| Simon Carabiner | The Simon Carabiner is another version of the game, Simon, which is an electronic version of the children’s game “Simon Says”. For the competition, the specific version of Simon being used is SKU:226CE810 from Toys R Us online [5], and can be seen in **Fig. 8.** |  |
| SoutheastCon | SoutheastCon is the annual IEEE Region 3 Technical, Professional, and Student Conference. The conference includes technical sessions, tutorials, and exhibits. Additionally, various challenges and competitions are held for students to demonstrate their technical knowledge and understanding.“IEEE Region 3 encompasses the southeastern United States and includes the states of Alabama, Florida, Georgia, areas of Indiana, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia and the country of Jamaica” [3]. |  |
| Starting Area | A one foot by one foot area on the competition area marked by Scotch Blue Painter’s tape [1]. |  |
| Usable Condition | SoutheastCon rules state that the playing card must be left in a usable condition [1]. |  |