Team Galaxy
System Requirements Specification

Project: Bowling on Lane Tracking System (BOLTS)

Team Members:
Sonia Hampton
Randal Blackmon
Ciawash Jawshan
Ahmad Saad

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1. Product Concept

This section describes the purpose, use, and intended user audience for the Bowling On Lane Tracking System. The Bowling On Lane Tracking System will be used in tandem with the Enhanced Automated Robotic Launcher which is provided by the sponsor Emily Troutman, not Team Galaxy. The Enhanced Automated Robotic Launcher was created to throw a bowling ball with immense precision and repeatability. The Enhanced Automated Robotic Launcher has the ability to be programmed to throw a bowling ball like any human bowler in regards to speed, amount of revolutions, tilt, axis rotation, and many other factors that are involved in a bowling balls motion. The Bowling On Lane Tracking System and the Enhanced Automated Robotic Launcher, from this point forward, will be referred to as BOLTS and EARL.

1.1 Purpose and Use

BOLTS will be a way to track each bowling ball’s motion after EARL releases the ball. EARL will be able to simulate the speed, number of revolutions, tilt, and axis rotation of any human bowler. When each shot is thrown by EARL, BOLTS will need to produce the position in the x and y direction along with the velocity at given points on the lane. These points will be displayed on a graphical user interface, which will allow the user to analyze multiple aspects of the ball’s motion and give a better understanding of what happens out on the lane. Different size, weight, and colored bowling balls will be used in testing. After a run is complete on each bowling ball, twenty factors of the ball’s motion will be looked at for each individual ball in the analysis. Each factor will tell the user a particular aspect about each ball’s motion. The information will be put together in a study for better understanding of the system of bowling. Also, the study will demonstrate the accuracy and repeatability EARL has to offer to the bowling community.

1.2 Intended Audience

Our intended audience is the United States Bowling Congress. BOLTS is not a product that is to be made publicly or commercially available to anyone outside of the United States Bowling Congress office.
Figure 1-1: System Overview
2. Product Description and Functional Overview

This section describes an overview of BOLTS. The primary operational aspects of the product, from the perspective of end users, maintainers and administrators, are defined here. The key features and functions found in the product, as well as critical user interactions and user interfaces are described in detail.

2.1 Features and Functions

The system shall be composed of digital video cameras hung in line above a bowling lane. The height above the lane that each camera is placed and the distance between each camera will be determined by the number of cameras used for BOLTS. The cameras will be connected, via Ethernet, to a PCI express card. The PCI express card will then send a single connection to a terminal to monitor ball position and speed. The system shall not track the ball beyond the head pin or into the gutters. The cameras in the figure 2-1 shows a four camera system mounted to the ceiling.

![Figure 2-1: Camera Setup](image-url)
2.2 External Inputs and Outputs

The user will activate BOLTS through the “Start Capture” button on the user interface. The cameras will begin capturing images of the lane. The images will be sent to the image processor. The image processor will use image analysis to retrieve the speed and position of the bowling ball. The user interface will display the speed and the position of the bowling ball to the user.

![Figure 2-2: BOLTS Data Flow](image)

Table 2-1: Description of external inputs and outputs

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cameras</td>
<td>High quality cameras that will capture images from the bowling lane.</td>
<td>Outputs images to image processor.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accepts activation or deactivation input from user interface.</td>
</tr>
<tr>
<td>Image Processor</td>
<td>A PCI Express card, the component between the cameras and user interface; performs image analysis.</td>
<td>Accepts images as input from the cameras.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outputs speed and position to the user interface.</td>
</tr>
<tr>
<td>User Interface</td>
<td>A monitor and computer that displays data to the user and activate or deactivate BOLTS</td>
<td>Accepts input from image processor.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outputs speed and position to the user.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outputs activation or deactivation signal to cameras.</td>
</tr>
</tbody>
</table>
2.3 Product Interfaces

The graphical user interface (GUI) will allow the user to start and end capture of video, will allow the user to save the acquired information and/or video to a file, will allow user to create a file where they can input various information about a test shot, will allow user to export data, will allow user to delete the last test shot from the GUI, and will allow the user to view a previously saved file. Start Capture will begin video of bowling lane. End capture will end video of bowling lane. Shot numbers represent a particular release by EARL of a bowling ball. Numerical numbers on left hand side of GUI represent a given frame number of the given test shot released by EARL. The “x” value will be the vertical position of the bowling ball on the bowling lane for a particular shot and a particular frame. The “y” value will be the horizontal position of the bowling ball on the bowling lane for a particular shot and a particular frame. The “v” value will be the velocity of the bowling ball on the bowling lane for a particular shot and a particular frame.

The figure below shows a prototype of the graphical user interface that will be displayed on the user’s computer when BOLTS is active.

![B.O.L.T.S. GUI Prototype](image-url)

**Figure 2-3 Preliminary Graphical User Interface Display**
3. Customer Requirements

This section provides the basic functions, features, and appearance of BOLTS as requested by the customer. The customer is the United States Bowling Congress and our sponsor is Emily Troutman. Requirements in this section cannot be changed without customer and/or sponsor approval. Requirements that have a priority of critical are requirements that shall be used in the implementation of BOLTS.

3.1 Ball Tracking

3.1.1 Description: BOLTS shall keep track of the vertical and horizontal position of a bowling ball as it rolls down the lane (Figure 2-3). Video tracking will begin at foul line and end at the head pin.

3.1.2 Source: Sponsor

3.1.3 Constraints: Background movement such as shadows could affect tracking.

3.1.4 Standards: None

3.1.5 Priority: 1 – Critical

3.2 Ball Speed

3.2.1 Description: BOLTS shall output the speed of the bowling ball at a given position on the bowling lane. Accuracy of speed must be within 0.1 mph.

3.2.2 Source: Sponsor

3.2.3 Constraints: Measurement shall be accurate to within 0.1 mph.

3.2.4 Standards: BOLTS shall use United States customary units of measurement.

3.2.5 Priority: 1 – Critical
3.3 Distance from Foul Line

3.3.1 Description: BOLTS shall output how far the bowling ball is from the foul line. This value will be reflected on the GUI as the “x” position of the ball. Accuracy of positioning of ball must be within 0.1 inch.

3.3.2 Source: Sponsor

3.3.3 Constraints: Measurement shall be accurate to within 0.1 inch.

3.3.4 Standards: BOLTS shall use United States customary units of measurement. BOLTS shall follow the United States Bowling Congress play area regulations.

3.3.5 Priority: 1 – Critical

3.4 Board Position

3.4.1 Description: BOLTS shall output the board number the bowling ball is on at a given position on the bowling lane. This value will be reflected on the GUI as the “y” position of the ball. Accuracy of positioning of ball must be within 0.1 inch.

3.4.2 Source: Sponsor

3.4.3 Constraints: Measurement shall be accurate to within 0.1 inch.

3.4.4 Standards: BOLTS shall use United States customary units of measurement. BOLTS shall follow the United States Bowling Congress play area regulations.

3.4.5 Priority: 1 – Critical

3.5 Cameras Elevated

3.5.1 Description: The cameras shall be elevated above the ground and pointed on the lane.

3.5.2 Source: Sponsor

3.5.3 Constraints: The cameras shall be connected by Ethernet.

3.5.4 Standards: Category 6 cable standards shall be used.

3.5.5 Priority: 1 – Critical
3.6 Store data

3.6.1 Description: BOLTS shall store the output data to a storage device.

3.6.2 Source: Sponsor

3.6.3 Constraints: Space of the storage device.

3.6.4 Standards: None

3.6.5 Priority: 1 – Critical

3.7 Retrieve Data

3.7.1 Description: BOLTS shall retrieve data from a storage device and display the data to the user.

3.7.2 Source: Sponsor

3.7.3 Constraints: None

3.7.4 Standards: None

3.7.5 Priority: 1 – Critical

3.8 Operate on Computer Provided

3.8.1 Description: BOLTS shall run on the computer in the United States Bowling Congress research facility.

3.8.2 Source: Sponsor

3.8.3 Constraints: The specifications of the computer.

3.8.4 Standards: None

3.8.5 Priority: 1 – Critical
3.9 Graphical User Interface

3.9.1 Description: BOLTS shall have a graphical user interface to activate and deactivate BOLTS, save and retrieve data, and display the outputs.

3.9.2 Source: Team Galaxy

3.9.3 Constraints: None

3.9.4 Standards: Outputs shall be displayed in United States customary units.

Graphical user interface items shall be displayed in American English.

3.9.5 Priority: 1 – Critical

3.10 Save Video

3.10.1 Description: BOLTS shall have the option to save captured video.

3.10.2 Source: Sponsor

3.10.3 Constraints: Space of the storage device.

3.10.4 Standards: None

3.10.5 Priority: 1 – Critical

3.11 Export Data

3.11.1 Description: BOLTS shall have the option to export the data displayed on the screen.

3.11.2 Source: Sponsor

3.11.3 Constraints: None

3.11.4 Standards: None

3.11.5 Priority: 1 – Critical
3.12 Clear Last Shot

3.12.1 Description: BOLTS shall have the option to clear the last shot from the user interface.

3.12.2 Source: Sponsor

3.12.3 Constraints: None

3.12.4 Standards: None

3.12.5 Priority: 1 – Critical

3.13 Create File

3.13.1 Description: BOLTS shall have the option for the user to create a file where they can input various information about a test shot.

3.13.2 Source: Sponsor

3.13.3 Constraints: None

3.13.4 Standards: None

3.13.5 Priority: 1 – Critical
4. Packaging Requirements

This section describes the packaging requirements for BOLTS. The BOLTS will be delivered to the United States Bowling Congress in the form of an executable file on DVD. The software will also be preloaded on the customer’s computer located at the United States Bowling Congress. The software will interface with cameras located at the United States Bowling Congress. Requirements that have a priority of critical are requirements that shall be delivered with BOLTS. Requirements that have a priority of moderate are requirements that may be delivered with BOLTS if all critical requirements are completed.

4.1 Software Installation

4.1.1 Description: BOLTS shall be loaded onto the computer in the United States Bowling Congress research lab.

4.1.2 Source: Sponsor

4.1.3 Constraints: None

4.1.4 Standards: None

4.1.5 Priority: 1 – Critical

4.2 DVD

4.2.1 Description: A DVD shall be delivered to the United States Bowling Congress containing BOLTS executable program, source code, and documentation.

4.2.2 Source: Team Galaxy

4.2.3 Constraints: None

4.2.4 Standards: Documentation shall be written in American English.

4.2.5 Priority: 1 – Critical
4.3 User Manual

4.3.1 Description: BOLTS shall include a user manual, which includes operating procedure, system specification and requirements, and troubleshooting.

4.3.2 Source: Team Galaxy

4.3.3 Constraints: None

4.3.4 Standards: User manual shall be written in American English.

4.3.5 Priority: 3 – Moderate

4.4 EARL

4.4.1 Description: EARL shall be provided by the United States Bowling Congress.

4.4.2 Source: Mr. O’Dell

4.4.3 Constraints: None

4.4.4 Standards: None

4.4.5 Priority: 1 - Critical
5. Performance Requirements

This section describes the performance requirements BOLTS should meet. The performance requirements include the response time, the accuracy of the output, and the ability to track different colored bowling balls under different lighting conditions. Requirements that have a priority of critical are conditions that BOLTS shall be able to perform. Requirements that have a priority of high are requirements that BOLTS can perform under, but can be adjusted if BOLTS cannot perform under those conditions.

5.1 Response Time

5.1.1 Description: The output for each run shall be displayed on the computer within 15 seconds.

5.1.2 Source: Sponsor

5.1.3 Constraints: The response time is affected by the amount of data being transferred and analyzed from the cameras.

5.1.4 Standards: None

5.1.5 Priority: 1 – Critical

5.2 Accuracy

5.2.1 Description: All measurements shall be within 0.1 units.

5.2.2 Source: Sponsor

5.2.3 Constraints: The accuracy is affected by the number of cameras being used.

5.2.4 Standards: Accuracy shall use United States customary units of measurements.

5.2.5 Priority: 1 – Critical
5.3 Lighting

5.3.1 Description: The system shall detect the movement of the bowling ball on a lane illuminated to 50-500 lumens per square meter (lux).

5.3.2 Source: Sponsor

5.3.3 Constraints: None

5.3.4 Standards: None

5.3.5 Priority: 2 – High

5.4 Ball Color

5.4.1 Description: The system shall be able to track a bowling ball of any color.

5.4.2 Source: Sponsor

5.4.3 Constraints: None

5.4.4 Standards: None

5.4.5 Priority: 1 - Critical
6. Safety Requirements

This section describes the safety requirements for BOLTS. These requirements ensure the safe operation of BOLTS and safety of the user. Requirements that have a priority of critical are items that will be used in the implementation of BOLTS.

6.1 Overhead Camera Security

6.1.1 Description: The cameras shall be securely fixed to the ceiling, evenly spaced down the center of the lane between the foul line and the head pin.

6.1.2 Source: Team Galaxy

6.1.3 Constraints: Securing material must be strong enough to hold the cameras in place.

6.1.4 Standards: None

6.1.5 Priority: 1 - Critical

6.2 No Obstructing Wires

6.2.1 Description: Any wires shall be out of the way so they do not block a path or trip anyone.

6.2.2 Source: Team Galaxy

6.2.3 Constraints: None

6.2.4 Standards: None

6.2.5 Priority: 1 - Critical
6.3 No Exposed Wires

6.3.1 Description: Wires shall not be exposed.

6.3.2 Source: Team Galaxy

6.3.3 Constraints: None

6.3.4 Standards: None

6.3.5 Priority: 1 - Critical
7. Maintenance and Support Requirements

This section describes the maintenance and support requirements for BOLTS. This section includes information on code documentation, product testing and system maintenance. This section also explains the measures we will take to ensure the product is able to be modified and expanded upon. Requirements that have a priority of critical are items that will be used in the implementation of BOLTS.

7.1 Source Code

7.1.1 Description: Team Galaxy’s source code shall be well documented with comments and details to allow future teams to add functionality.

7.1.2 Source: Team Galaxy

7.1.3 Constraints: None

7.1.4 Standards: Comments shall be written in American English.

7.1.5 Priority: 1 – Critical

7.2 Testing

7.2.1 Description: Team Galaxy shall test the BOLTS for performance and accuracy of output to ensure it meets the required functionality.

7.2.2 Source: Team Galaxy

7.2.3 Constraints: None

7.2.4 Standards: None

7.2.5 Priority: 1 – Critical
7.3 Code Naming Conventions

7.3.1 Description: Team Galaxy shall dictate the code’s naming conventions.

7.3.2 Source: Team Galaxy

7.3.3 Constraints: None

7.3.4 Standards: Naming conventions shall be meaningful.

7.3.5 Priority: 1 – Critical

7.4 Calibrate System

7.4.1 Description: BOLTS shall have the option to calibrate the system.

7.4.2 Source: Sponsor

7.4.3 Constraints: None

7.4.4 Standards: None

7.4.5 Priority: 1 – Critical
8. Other Requirements

This section describes the requirements that do not fall under any of the previous categories. Requirements that have a priority of critical are items that will be used in the implementation of BOLTS.

8.1 American English Written Standard

8.1.1 Description: All required documentation and user interfaces shall be written in American English standard language.

8.1.2 Source: Team Galaxy

8.1.3 Constraints: None

8.1.4 Standards: American English standard language shall be used.

8.1.5 Priority: 1 – Critical

8.2 United States Customary Units

8.2.1 Description: All measurements shall be measured in United States customary units.

8.2.2 Source: Team Galaxy

8.2.3 Constraints: None

8.2.4 Standards: United States customary units shall be used.

8.2.5 Priority: 1 - Critical
9. Acceptance Criteria

This section describes the acceptance criteria for BOLTS. Based on the following criteria, the final product will be determined to be complete or incomplete by the sponsor.

9.1 Verify that the system is providing accurate feedback

9.1.1 Requirement(s) addressed

<table>
<thead>
<tr>
<th>No.</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Ball Position</td>
</tr>
<tr>
<td>3.2</td>
<td>Ball Speed</td>
</tr>
<tr>
<td>3.8</td>
<td>Operate on Computer Provided</td>
</tr>
<tr>
<td>3.9</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>5.2</td>
<td>Accuracy</td>
</tr>
<tr>
<td>7.4</td>
<td>Calibrate System</td>
</tr>
</tbody>
</table>

9.1.2 Verification Procedure

BOLTS will be tested to ensure that the system is recording the video and sending the information to the computer. This will be verified by starting the video capture on the GUI and verifying that the video captured is displayed on the GUI.
9.2 Verify that the system runs in real time

9.2.1 Requirement(s) addressed

<table>
<thead>
<tr>
<th>No.</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>Response Time</td>
</tr>
</tbody>
</table>

9.2.2 Verification Procedure

BOLTS will be tested and verified that the data is displayed on the GUI within 15 seconds.

9.3 Verify that the system saves all data

9.3.1 Requirement(s) addressed

<table>
<thead>
<tr>
<th>No.</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Ball Position</td>
</tr>
<tr>
<td>3.2</td>
<td>Ball Speed</td>
</tr>
<tr>
<td>3.6</td>
<td>Store Data</td>
</tr>
<tr>
<td>3.7</td>
<td>Retrieve Data</td>
</tr>
<tr>
<td>3.8</td>
<td>Operate on Computer Provided</td>
</tr>
<tr>
<td>3.9</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>3.10</td>
<td>Save Video</td>
</tr>
<tr>
<td>5.2</td>
<td>Accuracy</td>
</tr>
</tbody>
</table>

9.3.2 Verification Procedure

A test run will be executed and data will be saved to a file using the GUI. The saved file will then be retrieved using the GUI and user will verify that the saved data is displayed on the screen.
9.4 Verify that system detects different color balls

9.4.1 Requirement(s) addressed

<table>
<thead>
<tr>
<th>No.</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Ball Position</td>
</tr>
<tr>
<td>3.2</td>
<td>Ball Speed</td>
</tr>
<tr>
<td>3.8</td>
<td>Operate on Computer Provided</td>
</tr>
<tr>
<td>3.9</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>5.2</td>
<td>Accuracy</td>
</tr>
<tr>
<td>5.3</td>
<td>Lighting</td>
</tr>
<tr>
<td>5.4</td>
<td>Ball Color</td>
</tr>
</tbody>
</table>

9.4.2 Verification Procedure

Multiple test cases will be executed using different colored balls under different lighting conditions. After each test case is executed data will be verified to ensure that ball is detected and data is displayed on the GUI.

9.5 Verify that system is safe for user

9.5.1 Requirement(s) addressed

<table>
<thead>
<tr>
<th>No.</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>Overhead Camera Security</td>
</tr>
<tr>
<td>6.2</td>
<td>No Obstructing Wires</td>
</tr>
<tr>
<td>6.3</td>
<td>No Exposed Wires</td>
</tr>
</tbody>
</table>
9.5.2 Verification Procedure

The product will be inspected to ensure that cameras are affixed securely above the lane and that no exposed wires pose a hazard of tripping.

9.6 Verify that system is user friendly

9.6.1 Requirement(s) addressed

<table>
<thead>
<tr>
<th>No.</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.6</td>
<td>Store Data</td>
</tr>
<tr>
<td>3.7</td>
<td>Retrieve Data</td>
</tr>
<tr>
<td>3.8</td>
<td>Operate on Computer Provided</td>
</tr>
<tr>
<td>3.9</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>3.10</td>
<td>Save Video</td>
</tr>
<tr>
<td>3.11</td>
<td>Export Data</td>
</tr>
<tr>
<td>3.12</td>
<td>Clear Last Shot</td>
</tr>
<tr>
<td>3.14</td>
<td>Create File</td>
</tr>
<tr>
<td>4.1</td>
<td>Software Installation</td>
</tr>
<tr>
<td>4.2</td>
<td>DVD</td>
</tr>
<tr>
<td>4.3</td>
<td>User Manual</td>
</tr>
</tbody>
</table>

9.6.2 Verification Procedure

The sponsor will be consulted in regards to how they would like the GUI set up. Once the product is installed on the sponsor’s computer the sponsor will operate the system under the direction of the team to ensure that the sponsor understands how the system is supposed to work. A user’s manual will also be provided to the sponsor.
10. Use Cases

This section will describe how the user will interact with the system. Each use case will involve a series of steps that will be taken when initiated by a user that will complete a business task for the user. Each use case will begin with an action by the user described as TUCBW (This Use Case Begins With) and will end with TUCEW (This Use Case Ends With). Each use case will be visually represented with a use case diagram depicting the user / system interaction.

10.1 Video Capture

10.1.1 Scenario: The user clicks on the “Start Capture” or the “End Capture” button on the GUI. The system starts recording video footage when the “Start Capture” button is clicked and the system stops recording video footage when the “End Capture” button is pressed.

10.1.2 Actor: User

10.1.3 TUCBW: User clicks on the “Start Capture” button, sees the button highlighted and video recording begins.

10.1.4 TUCEW: The user clicks on the “End Capture” button, sees the button highlighted and video recording ends.

---

**Figure 10-1: Use Case: Video Capture**
10.2 View File

10.2.1 Scenario: The user clicks on the “View File” dropdown box on the GUI and chooses a file to view. The system displays the recorded data for the chosen file.

10.2.2 Actor: User

10.2.3 TUCBW: User clicks on the “View File” dropdown box and chooses a file to view.

10.2.4 TUCEW: The user sees the recorded data for the chosen file displayed on the screen.

Figure 10-2: Use Case: View File
10.3 Save File

10.3.1 Scenario: The user enters a file name in the text box and clicks on the “Save File” button on the GUI. The system saves the recorded data under the file name typed into the text box by the user.

10.3.2 Actor: User

10.3.3 TUCBW: User enters file name into text box and clicks on the “Save File” button on the GUI.

10.3.4 TUCEW: The user sees a notification displayed on the screen that the file was successfully saved.

![Use Case Diagram](image-url)

Figure 10-3: Use Case: Save File
10.4 Save Video

10.4.1 Scenario: The user clicks on the “Save Video” button on the GUI. The system opens a window for the user to enter a file name and a location for video file to be saved. The user enters requested information and the system saves the video file in the location specified by the user, under the file name entered by the user.

10.4.2 Actor: User

10.4.3 TUCBW: User clicks on the “Save Video” button on the GUI.

10.4.4 TUCEW: The user sees a notification displayed on the screen that the video file was successfully saved.

Figure 10-4: Use Case: Save Video
10.5 Export Data

10.5.1 Scenario: The user clicks on the “Export Data” button on the GUI. The system displays the exported data on the screen in the form of a text file. The user clicks to save the file and enters a location and a file name. The system saves the file.

10.5.2 Actor: User

10.5.3 TUCBW: User clicks on the “Export Data” button on the GUI.

10.5.4 TUCEW: The user sees a notification displayed on the screen that the text file was successfully saved.

![Figure 10-5: Use Case: Export Data](image-url)
10.6 Clear Last Shot

10.6.1 Scenario: The user clicks on the “Clear Last Shot” button on the GUI. The system deletes the data recorded from the last shot.

10.6.2 Actor: User

10.6.3 TUCBW: User clicks on the “Clear Last Shot” button on the GUI.

10.6.4 TUCEW: The user sees the data for the last shot deleted from the GUI.

Figure 10-6: Use Case: Clear Last Shot
10.7 Create File

10.7.1 Scenario: The user clicks on the “Create File” button on the GUI. The system opens a window where the user can enter various information about a test shot and save the information to a file.

10.7.2 Actor: User

10.7.3 TUCBW: User clicks on the “Clear File” button on the GUI.

10.7.4 TUCEW: The user sees a confirmation displayed on the GUI that the file was successfully saved.

Figure 10-7: Use Case: Create File
10.8 Calibrate System

10.8.1 Scenario: The user clicks on the “Calibrate System” button on the GUI. The system will reset all default values and display a confirmation on the GUI.

10.8.2 Actor: User

10.8.3 TUCBW: User clicks on the “Calibrate System” button on the GUI.

10.8.4 TUCEW: The user sees a confirmation displayed on the GUI that the system was calibrated successfully.

Figure 10-8: Use Case: Calibrate System
11. Feasibility Assessment

This section will discuss the feasibility of BOLTS. This will inform our stakeholders the likelihood of success at the end of the project. The feasibility assessment includes scope analysis, research, technical analysis, cost analysis, and schedule analysis.

11.1 Scope Analysis

The scope of work for our critical requirements and prototyping of these requirements by the deadline appears to be feasible. This assessment is based on the research we have accomplished and information provided by our sponsor. The bulk of the work will come from research and using image analysis to fulfill our three most important requirements. Our three biggest requirements are as follows:

- **Customer Requirement 3.2** - The system shall output the speed of the bowling ball at a given position on the bowling lane.

- **Customer Requirement 3.3** - The system shall output the distance of the bowling ball from the foul line.

- **Customer Requirement 3.4** - The system shall output the board number the bowling ball is on at a given position on the bowling lane.

The requirements that are listed as classified as future requirements are beyond the scope of this project are not considered in this section.

11.2 Research

We have started the appropriate research on this project in order to build a working prototype. This research includes image analysis algorithms and interfacing with the cameras using the Basler Pylon SDK. According to our current research there are plenty of resources, guides, and source code to help us figure out how to do image analysis. There is plenty of documentation and guides on the Basler company website that will help us in figuring out the SDK and interface with the cameras. We have also received previous research and documentation from our sponsor. The previous research includes what other companies have tried, what succeeded, and what failed. With the research we have currently done and previous research obtained from our sponsor, we feel that the concept of our project is feasible.
11.3 Technical Analysis

The technical aspects of our project include three major components: the cameras, the image processor, and the user interface.

The cameras will record video of the ball rolling down the lane and send the frames to the image processor. This will require using the Basler Pylon SDK in C++ to interface with the cameras to send the data to the image processor.

The image processor will analyze each frame it receives and determine where the ball is located in each frame. Once the ball is located the processor will calculate the bowling ball’s distance from the foul line, the board number the bowling ball is on, and the speed of the bowling ball at that given frame. The calculations will be sent to the user interface. This will be using MATLAB and the OpenCV library in C++.

The user interface will display the data it receives from the image processor. The user interface will contain buttons that allows the user to begin and end tracking of the bowling ball, save data to a storage device, and retrieve data from a storage device. When the “Start Capture” button is pressed, the cameras will begin recording video of the lane and sending frames to the image processor. When the “End Capture” button is pressed, the cameras will stop recording video of the lane. When the “Save File” button is pressed, the data currently displayed on the user interface will be saved to a storage device. When the “View Data” drop down box is pressed, files saved to the storage device will be displayed so that the user can choose which file they would like to view.

The team will contact professors who have experience with image analysis for assistance with any image analysis algorithms. We have already discussed the feasibility of this project with Dr. Athitsos and he believes this project is feasible.

With regards to technical skills, each member possesses some of the basic skills to implement the components of BOLTS

11.4 Cost Analysis

The cost of the cameras for the project will be covered by the United States Bowling Congress. Tables 11-1 and 11-2 show the projected costs for potential camera systems.

<table>
<thead>
<tr>
<th>Camera</th>
<th>Quantity</th>
<th>Single Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basler acA2000-50gm</td>
<td>5</td>
<td>$1500</td>
<td>$7500</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td></td>
<td><strong>$7500</strong></td>
</tr>
</tbody>
</table>
Table 11-2: Basler acA1300-30gc Camera Cost

<table>
<thead>
<tr>
<th>Camera</th>
<th>Quantity</th>
<th>Single Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basler acA1300-30gc</td>
<td>8</td>
<td>$600</td>
<td>$4800</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td></td>
<td><strong>$4800</strong></td>
</tr>
</tbody>
</table>

Table 11-3 displays the projected costs we have identified assuming we are using a 5-8 camera system.

Table 11-3: Projected Costs

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
<th>Single Cost</th>
<th>Quantity Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT6 Cable 500ft</td>
<td>1</td>
<td>$43</td>
<td>$43</td>
</tr>
<tr>
<td>Pack 100 RJ45 Plugs</td>
<td>1</td>
<td>$4</td>
<td>$4</td>
</tr>
<tr>
<td>GigE Card PCIe AdLink GIE64+</td>
<td>2</td>
<td>$320</td>
<td>$740</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>$787</strong></td>
</tr>
</tbody>
</table>

11.5 **Resource Analysis**

Team Galaxy consists of two computer scientists, one computer engineer, and one software engineer. We have identified the following resources to be critical to the success of our project: efficient project management, effective scheduling and tracking, programming skills, and knowledge of image analysis. To ensure that the team is capable in each of the aforementioned areas the team has completed resource analysis. Upon completion of resource analysis the team has determined that we possess the required resources to complete the project to required specifications by the pre-determined deadline.

This determination is based on the following resources. The team has experience with project management and MS Project and both will be applied to ensure efficient project management and effective scheduling and tracking. The team also has experience with various programming languages including C++ which has been identified by the team as the necessary programming language for our project.

The team lacks knowledge in image analysis but to compensate for this resource we have acquired the support of Dr. Athitsos who is knowledgeable in this area and is providing the team with help and resources for image analysis. After careful consideration of the required resources needed it is the determination of the project team that we possess the resources needed to complete the project to specification within the budgeted time.
11.6 Schedule Analysis

In this section, we have used function point analysis, Jones-first order estimation, and the COCOMO 81 model to estimate the effort needed to complete the project.

11.6.1 Function Point Analysis

A function point is a measure of program size. The function point total is based on the number and complexity of the following program characteristics: input, output, inquiries, logical internal files, and external interface files. The list below shows the program characteristics of BOLTS

**Inputs:**
- Activate BOLTS button (Low)
- Deactivate BOLTS button (Low)
- Delete last shot thrown button (Low)
- Export data button (Low)
- Save video button (Medium)
- Calibrate BOLTS button (Medium)
- Create/save file button (Medium)
- Images of camera of processing component (High)

**Outputs:**
- Ball speed (High)
- Board number (High)
- Distance from bowler (High)

**Inquiries:**
- Retrieve previous data from disk (Medium)

**Logical Internal Files:**
- None

**External Interface Files:**
- Images from Camera (High)

When these program characteristics are into the function point multipliers table (Table 11-2), we obtain an unadjusted function point total for 65.
Table 11-4: Function Point Analysis

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Low Complexity</th>
<th>Medium Complexity</th>
<th>High Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs</td>
<td>4 x3</td>
<td>3 x4</td>
<td>1 x6</td>
</tr>
<tr>
<td>Outputs</td>
<td>0 x4</td>
<td>0 x5</td>
<td>3 x7</td>
</tr>
<tr>
<td>Inquiries</td>
<td>0 x3</td>
<td>1 x4</td>
<td>0 x6</td>
</tr>
<tr>
<td>Logical Internal Files</td>
<td>0 x7</td>
<td>0 x10</td>
<td>0 x15</td>
</tr>
<tr>
<td>External Interface Files</td>
<td>0 x5</td>
<td>0 x7</td>
<td>1 x10</td>
</tr>
<tr>
<td><strong>Unadjusted function-point total</strong></td>
<td></td>
<td></td>
<td><strong>65</strong></td>
</tr>
</tbody>
</table>

To obtain our adjusted function point total, we need to obtain our influence multiplier. The influence multiplier is based on the influence of 14 factors of a program. The influence factor would be assigned a 0 or 1, adding 0.0 or 0.5 to the influence multiplier. Instead, we adjusted the technique to use values 0-5 for each factor, adding 0.0 – 0.5 to the influence multiplier. This adjustment provides a more accurate estimate.

Table 11-5: Influence Factors

<table>
<thead>
<tr>
<th>Influence Factors</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Communications</td>
<td>4</td>
</tr>
<tr>
<td>Distributed Data Processing</td>
<td>3</td>
</tr>
<tr>
<td>Performance</td>
<td>5</td>
</tr>
<tr>
<td>Heavily Used Configuration</td>
<td>2</td>
</tr>
<tr>
<td>Transaction Rate</td>
<td>3</td>
</tr>
<tr>
<td>On-Line Data Entry</td>
<td>0</td>
</tr>
<tr>
<td>End-User efficiency</td>
<td>3</td>
</tr>
<tr>
<td>On-Line Update</td>
<td>0</td>
</tr>
<tr>
<td>Complex processing</td>
<td>5</td>
</tr>
<tr>
<td>Reusability</td>
<td>5</td>
</tr>
<tr>
<td>Installation Ease</td>
<td>3</td>
</tr>
<tr>
<td>Operational Ease</td>
<td>4</td>
</tr>
<tr>
<td>Multiple Sites</td>
<td>0</td>
</tr>
<tr>
<td>Facilitate Change</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>42</strong></td>
</tr>
</tbody>
</table>

**Influence multiplier = 0.65 + 0.42 = 1.07**
Using the unadjusted function point total and the influence multiplier, we obtain an adjusted function point total of 69.55

<table>
<thead>
<tr>
<th>Table 11-6: Adjusted Function Point Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unadjusted Function Point Total</td>
</tr>
<tr>
<td>Influence Multiplier</td>
</tr>
<tr>
<td>Adjusted Function Point Total</td>
</tr>
</tbody>
</table>

11.6.2 Jones First-Order Estimation

Using the adjusted function point total, we can use the Jones First-Order exponents to obtain the effort estimations for best, average, and worst case. The business exponents were used to calculate our effort estimation. The rule of thumb estimation was used to estimate the number of man-months. Since our team is not full time, we have used a 15 hour work week (37.5% of a 40 hour work week) to estimate our schedule.

<table>
<thead>
<tr>
<th>Table 11-7: Effort Estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Function Point Raised to Power</td>
</tr>
<tr>
<td>Calendar Months</td>
</tr>
<tr>
<td>Man Months</td>
</tr>
<tr>
<td>Man months for 4 person team</td>
</tr>
<tr>
<td>15 hour work week</td>
</tr>
</tbody>
</table>

11.6.3 COCOMO 81 Model

Using the Intermediate COCOMO 81 model, we have estimated the effort applied (man-months) and development time (Calendar months). Below are the 15 attributes that receive a rating on a scale from very low to extra high which correspond with an effort multiplier value. The effort multipliers are multiplied with each other to give the effort adjustment factor (EAF).

**SLOC – 5000 (Very rough Estimate)**

**Software Development Mode** – Embedded

**Product Attributes:**
- Required Reliability: **High** (1.15)
- Database Size: **Low** (0.94)
• Product Complexity: **High** (1.15)

**Computer Attributes:**
• Execution Time Constraint: **Nominal** (1.00)
• Main Storage Constraint: **Nominal** (1.00)
• Virtual Machine Volatility: **Low** (0.87)
• Computer Turnaround Time: **Nominal** (1.00)

**Personnel Attributes:**
• Analyst Capabilities: **Nominal** (1.00)
• Applications Experience: **Nominal** (1.00)
• Programmer Capability: **Nominal** (1.00)
• Virtual Machine Experience: **Nominal** (1.00)
• Programming Language Experience: **Nominal** (1.00)

**Project Attributes:**
• Modern Programming Practices: **Very High** (0.82)
• Use of Software Tools: **Nominal** (1.00)
• Required Development Schedule: **Very High** (1.10)

<table>
<thead>
<tr>
<th>Table 11-8: COCOMO 81 Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAF</td>
</tr>
<tr>
<td>Effort</td>
</tr>
<tr>
<td>Schedule (Calendar Months)</td>
</tr>
<tr>
<td>Person Months</td>
</tr>
<tr>
<td>Person Months for 4 person team</td>
</tr>
<tr>
<td>15 hour work week</td>
</tr>
</tbody>
</table>

The COCOMO 81 estimate for calendar months is in between our average case of 6.197 months and worst case of 7.038 using Jones first-order estimation.

In conclusion, we believe that our team of four members will be able to fully complete BOLTS in the allotted time.
12. Future Items

This section defines the requirements that are classified as future items. It is understood between Team Galaxy and the project sponsor that these requirements will only be provided for if sufficient time remains after completing the higher priority requirements. Team Galaxy will consider these requirements when designing BOLTS, and when possible, will design BOLTS to provide for the ability to add the future requirements. The following describes those requirements that have been assigned future priority and are considered to be future items.

12. Future Items

12.1 Number of Revolutions: BOLTS shall output the number of revolutions the bowling ball has made at a given position on the bowling lane.

12.2 Axis Tilt Change: BOLTS shall measure the vertical angle to which the bowling ball rotates at a given position on the bowling lane.

12.3 Axis Rotation Change: BOLTS shall output the horizontal angle through which the bowling ball rotates at a given position on the bowling lane.

12.4 Output Axis Migration: BOLTS shall output the path of which the axis point travels across the surface of a bowling ball at a given position on the bowling lane.