Team: Team MASS

Project: Rocket Recovery System

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<td>01/05/2013</td>
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<td>Team input/start first draft</td>
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4. - Introduction

4.1 - Document Overview

The Architectural Design Document will provide a high level description of the Rocket Recovery System based on the system requirements. The document will provide information sufficient enough to begin a detailed design of the systems. The document will discuss the various architectural layers, and their intended purpose and design. It will also contain a detailed description of the various subsystems, and their data flows inside of each architectural layer. Finally, the document will cover all the necessary testing considerations to ensure a flawless testing plan.

4.2 - Project Scope and Overview

The Rocket Recovery System’s central purpose is to launch a low powered model rocket and land it near the area where it was launched from. The Rocket Recovery System (RRS) has three components; The Intelligent Rotating Base Station (IRBS), The SD-12 Rocket, and the Rocket Recovery Module (RRM). The Intelligent Rotating Base Station is a launch pad that gathers information about the wind speed and direction using an attached anemometer. The IRBS will then compensate for the wind by rotating and tilting the launch pad in the appropriate direction. The IRBS will pass the wind data to the SD-12 Rocket equipped with the Rocket Recovery Module before launch. After the launch of the SD-12 rocket, the RRM will make real time calculations, using the IRBS data, to direct the rocket to a specified location. After the engine burn phase, a parachute will be deployed, and the SD-12 will float back to the coordinates where it was launched. The system will have an LCD screen and buttons attached to the IRBS for the user to use.

The Rocket Recovery System will have three modes. These modes include: Standby Mode, Preparation Mode, and Launch Mode. The Standby mode will allow the user to attach the SD-12 rocket to the IRBS and make necessary adjustments. In this mode no data is being collected or used. The Preparation Mode will start to collect wind data from the attached anemometer, and make the adjustments to the IRBS. The Launch Mode will have the IRBS stop making adjustments, and start transmitting the aggregated wind data to the RRM. Once the SD-12 rocket receives all the information, the rocket is ready to launch.
FIGURE 4-1 - ROCKET RECOVERY SYSTEM
FIGURE 4-2-ROCKET RECOVERY SYSTEM

SD-12 Rocket w/ Rocket Recovery Module

Launch Angle

Intelligent Rotating Base Station (IRBS)

- 30 degrees

+ 30 degrees

Wind <20 mph
### 4.3 - Definitions and Acronyms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tr>
<td>RRM</td>
<td>Rocket Recovery Module</td>
</tr>
<tr>
<td>IRBS</td>
<td>Intelligent Rotating Base Station</td>
</tr>
<tr>
<td>SD-12</td>
<td>The actual rocket that will have the Rocket Recovery Module inside of it</td>
</tr>
<tr>
<td>LCD</td>
<td>Liquid Crystal Display</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
</tr>
<tr>
<td>OS</td>
<td>Operating System</td>
</tr>
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*TABLE 4.1- DEFINITIONS AND ACRONYMS*
5. - Meta-Architecture

5.1 - Architectural Vision
The Rocket Recovery System will use the intelligent rotating base station with an attached anemometer to detect and gather wind speed and direction. It will also have an accelerometer attached to prevent the base station from over tilting the 30 degree limitation. The collected data from the anemometer will then be sent to the attached SD-12 Rocket with the embedded RRM. After the data transfer has been completed to the SD-12 Rocket, the rocket will launch. The SD-12 Rocket will then operate using an attached barometer, accelerometer, and data sent from the IRBS. In order for all of this to function properly The Rocket Recovery System will be divided into 2 separate independent systems. These systems include the Intelligent Rotating Base Station System and the Rocket Recovery Module System. Each System includes its own specific layers and subsystems. The layers of the Intelligent Rotating Base Station System include: User Interface Layer, Data Input Layer, Data Processing Layer, Hardware Interface Layer, and the Network Layer. The layers for the Rocket Recovery Module System include: Data Input Layer, Data Processing Layer, Hardware Interface Layer, and the Network Layer. The goal of this design is to ensure simplicity and independence.

5.2 - Guiding Principles and Rules

5.2.1 - Reliability
The system should perform its required functions under the conditions that are stated in the system requirement specifications. The system should also have a failure rate of less than 1%.

5.2.2 - Portability
The system is delivered to the customer unassembled, and must be used in remote areas. Thus, the system must be easy to disassemble and transport. The weight and size of the components should be kept to a minimum.

5.2.3 - Safety
The system will be launching a live rocket several hundred feet into the air. Safety of the user and others around the system is paramount. The user must follow certain safety guidelines to ensure the safety of themselves and spectators.

5.2.4 - Reusability
The system’s goal is for users to be able to launch their rocket, recover it, and then launch it again if they wish. Keeping this in mind, the system must be able to support several launches.

5.2.5 - Durability
The system’s components need to not break or deteriorate. To ensure that this does not happen, the system’s part will only be constructed with high quality durable components. The system’s design will also need to be approved by design experts to ensure quality.
5.2.6 - **Integrity**
The system will need to make very precise and accurate calculations to ensure a successful flight. In order for this to happen, the system must maintain the accuracy and consistency of its data throughout entire data flow.

5.2.7 - **Modularity**
The system will have three main components; The Intelligent Rotating Base Station, The Rocket Recovery Module, and the SD-12 Rocket. The systems will be designed in a way such that each system can be tested independently of one another.

5.3 - **Assumptions and Tradeoffs**

5.3.1 - **Assumptions**
- The user will not modify the rocket in any way.
- The user has read and understands the launch procedures and instructions and follows them accordingly.
- The user has read and understands all the safety rules and regulations before using the system.
- The rocket should only be launched in ideal weather conditions.

5.3.2 - **Tradeoffs**
- There are different manners in which a rocket can be controlled in flight. These include gimbaling the rocket engine, deflecting the engine nozzle, or having a control surface. The team chose to have a control surface attached to the rocket. We decided to use this method because of the ease of use, and the safety concerns with the other methods.
- Originally the team had an idea to only use the Rocket Recovery Module in the rocket without the additional use of the Intelligent Rotating Base Station. The team decided that it was best to also include the Intelligent Rotating Base Station to ease the amount of work the Rocket Recovery Module will have to do.
- The team has decided to use an Arduino Development board instead of creating our own layered circuit board. This is mainly because of the group’s overall lack of experience in creating and designing circuit boards.
- The team originally had a Data Access Layer that acted as a storage area and access control for the system’s critical data. The addition of Get Data subsystem to the appropriate layers made this layer redundant. We removed the layer and added the Get Data subsystem to make the architecture more consistent.
6. – Architecture Overview

The Rocket Recovery System is divided into 2 separate systems. The intelligent Rotating Base Station is divided further into 5 separate layers; The User Interface, The Data Input, The Data Processing, The Hardware Interface, and The Network Layer. The Rocket Recovery Module is divided into 4 distinct layers; The Network, The RRM Data Input, The RRM Data Processing, and The RRM Hardware Interface.

FIGURE 6-1 - ARCHITECTURE OVERVIEW
6.1 - The Intelligent Rotating Base Station

6.1.1 - User Interface
The IRBS User Interface Layer is responsible for allowing the user to visually interact with the system. This layer allows the user to see what user input has been entered and what data has been collected and processed. This layer consists of two subsystems; Get Data and Display Output.

6.1.2 - Data Input
The IRBS Data Input Layer is responsible for handling the user input, the anemometer input, and the accelerometer. The IRBS Data Input layer consists of three subsystems, the User Input, the Anemometer Input, and the Accelerometer Input.

6.1.3 - Data Processing
The IRBS Data Processing Layer’s purpose is to emphasize modularity in the design structure of the system. All processing of data will be encapsulated within this layer and the resulting comprehensible data will be made available to the respective systems, the hardware layer, the user interface layer, and the network layer.

6.1.4 - Hardware Interface
The IRBS Hardware Layer is responsible for obtaining the data that will be used by the servo to rotate at a specific angle depending on the speed of the wind.

6.1.5 - Network
The IRBS Network layer is the last layer of the IRBS system and retrieves data from the IRBS Data Processing Layer. The layer either de-multiplexes or multiplexes the data with the RRM Network layer. IRBS Network layer consists of Send/Receive Subsystem and Get Data Subsystem.

6.2 - The Rocket Recovery System

6.2.1 - Network
The RRM Network Layer is the first layer of the RRM system, and it connects RRM system with the IRBS system. The layer either multiplexes or de-multiplexes the data with the IRBS Network layer. RRM Network layer consists of Send Data Subsystem and Receive Data Subsystem.

6.2.2 - RRM Data Input
The RRM Data Input Layer is responsible for handling the input data from the accelerometer, barometer, and the processed data from Network Layer. The RRM Data Input layer consists of three subsystems; The Accelerometer Input, The Barometer input, and the IRBS Processed Input.
6.2.3 - RRM Data Processing
The purpose of the RRM Data Processing Layer is to emphasize modularity in the design structure of the system. All processing of data will be encapsulated within this layer and the resulting comprehensible data will be made available to the hardware layer.

6.2.4 - RRM Hardware Interface
The RRM Hardware Layer is responsible for obtaining the air pressure and acceleration data from the RRM Data Process layer in determine the stability of the rocket and the servo opening for the landing.
7. - IRBS User Interface

7.1 - Description
The IRBS User Interface Layer is responsible for allowing the user to visually interact with the system. This layer allows the user to see what user input has been entered and what data has been collected and processed. This layer consists of two subsystems; Get Data and Display Output.

7.2 - Purpose
The IRBS User Interface Layer’s purpose is to get the user input software objects from the IRBS Data Input Layer and display it to the user. It also displays what mode the system is in at a particular moment. Moreover, this layer gets the processed wind data from the IRBS Data Processing Layer and also displays this data to the user in an easily readable format.

7.3 - Function
The IRBS User Interface Layer will display all the necessary information to the user. The Get Data Subsystem will get the software objects from the IRBS Data Input Layer and the processed wind data from the IRBS Data Processing Layer. The Get Data Subsystem will then send this information to the Display Output Subsystem, and the Display Output Subsystem will display this information to the user on an LCD screen.

7.4 - Dependencies
The IRBS User Interface Layer is dependent on the IRBS Data Input Layer for the user input. It also depends on the IRBS Data Processing Layer for the processed wind data.
7.5 - Interfaces

<table>
<thead>
<tr>
<th>Type</th>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
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<tbody>
<tr>
<td>External</td>
<td>User Input Subsystem</td>
<td>Get Data Subsystem</td>
<td>Values from User Input components converted to software objects.</td>
</tr>
<tr>
<td>External</td>
<td>Set Data Subsystem</td>
<td>Get Data Subsystem</td>
<td>Processed Wind Data.</td>
</tr>
<tr>
<td>Internal</td>
<td>Get Data Subsystem</td>
<td>Display Output Subsystem</td>
<td>Software Objects and Processed Wind Data.</td>
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<tr>
<td>Internal</td>
<td>Display Output Subsystem</td>
<td>LCD screen</td>
<td>Software objects converted to human readable format and Processed Wind Data.</td>
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</tbody>
</table>

**TABLE 7.1 - IRBS USER INTERFACE INTERFACES**

7.6 - Processing

The IRBS user interface layer will convert user input software objects to human readable format and display it to the user. It will also display the processed wind data to the user.

7.7 - Data

The data will consist of software objects, system modes, and processed wind data.

7.8 - Subsystems

7.8.1 - Get Data Subsystem

7.8.1.1 - Purpose

The purpose of the Get Data Subsystem is to get processed wind data and software objects from other layers.

7.8.1.2 - Function

The function of Get Data Subsystem is to get the software objects from IRBS User Input Layer and processed wind data from IRBS Data Processing Layer. After receiving this information, it makes it available to the Display Output subsystem.

7.8.1.3 - Dependencies

The Get Data Subsystem is dependent on the software objects from the User Input Layer and processed wind data from the IRBS Data Processing Layer. It also communicates with the display output subsystem.

7.8.1.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
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<td>User Input Subsystem</td>
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<tr>
<td>Set Data Subsystem</td>
<td>Get Data Subsystem</td>
<td>Processed Wind Data.</td>
</tr>
<tr>
<td>Get Data Subsystem</td>
<td>Display Output Subsystem</td>
<td>Software Objects and Processed Wind Data.</td>
</tr>
</tbody>
</table>
7.8.1.5 - **Processing**
No processing is done.

7.8.1.6 - **Data**
The Get Data Subsystem data consists of software objects, system modes, and processed wind data.

### 7.8.2 - **Display Output Subsystem**

7.8.2.1 - **Purpose**
The purpose of the Display Output Subsystem is to display the processed wind data and the user input on the LCD screen. It also displays the different modes of the system to the user.

7.8.2.2 - **Function**
The function of the Display Output Subsystem is to receive software objects and processed data from the Get Data Subsystem. It converts the software objects to human readable format. It then displays the user input and the processed data to the user on an LCD screen.

7.8.2.3 - **Dependencies**
The Display Output Subsystem is dependent on the information from the Get Data Subsystem.

7.8.2.4 - **Interfaces**

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<th>Destination</th>
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<td>Software Objects and Processed Wind Data.</td>
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<tr>
<td>Display Output Subsystem</td>
<td>LCD screen</td>
<td>Software Objects converted to human readable format and Processed Wind Data.</td>
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</tbody>
</table>

### Table 7.3 - **Display Output Subsystem Interfaces**

7.8.2.5 - **Processing**
The Display Output Subsystem processes the software objects and converts them into human readable format.

7.8.2.6 - **Data**
The Display Output Subsystem data consists of software objects, system modes, and processed wind data.
8. - IRBS Data Input

8.1 - Description
The IRBS Data Input Layer is responsible for handling the user input, the anemometer input, and the accelerometer input. The IRBS Data Input layer consists of three subsystems, the User Input, the Anemometer Input, and the Accelerometer Input.

8.2 - Purpose
The IRBS Data Input Layer’s purpose is to gather external data from the user of the system, the wind data from the anemometer, and the orientation of the launch platform from the accelerometer. This data is passed to the appropriate layer depending on what type of input is received.

8.3 - Function
The IRBS Data input layer will gather external data from button presses from the user interacting with the system. The IRBS Data input will then pass the processed button press to the Get Data subsystem of the User Interface Layer. The layer will also gather external wind data via the anemometer. The wind data that is collected is then sent to the Verify Data subsystem of the Data Processing Layer. The layer will also gather orientation of the launch platform from the accelerometer. The orientation data that is collected is then sent to the Verify Data subsystem of the Data Processing Layer.

8.4 - Dependencies
The IRBS Data Input Layer is not dependent on any data from any other layer. The layer is only dependent on the external inputs.
8.5 - Interfaces

<table>
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<th>Source</th>
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<th>Data</th>
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</thead>
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<td>User Input Subsystem</td>
<td>The digital signal from physical button press.</td>
</tr>
<tr>
<td>External</td>
<td>Anemometer</td>
<td>Anemometer Input Subsystem</td>
<td>The digital signal from the anemometer.</td>
</tr>
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<td>User Input Subsystem</td>
<td>Get Data Subsystem</td>
<td>Value from User Input components to be converted to software objects.</td>
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<td>External</td>
<td>Anemometer input Subsystem</td>
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<td>Values from Anemometer Input components to be converted to software objects.</td>
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<td>Accelerometer Input Subsystem</td>
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<td>Values from Accelerometer Input components to be converted to software objects.</td>
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TABLE 8.1: DATA INPUT INTERFACES

8.6 - Processing
The IRBS Data Input Layer will receive a user button press and convert the digital signal into software objects and will be sent to the Get Data subsystem of the User Interface Layer. The IRBS Data Input Layer will also receive an analog digital signal from the attached anemometer and will convert the values to software objects and will be sent to the Verify Data subsystem of the Data Processing Layer. The IRBS Data Input Layer will also receive an analog digital signal from the accelerometer and will convert the values to software objects and will be sent to the Verify Data subsystem of the Data Processing Layer.

8.7 - Data
The data will consist of discrete digital inputs, discrete analog inputs, and software objects.

8.8 - Subsystems

8.8.1 - User Input Subsystem

8.8.1.1 - Purpose
The purpose of the User Input Subsystem is to detect and handle physical button presses from the user.

8.8.1.2 - Function
The function of the User Input Subsystem is to detect physical button presses from the user and then convert the digital signal into a usable software object.

8.8.1.3 - Dependencies
The User Input Subsystem is only dependent on the user input and no other data in the system.
8.8.1.4 - Interfaces

<table>
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<th>Source</th>
<th>Destination</th>
<th>Data</th>
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<td><strong>User Button Presses</strong></td>
<td>User Input Subsystem</td>
<td>The digital signal from physical button press.</td>
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<tr>
<td><strong>User Input Subsystem</strong></td>
<td>Get Data subsystem</td>
<td>Value from User Input components to be converted to software objects.</td>
</tr>
</tbody>
</table>

TABLE 8.2 - USER INPUT SUBSYSTEM INTERFACES

8.8.1.5 - Processing
The User Input Subsystem processes the digital button press into software objects.

8.8.1.6 - Data
The User Input Subsystem data consists of digital input and software objects.

8.8.2 - Anemometer Input Subsystem

8.8.2.1 - Purpose
The purpose of the Anemometer Input Subsystem is to detect and handle the wind speed and direction data that is collected via the attached anemometer.

8.8.2.2 - Function
The function of the Anemometer Input Subsystem is to detect the analog digital input from the anemometer and then convert the digital signal into a usable software object.

8.8.2.3 - Dependencies
The Anemometer Input Subsystem is only dependent on the anemometer input and no other data in the system.

8.8.2.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anemometer</strong></td>
<td>Anemometer input Subsystem</td>
<td>The analog digital signal from the anemometer.</td>
</tr>
<tr>
<td><strong>Anemometer input Subsystem</strong></td>
<td>Verify Data subsystem</td>
<td>Values from Anemometer Input components to be converted to software objects.</td>
</tr>
</tbody>
</table>

TABLE 8.3 - ANEMOMETER INPUT SUBSYSTEM INTERFACES

8.8.2.5 - Processing
The Anemometer Input Subsystem processes the analog wind data into software objects.

8.8.2.6 - Data
The Anemometer Input Subsystem data consists of an analog input and software objects.

8.8.3 - Accelerometer input Subsystem

8.8.3.1 - Purpose
The purpose of the Accelerometer Input Subsystem is to detect orientation of the launch platform that is collected via the attached accelerometer.

8.8.3.2 - Function
The function of the Accelerometer Input Subsystem is to detect the analog digital input from the Accelerometer and then convert the digital signal into a usable software object.

8.8.3.3 - Dependencies
The Accelerometer Input Subsystem is only dependent on the Accelerometer input and no other data in the system.

8.8.3.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerometer</td>
<td>Accelerometer input Subsystem</td>
<td>The analog digital signal from the Accelerometer.</td>
</tr>
<tr>
<td>Accelerometer input Subsystem</td>
<td>Verify Data subsystem</td>
<td>Values from Accelerometer Input components to be converted to software objects.</td>
</tr>
</tbody>
</table>

8.8.3.5 - Processing
The Accelerometer Input Subsystem processes the launch platform angle into software objects.

8.8.3.6 - Data
The Accelerometer Input Subsystem data consists of an analog input and software objects.
9. - IRBS Data Processing

9.1 - Description
The IRBS data processing layer is responsible for the processing and validation of raw data prior to launch.

9.2 - Purpose
The purpose of this layer is to emphasize modularity in the design structure of the system. All processing of data will be encapsulated within this layer and the resulting comprehensible data will be made available to the respective subsystems.

9.3 - Function
The IRBS Processing Layer will simply process and validate the raw data from the data input layer. In cases where outliers are detected the system will ignore them and take an average of the acceptable input. Data received will include wind direction and speed. This layer will process this data and determine the pad orientation and tilt angle. Remember that the user will place the pad in the correct orientation, this will allow the pad to roughly know it's original orientation. Technically speaking we will line up the world frame with the frame of the pad.

9.4 - Dependencies
The IRBS Data Processing Layer is dependent on the raw data from the Data Input Layer.

9.5 - Interfaces

<table>
<thead>
<tr>
<th>Type</th>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>External</td>
<td>Data Input Layer</td>
<td>Data Process Layer</td>
<td>Raw data from the anemometer</td>
</tr>
<tr>
<td>Internal</td>
<td>Data Process Layer</td>
<td>Hardware Layer</td>
<td>Processed data</td>
</tr>
</tbody>
</table>

TABLE 9.1 - IRBS DATA PROCESSING INTERFACES
9.1 - Processing
The IRBS Data Processing Layer processes the raw data from the data input layer to comprehensible data as defined by the hardware and network layer. Data to be processed includes: determining the wind speed average, direction average for the IRBS, and turn altitude for the SD-12 Rocket.

9.2 - Data
The data will consist of wind speed, direction, SD-12 Rocket turn altitude, and user input such as phase selection and initiate launch.

9.3 - Subsystems

9.3.1 - Verify Data Subsystem

9.3.1.1 - Purpose
We acknowledge that there are uncertainties implied in taking measurements from the environment and hence we have implemented this subsystem to verify input data. This subsystem will check for extreme outliers from all incoming data that is received by the anemometer and accelerometer. If any are detected they will be thrown out.

9.3.1.2 - Function
The function of Verify Data Subsystem is to verify data and throw out any outliers.

9.3.1.3 - Dependencies
The Verify Subsystem Layer is dependent on input data from the anemometer and accelerometer.

9.3.1.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerometer Input Subsystem</td>
<td>Verify data Subsystem</td>
<td>Raw data</td>
</tr>
<tr>
<td>Verify Data Subsystem</td>
<td>Encapsulate Data Subsystem</td>
<td>Raw data without extreme outliers</td>
</tr>
</tbody>
</table>

TABLE 9.2 - VERIFY DATA SUBSYSTEM INTERFACES

9.3.1.5 - Processing
The Verify Data Subsystem detects data that is identified as an outlier based on the current average.

9.3.1.6 - Data
The Verify Data Subsystem Data consists of raw data from the sensors.
9.3.2 - Encapsulate Data Subsystem

9.3.2.1 - Purpose
Given that the data that is sent from the sensors is not comprehensible as a standard unit we have created this subsystem that will convert the data for us. After it’s converted it will be sent to the process data subsystem for processing.

9.3.2.2 - Function
The function of Encapsulate Data Subsystem is to convert the raw data to wind speed in MPH and direction in degrees.

9.3.2.3 - Dependencies
The Encapsulate Data Subsystem is dependent on raw data from the Verify data Subsystem.

9.3.2.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verify Data Subsystem</td>
<td>Data</td>
<td>Raw data</td>
</tr>
<tr>
<td>Data</td>
<td>Encapsulate Data Subsystem</td>
<td></td>
</tr>
<tr>
<td>Encapsulate Data Subsystem</td>
<td>Process Data Subsystem</td>
<td>Data (float and int) in MPH, degrees</td>
</tr>
</tbody>
</table>

TABLE 9.3 - ENCAPSULATE DATA SUBSYSTEM INTERFACES

9.3.2.5 - Processing
The Encapsulate Data Subsystem converts each number that comes in from Verify Data Subsystem to its respective unit.

9.3.2.6 - Data
Encapsulate Data Subsystem data consists of miles per hour and degrees.

9.3.3 - Process Data Subsystem

9.3.3.1 - Purpose
The RRM will understand one input variables: the altitude to turn. This subsystem will do this computation and make it available to other systems in the IRBS.

9.3.3.2 - Function
The function of Process Data Subsystem is to compute the average of each set using the data from the Encapsulate Data Subsystem.

9.3.3.3 - Dependencies
The Process Data Subsystem is dependent on the data from the encapsulate data subsystem.

9.3.3.4 - Interfaces
9.3.3.5 - Processing
The Computer Average Subsystem computes the average wind speed, direction, altitude to turn.

9.3.3.6 - Data
Compute Average Subsystem data consists of wind speed, direction, and altitude.

9.3.4 - Set Data Subsystem

9.3.4.1 - Purpose
The purpose of the Set Data Subsystem is to ensure the availability of the processed data to the IRBS User Interface Layer and the IRBS Network Layer. It also ensures the availability of the processed wind data to the User Interface Layer, Network Layer, and Hardware Layer.

9.3.4.2 - Function
The function of Set Data Subsystem is to act like a temporary storage for the IRBS. It gets the processed wind data from the Process Data Subsystem and makes it available to the Get Data Subsystem of the IRBS User Interface Layer, Get Data Subsystem of the IRBS Network Layer, and the Get Data Subsystem of the IRBS Hardware Interface Layer.

9.3.4.3 - Dependencies
The Set Data Subsystem is dependent on the finalized wind variables from the Process Data Subsystem.

9.3.4.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Data Subsystem</td>
<td>Set Data Subsystem</td>
<td>Average wind speed, direction, time/altitude to turn</td>
</tr>
<tr>
<td>Set Data Subsystem</td>
<td>Get Data (Network Layer) Subsystem</td>
<td>Average wind speed, direction, time/altitude to turn</td>
</tr>
<tr>
<td>Set Data Subsystem</td>
<td>Get Data (Hardware Interface) Subsystem</td>
<td>Average wind speed, direction, time/altitude to turn</td>
</tr>
<tr>
<td>Set Data Subsystem</td>
<td>Get Data (User Interface) Subsystem</td>
<td>Average wind speed, direction, time/altitude to turn</td>
</tr>
</tbody>
</table>

TABLE 9.5 - SET DATA SUBSYSTEM INTERFACES

9.3.4.5 - Processing
No processing is done.
9.3.4.6 - Data

The Set Data Subsystem data consists of the finalized variables computed from processed wind data that was calculated in the Process Data Subsystem.
10. - IRBS Hardware Interface

![IRBS Hardware Interface](image)

**FIGURE 10-1 - IRBS HARDWARE INTERFACE LAYER**

10.1 - Description
The IRBS Hardware Interface layer is a layer that depends on the Data Processing Layer and consists of two subsystems namely Get Data and Hardware Process subsystems.

10.2 - Purpose
The purpose of the hardware layer is to receive wind speed data from the data process layer to be used by the servo.

10.3 - Function
The IRBS Hardware Interface will obtain the data that will be used by the servo to rotate at a specific angle depending on the speed of the wind.

10.4 - Dependencies
The IRBS Hardware Interface Layer is dependent on the wind data from Data Processing Layer.

10.5 - Interfaces

<table>
<thead>
<tr>
<th>Type</th>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal</td>
<td>Data Process</td>
<td>Hardware Process</td>
<td>Wind speed and dimension from data process layer</td>
</tr>
<tr>
<td></td>
<td>Subsystem</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 10.1 - IRBS HARDWARE INTERFACE INTERFACES**

10.6 - Processing
No processing is done.

10.7 - Data
The data will consist of wind speed to determine the angle of rotation of the servo.
10.8 - Subsystems

10.8.1 - Get Data Subsystem

10.8.1.1 - Purpose
The purpose of the subsystem is to receive data from data process subsystem and store the data for the servo.

10.8.1.2 - Function
The function of the Get Data Subsystem is to store the data received into an array which can be used for the rotation of the servo.

10.8.1.3 - Dependencies
The Get Data Subsystem is dependent on the Data Process subsystem because the data processed by the subsystem will be received and stored for the servo usage.

10.8.1.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Get Data</td>
<td>Get Data Subsystem</td>
<td>Wind data and direction</td>
</tr>
<tr>
<td>Get Data</td>
<td>Hardware Process Subsystem</td>
<td>Stored data for servo</td>
</tr>
</tbody>
</table>

TABLE 10.2 - GET DATA SUBSYSTEM INTERFACES

10.8.1.5 - Processing
No processing is done.

10.8.1.6 - Data
The Get Data Subsystem data consists of stored data to be used by the hardware process subsystem.

10.8.2 - Hardware Process Subsystem

10.8.2.1 - Purpose
The purpose of the Hardware Process Subsystem is to activate and rotate the servo.

10.8.2.2 - Function
The function of the Hardware Process Subsystem is to take the data stored in the Get Data Subsystem to rotate the servo in response to the wind data.

10.8.2.3 - Dependencies
The Hardware Process Subsystem is dependent on the wind data stored in the Get Data Subsystem.

10.8.2.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Get Data</td>
<td>Hardware Process</td>
<td>Wind data</td>
</tr>
</tbody>
</table>

10.8.2.5 - Processing
No processing is done.

10.8.2.6 - Data
The Hardware Process Subsystem data consists of wind data.
11. - IRBS Network

11.1 - Description
The IRBS Network layer is the last layer of the IRBS system and retrieves data from the Data Process layer. The layer either de-multiplexes or multiplexes the data with the RRM Network layer. IRBS Network layer consists of Send/Receive Subsystem and Get Data Subsystem.

11.2 - Purpose
The IRBS Network integrates the IRBS system with the RRM system by receiving or sending packets to the RRM Network layer.

11.3 - Function
The IRBS Network layer will encode/decode packets received from the Data Processing Layer to the RRM Network layer.

11.4 - Dependencies
The IRBS Network Layer is dependent on the Data Process Layer for the packets to be used by the RRM system.

11.5 - Interfaces

<table>
<thead>
<tr>
<th>Type</th>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal</td>
<td>Data Process layer</td>
<td>Get Data subsystem</td>
<td>Wind speed packets</td>
</tr>
<tr>
<td>Internal</td>
<td>RRM Network layer</td>
<td>Receive/Send subsystem</td>
<td>Wind speed packets</td>
</tr>
</tbody>
</table>

TABLE 11.1 - IRBS NETWORK INTERFACES
11.6 - **Processing**  
No processing is done.

11.7 - **Data**  
The data will consist of the processed wind speed data.

11.8 - **Subsystems**

11.8.1 - **Get Data Subsystem**

11.8.1.1 - **Purpose**  
The purpose of the Get Data Subsystem is to receive the wind packet and store the packet.

11.8.1.2 - **Function**  
The function of the subsystem is to take the wind data from the Data Process layer subsystem and store the data for the send/receive subsystem to encode/decode the packet.

11.8.1.3 - **Dependencies**  
The Get Data Subsystem is dependent on the Set Data Subsystem on the Data Processing Layer.

11.8.1.4 - **Interfaces**

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Set Data Subsystem</strong></td>
<td>Get Data Subsystem</td>
<td>Processed wind speed data</td>
</tr>
<tr>
<td><strong>Send/Receive Subsystem</strong></td>
<td>Receive Data Subsystem</td>
<td>Wind data</td>
</tr>
</tbody>
</table>

**TABLE 11.2 - GET DATA SUBSYSTEM INTERFACES**

11.8.1.5 - **Processing**  
No processing is done.

11.8.1.6 - **Data**  
The Get Data Subsystem data consists of wind data.

11.8.2 - **Send/Receive Subsystem**

11.8.2.1 - **Purpose**  
The purpose of the Send/Receive Subsystem is to feed the Receive Data Subsystem of the RRM Network layer the wind data needed for the RRM Data Input.

11.8.2.2 - **Function**  
The function of the Send/Receive Subsystem is to multiplex data received from Data Processing Layer.

11.8.2.3 - **Dependencies**
The Send/Receive Subsystem is dependent on the Get Data Subsystem.

### 11.8.2.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Get Data Subsystem</td>
<td>Send/Receive Subsystem</td>
<td>Wind Data</td>
</tr>
<tr>
<td>Receive Data Subsystem</td>
<td>Wind Process Subsystem</td>
<td>Wind Data</td>
</tr>
</tbody>
</table>

**TABLE 11.3 - SEND/RECEIVE SUBSYSTEM INTERFACES**

### 11.8.2.5 - Processing

No processing is done.

### 11.8.2.6 - Data

The Send/Receive Subsystem data consists of encoded/decoded packets.
12. - RRM Network

12.1 - Description
The RRM Network layer is the first layer of the RRM system and connects the IRBS system. The layer either multiplexes or de-multiplexes the data with the IRBS Network layer. RRM Network layer consists of Send Data Subsystem and Receive Data Subsystem.

12.2 - Purpose
The RRM Network integrates the RRM system with the IRBS system by receiving packets from the IRBS Network layer.

12.3 - Function
The RRM Network Layer will encode/decode packets received from IRBS Network layer. It saves the wind speed data to be verified by the Data Process Subsystem.

12.4 - Dependencies
The RRM Network Layer is dependent on the IRBS Network layer.

12.5 - Interfaces

<table>
<thead>
<tr>
<th>Type</th>
<th>Source Subsystem</th>
<th>Destination Subsystem</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal</td>
<td>Send/Receive Data Subsystem</td>
<td>Receive Data Subsystem</td>
<td>Wind speed packets</td>
</tr>
<tr>
<td>Internal</td>
<td>Send Data Subsystem</td>
<td>Wind Process Subsystem</td>
<td>Wind speed packets</td>
</tr>
</tbody>
</table>

TABLE 12.1 - RRM NETWORK INTERFACES

12.6 - Processing
No processing is done.

12.7 - Data
The data will consist of the wind speed data.

12.8 - Subsystems
12.8.1 - Receive Data Subsystem

12.8.1.1 - Purpose
The purpose of the Receive Data Subsystem is de-multiplexing the wind packet and stores the packet.

12.8.1.2 - Function
The function of the Receive Data Subsystem is to decode the wind data from IRBS Network layer to be sent to the Data Process Subsystem.

12.8.1.3 - Dependencies
The Receive Data Subsystem is dependent on Send/Receive Data Subsystem of IRBS Network layer.

12.8.1.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Send/Receive Data Subsystem</td>
<td>Receive Data Subsystem</td>
<td>Data packets</td>
</tr>
<tr>
<td>Send Subsystem</td>
<td>Wind Process Subsystem</td>
<td>Wind data</td>
</tr>
</tbody>
</table>

TABLE 12.2 - RECEIVE DATA SUBSYSTEM INTERFACES

12.8.1.5 - Processing
No processing is done.

12.8.1.6 - Data
The Receive Data Subsystem consists of wind data.

12.8.2 - Send Data Subsystem

12.8.2.1 - Purpose
The purpose of the Send Data Subsystem is

12.8.2.2 - Function
The function of the Send/Receive Subsystem is to either de-multiplexes or multiplexes the packet.

12.8.2.3 - Dependencies
The Send Data subsystem is dependent on the Receive Data Subsystem.

12.8.2.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receive Data Subsystem</td>
<td>Wind Process Subsystem</td>
<td>Wind Data</td>
</tr>
</tbody>
</table>

TABLE 12.3 - SEND DATA SUBSYSTEM INTERFACES

12.8.2.5 - Processing
No processing is done.
12.8.2.6 - **Data**

The Send Data Subsystem consists of wind data.
13. - RRM Data Input

FIGURE 13-1- RRM DATA INPUT LAYER

13.1 - Description
The RRM Data Input Layer is responsible for handling the input data from the accelerometer, barometer, and the processed data from Network Layer. The RRM Data Input layer consists of three subsystems; The Accelerometer Input, The Barometer input, and the IRBS Processed Input.

13.2 - Purpose
The RRM Data Input Layer’s purpose is to gather external data from the accelerometer, barometer and the internal processed wind data from the network layer. This data is passed to the next appropriate layer to be processed.

13.3 - Function
The RRM Data Input Layer will gather external data from the attached accelerometer and the barometer. The RRM Data input will then pass the processed data from the accelerometer and barometer to the Verify Data subsystem in the RRM Data Processing Layer. The layer will also transport the processed IRBS wind data from the Network Layer to the Verify Data subsystem in the RRM Data Processing Layer.

13.4 - Dependencies
The RRM Data Input Layer is dependent upon the Network Layer to provide decoded packets and is also dependent upon external input from the accelerometer and barometer.

13.5 - Interfaces

<table>
<thead>
<tr>
<th>Type</th>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>External</td>
<td>Accelerometer</td>
<td>Accelerometer Input subsystem</td>
<td>The analog digital signal from the accelerometer.</td>
</tr>
</tbody>
</table>
### Table 13.1 - RRM Data Input Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>External</td>
<td>Barometer</td>
<td>The analog digital signal from the Barometer.</td>
</tr>
<tr>
<td>Internal</td>
<td>Network Layer</td>
<td>The decoded Wind Data packet.</td>
</tr>
<tr>
<td>Internal</td>
<td>Accelerometer Input subsystem</td>
<td>Values from Accelerometer Input components to be converted to software objects.</td>
</tr>
<tr>
<td>Internal</td>
<td>Barometer Input subsystem</td>
<td>Values from Barometer Input components to be converted to software objects.</td>
</tr>
<tr>
<td>Internal</td>
<td>IRBS Wind Data subsystem</td>
<td>The decoded Wind Data packet converted into a software object.</td>
</tr>
</tbody>
</table>

### 13.6 - Processing

The RRM Data Input Layer will receive raw digital data from both the accelerometer and barometer. The appropriate subsystem will convert the digital signal into software objects and will be sent to the Verify Data Subsystem of the Data Processing Layer. The RRM Data Input Layer will also receive the decoded IRBS wind data packets. The IRBS Processed Input subsystem will convert the decoded packet to software objects and will be sent to the Verify Data subsystem of the Data Processing Layer.

### 13.7 - Data

The data will consist of discrete digital inputs, discrete analog inputs, and software objects.

### 13.8 - Subsystems

#### 13.8.1 - Accelerometer Input Subsystem

**13.8.1.1 - Purpose**

The purpose of the Accelerometer Input Subsystem is to detect and handle the accelerometer direction and force data that is collected via the attached accelerometer.

**13.8.1.2 - Function**

The function of the Accelerometer Input Subsystem is to detect the digital input from the accelerometer and then convert the digital signal into a usable software object.

**13.8.1.3 - Dependencies**

The Accelerometer Input Subsystem is only dependent on the anemometer input and no other data in the system.

**13.8.1.4 - Interfaces**

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerometer</td>
<td>Accelerometer Input subsystem</td>
<td>The analog digital signal from the accelerometer.</td>
</tr>
</tbody>
</table>
13.8.1.5 - Processing
The Accelerometer Input Subsystem processes the analog accelerometer data into software objects.

13.8.1.6 - Data
The Accelerometer Input Subsystem data consists of an analog input and software objects.

13.8.2 - Barometer Input Subsystem

13.8.2.1 - Purpose
The purpose of the Barometer Input Subsystem is to detect and handle the Barometer air pressure data that is collected via the attached barometer.

13.8.2.2 - Function
The function of the Barometer Input Subsystem is to detect the analog digital input from the barometer and then convert the digital signal into a usable software object.

13.8.2.3 - Dependencies
The Barometer Input Subsystem is only dependent on the barometer input and no other data in the system.

13.8.2.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barometer input Subsystem</td>
<td>Barometer input Subsystem</td>
<td>The analog digital signal from the Barometer.</td>
</tr>
<tr>
<td>Barometer input Subsystem</td>
<td>Verify Data subsystem</td>
<td>Values from Barometer Input components to be converted to software objects.</td>
</tr>
</tbody>
</table>

13.8.2.5 - Processing
The Barometer Input Subsystem processes the analog barometer data into software objects.

13.8.2.6 - Data
The Barometer Input Subsystem data consists of an analog input and software objects.

13.8.3 - IRBS Processed Input Subsystem

13.8.3.1 - Purpose
The purpose of the IRBS Processed Input subsystem is to detect and handle the decoded wind data packets from the Network Layer.
13.8.3.2 - Function
The function of the IRBS Processed Input Subsystem is to detect and handle the decoded wind data packets from the Network Layer and then convert the digital signal into a usable software object.

13.8.3.3 - Dependencies
The IRBS Processed Input Subsystem is only dependent on the decoded packets from the Network Layer.

13.8.3.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Layer</td>
<td>IRBS Processed Input subsystem</td>
<td>The decoded Wind Data packet.</td>
</tr>
<tr>
<td>IRBS Processed Input subsystem</td>
<td>Verify Data Subsystem</td>
<td>The decoded Wind Data packet converted into a software object.</td>
</tr>
</tbody>
</table>

TABLE 13.4-IRBS PROCESSED INPUT INTERFACES

13.8.3.5 - Processing
The IRBS Processed Input Subsystem processes the decoded packets of wind data into software objects.

13.8.3.6 - Data
The IRBS Processed Input Subsystem data consists of decoded packets and software objects.
14. - RRM Data Processing

The RRM data processing layer is responsible for the processing and validation of raw data during flight.

14.2 - Purpose
The purpose of this layer is to emphasize modularity in the design structure of the system. All processing of data will be encapsulated within this layer and the resulting comprehensible data will be made available to the hardware layer. This layer will be constantly processing input data to detect if the rocket has drifted or turned away from its original orientation. If it has altered its orientation commands will be sent to the hardware layer to correct them.

14.3 - Function
The RRM Data Processing will process and validate the raw data from the data input layer. In cases where outliers are detected the system will ignore them and take an average of the acceptable input. Data received will include air pressure, acceleration, and directional orientation.

14.4 - Dependencies
The RRM Data Processing Layer is dependent on raw data from the Data Input Layer.

14.5 - Interfaces

<table>
<thead>
<tr>
<th>Type</th>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal</td>
<td>Data Input Layer</td>
<td>Data Process Layer</td>
<td>Raw data from barometer and accelerometer</td>
</tr>
<tr>
<td>Internal</td>
<td>Data Process Layer</td>
<td>Hardware Layer</td>
<td>Processed data</td>
</tr>
</tbody>
</table>

TABLE 14.1 - RRM DATA PROCESS INTERFACES
14.6 - Processing
The RRM Data Process Layer will process the raw data from the Data Input Layer to comprehensible data as defined by the hardware layer. The bulk of the processing will be determining the altitude, orientation, and acceleration.

14.7 - Data
The data will consist of air pressure, force, and direction.

14.8 - Subsystems

14.8.1 - Stabilization Subsystem

14.8.1.1 - Purpose
While the SD-12 Rocket is in flight there will be necessary stabilization corrections to keep the rocket on course both before and after it turns. Prior to flight the rocket will take note of its orientation which it will try to maintain up until it turns. This orientation is very important because the rocket pad (IRBS) has requirements to tilt. Given this, we want the rocket to make every effort during flight to maintain its original orientation.

14.8.1.2 - Function
The function of Stabilization Subsystem is to read input from the accelerometer and make the flight corrections necessary to keep the rocket on course. This information will then be sent to the hardware layer to execution.

14.8.1.3 - Dependencies
The Stabilization Subsystem is dependent on input data from the accelerometer.

14.8.1.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerometer</td>
<td>Stabilization</td>
<td>Raw data</td>
</tr>
<tr>
<td>Hardware</td>
<td>Subsystem</td>
<td></td>
</tr>
<tr>
<td>Stabilization</td>
<td>Verify Data</td>
<td>Orientation data</td>
</tr>
<tr>
<td>Subsystem</td>
<td>Subsystem</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 14.2 - STABILIZATION SUBSYSTEM INTERFACES

14.8.1.1 - Processing
The Stabilization Subsystem calculates the difference from its original orientation to what it should be. This difference will correlate to flight path correction quantities for the servos to execute.

14.8.1.2 - Data
The Stabilization Subsystem data consists of raw input data from the accelerometer and output a degree of change for the servos.
14.8.2 - Air Pressure Subsystem

14.8.2.1 - Purpose
The SD-12 Rocket parachute system will activate based on its altitude which this subsystem provides.

14.8.2.2 - Function
The barometer will give air pressure readings which we can convert to altitude. Upon reaching a desired altitude for the second time the parachute will deploy.

14.8.2.3 - Dependencies
The Air Pressure Subsystem is dependent on input data from the barometer.

14.8.2.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barometer (Hardware)</td>
<td>Air Pressure Subsystem</td>
<td>Raw data</td>
</tr>
<tr>
<td>Air Pressure Subsystem</td>
<td>Verify Data Subsystem</td>
<td>Altitude data</td>
</tr>
</tbody>
</table>

TABLE 14.3 - AIR PRESSURE SUBSYSTEM INTERFACES

14.8.2.5 - Processing
The Air Pressure Subsystem calculates the altitude based on the current air pressure.

14.8.2.6 - Data
The Air Pressure Subsystem data consists of raw input data from the barometer and output altitude information.

14.8.3 - Verify Data Subsystem

14.8.3.1 - Purpose
We acknowledge that there are uncertainties implied in taking measurements from the environment and hence we have implemented this subsystem to verify input data. This subsystem will check for extreme outliers from all incoming data that is received by the barometer and accelerometer. If any are detected they will be thrown out. It also verifies the data that the IRBS sent and sends that to the Set Data Subsystem.

14.8.3.2 - Function
The function of Verify Data Subsystem is to verify data and throw out any outliers.

14.8.3.3 - Dependencies
The Verify Data Subsystem is dependent on input data from the barometer and accelerometer.

14.8.3.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barometer (Hardware)</td>
<td>Air Pressure Subsystem</td>
</tr>
<tr>
<td>Air Pressure Subsystem</td>
<td>Verify Data Subsystem</td>
</tr>
</tbody>
</table>

TABLE 14.3 - AIR PRESSURE SUBSYSTEM INTERFACES
Architectural Design Specification

14.8.3.5 - Processing
The Verify Data Subsystem detects data that is identified as an outliers based on the current average.

14.8.3.6 - Data
Raw data from the sensors.

14.8.4 - Set Data Subsystem

14.8.4.1 - Purpose
The purpose of the Set Data Subsystem is to ensure the availability of the processed data to the RRM Hardware Layer.

14.8.4.2 - Function
It is essentially temporary storage for the RRM. It gets the processed wind data from the Verify Data Subsystem and makes it available to the Get Data Subsystem of the RRM Hardware Layer.

14.8.4.3 - Dependencies
The Set Data Subsystem is dependent on finalized altitude and stabilization variables from the Verify Data Subsystem.

14.8.4.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verify Data Subsystem</td>
<td>Set Data Subsystem</td>
<td>Altitude and stabilization corrections</td>
</tr>
<tr>
<td>Set Data Subsystem</td>
<td>Get Data Subsystem</td>
<td>Altitude and stabilization corrections</td>
</tr>
<tr>
<td></td>
<td>(Hardware Layer)</td>
<td></td>
</tr>
</tbody>
</table>

14.8.4.5 - Processing
No processing is done.

14.8.4.6 - Data
The Set Data Subsystem data consists of data from the Verify Data Subsystem which includes altitude and stabilization corrections for the hardware layer.
15. - RRM Hardware Interface

15.1 - Description
The RRM Hardware Interface Layer is the last layer of the Rocket Recovery System layers and consists of two subsystems namely Get Data and Hardware Process Subsystem.

15.2 - Purpose
The purpose of the hardware layer is to receive data from the RRM Data Process layer that will be used during the rocket stability section.

15.3 - Function
The RRM Hardware Interface will obtain the air pressure and acceleration data from the RRM Data Process layer in determine the stability of the rocket and the servo opening for the landing.

15.4 - Dependencies
The RRM Hardware Interface Layer is dependent on wind speed and acceleration data from RRM Data Process layer.

15.5 - Interfaces

<table>
<thead>
<tr>
<th>Type</th>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal</td>
<td>Data Process</td>
<td>Hardware Process Subsystem</td>
<td>Air Pressure and acceleration from data process layer</td>
</tr>
</tbody>
</table>

**TABLE 15.1 RRM HARDWARE INTERFACE**

15.6 - Processing
No processing is done.

15.7 - Data
The data will consist of air pressure and acceleration.
15.8 - Subsystems

15.8.1 - Get Data Subsystem

15.8.1.1 - Purpose
The purpose of the subsystem is to receive data from data process subsystem and store the data for the servo.

15.8.1.2 - Function
The function of the Get Data Subsystem is to store the data receives into an array which can be used for the rotation of the servo.

15.8.1.3 - Dependencies
The Get Data Subsystem is dependent on the Data Process subsystem because the data processed by the subsystem will be received and stored for the servo usage.

15.8.1.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Get Data</td>
<td>Get Data Subsystem</td>
<td>Air Pressure and acceleration data</td>
</tr>
<tr>
<td>Get Data</td>
<td>Hardware Process Subsystem</td>
<td>Stored data for servo</td>
</tr>
</tbody>
</table>

TABLE 15.2 - GET DATA SUBSYSTEM INTERFACES

15.8.1.5 - Processing
No processing is done.

15.8.1.6 - Data
The Get Data Subsystem data consists of stored data to be used by the hardware process subsystem

15.8.2 - Hardware Process Subsystem

15.8.2.1 - Purpose
The purpose of the Hardware Process Subsystem is to activate and rotate the servo.

15.8.2.2 - Function
The function of the Hardware Process Subsystem is to take the data stored in the Get Data Subsystem to rotate the servo in response to the wind data.

15.8.2.3 - Dependencies
The Hardware Process Subsystem is dependent on the wind data and acceleration stored in the Get Data Subsystem.

15.8.2.4 - Interfaces

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Get Data</td>
<td>Hardware Process</td>
<td>Wind speed and acceleration data</td>
</tr>
</tbody>
</table>
15.8.2.5 - Processing
No processing is done.

15.8.2.6 - Data
Pressure and acceleration
16. - Operating System Dependencies

This project has no dependency to a specific desktop operating system in the development stage. Given that the RRM and IRBS will feature Arduino boards and the flexibility on such a platform is very liberal, development can be conducted on any modern desktop operating system. However there are many specific operating system dependencies relevant outside of the given computer that we will conduct development.

We will be using the Arduino IDE to develop the code necessary to drive the IRBS and RRM. The IRBS will have a few necessary libraries that we will use to drive the system. We will have an LCD screen, servos, an accelerometer and anemometer on the IRBS system so the libraries to support such hardware will be needed. For easy development we have found products that advertise compatibility with the Arduino development board and because of this there are pre written libraries associated with each that we will be using. The system will take advantage of this and will be loaded with these libraries and drivers.

The RRM on the other hand will be designed for efficiency. Given that it's a different board all together we will only be loading the necessary Arduino libraries and drivers to drive the servos, accelerometer, and barometer.
17. - Data Flow Mapping

Rocket Recovery Module (RRM)

Intelligent Rotating Base Station (IRBS)

Network
  Send/Receive

RRM Data Input
  Accelerometer Input
  Barometer Input
  Wind Data Input

RRM Data Processing
  Stabilization Processing
  Air Pressure Processing
  Verify Data
  Set Data

RRM Hardware Interface
  Get Data
  Hardware Processing

User Interface
  Get Data
  Display Output

Data Input
  User Input
  Anemometer Input
  Accelerometer Input

Data Processing
  Verify Data
  Encapsulate Data
  Verify Data

Network
  Get Data
  Send/Receive

Hardware Interface
  Get Data
  Hardware Processing

FIGURE 17-1 - SYSTEM DATA FLOW
17.1 - Intelligent Rotating Base Station System

17.1.1 - Overview

Relationship mapping describes the data flow between the layers and subsystems of the Intelligent Rotating Base Station System.

![Data Flow Diagram]

**Figure 17-2 - IRBS Data Flow**
17.1.1 – IRBS Producer-Consumer Relationship

<table>
<thead>
<tr>
<th>Data Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>The raw digital data sent as a result of a user button press.</td>
</tr>
<tr>
<td>B2</td>
<td>The raw digital data sent from the attached anemometer.</td>
</tr>
<tr>
<td>B3</td>
<td>The raw digital data sent from the attached accelerometer.</td>
</tr>
<tr>
<td>B4</td>
<td>Converted button press into software object</td>
</tr>
<tr>
<td>B5</td>
<td>Converted anemometer data into software object</td>
</tr>
<tr>
<td>B6</td>
<td>Converted accelerometer data into software object</td>
</tr>
<tr>
<td>B7</td>
<td>Error checked software objects either from the anemometer or accelerometer software object.</td>
</tr>
<tr>
<td>B8</td>
<td>The software objects encapsulated into some data structure</td>
</tr>
<tr>
<td>B9</td>
<td>The fully processed wind and accelerometer data structure (includes angle, turn time/altitude, and launch pad safety angle check)</td>
</tr>
<tr>
<td>B10</td>
<td>The finalized non editable wind info data structure needed for rocket flight</td>
</tr>
<tr>
<td>B11</td>
<td>The finalized non editable angle info data structure needed for pad rotation</td>
</tr>
<tr>
<td>B12</td>
<td>The finalized non editable wind info data structure (wind speed, direction, and pad angle)</td>
</tr>
<tr>
<td>B13</td>
<td>The finalized non editable wind info data structure needed for rocket flight</td>
</tr>
<tr>
<td>B14</td>
<td>The finalized non editable angle info data structure needed for pad rotation</td>
</tr>
<tr>
<td>B15</td>
<td>The finalized non editable wind info data structure for display (wind speed, direction, and pad angle)</td>
</tr>
<tr>
<td>B16</td>
<td>The converted packet of the finalized non editable wind info data structure needed for rocket flight</td>
</tr>
<tr>
<td>TABLE 17.2 - IRBS PRODUCER-CONSUMER MATRIX</td>
<td>Producer</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Data Input Subsystem</td>
<td>User Input</td>
</tr>
<tr>
<td>C. Consumer</td>
<td>User Interface Subsystem</td>
</tr>
<tr>
<td>Hardware Layer</td>
<td>Get Data Subsystem</td>
</tr>
<tr>
<td>Network Layer</td>
<td>Get Data Subsystem</td>
</tr>
</tbody>
</table>
17.2 - Rocket Recovery Module System

17.2.1 - Overview

Relationship mapping describes the data flow between the layers and subsystems of the Rocket Recovery Module System.

![Diagram of Rocket Recovery Module System](image-url)
17.2.2 - RRM Producer-Consumer Relationship

<table>
<thead>
<tr>
<th>Data Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>Encapsulated packet of processed wind data from the IRBS</td>
</tr>
<tr>
<td>R2</td>
<td>Un-Encapsulated data structure of processed wind data from the IRBS</td>
</tr>
<tr>
<td>R3</td>
<td>The raw digital data sent from the attached accelerometer.</td>
</tr>
<tr>
<td>R4</td>
<td>The raw digital data sent from the attached barometer.</td>
</tr>
<tr>
<td>R5</td>
<td>The accelerometer software objects.</td>
</tr>
<tr>
<td>R6</td>
<td>The barometer software objects.</td>
</tr>
<tr>
<td>R7</td>
<td>The processed data structure of processed wind data from the IRBS</td>
</tr>
<tr>
<td>R8</td>
<td>The fully processed accelerometer (stabilization) software object.</td>
</tr>
<tr>
<td>R9</td>
<td>The fully processed barometer (altitude) software object.</td>
</tr>
<tr>
<td>R10</td>
<td>Error checked software objects either from the accelerometer or barometer software object.</td>
</tr>
<tr>
<td>R11</td>
<td>The finalized non editable flight info data structure needed for rocket trajectory.</td>
</tr>
<tr>
<td>R12</td>
<td>The finalized non editable flight info data structure needed for rocket trajectory.</td>
</tr>
</tbody>
</table>

TABLE 17.3 - RRM PRODUCER-CONSUMER RELATIONSHIP
### RRM Producer-Consumer Matrix

<table>
<thead>
<tr>
<th>Network Layer</th>
<th>RRM Data Input</th>
<th>RRM Data Processing</th>
<th>RRM Hardware Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Layer</td>
<td>From IRBS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RRM Data Input</td>
<td>Send/Receive Subsystem</td>
<td>Anemometer Input</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Barometer Input</td>
<td>Barometer Input Subsystem</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wind Data Input Subsystem</td>
<td>Stabilization Processing Subsystem</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Air Pressure Processing Subsystem</td>
<td>Verify Data Subsystem</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Set Data Subsystem</td>
<td>Get Data Subsystem</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hardware Processing</td>
<td>Hardware Processing</td>
<td></td>
</tr>
</tbody>
</table>

| Table 17.5 - RRM PRODUCER-CONSUMER MATRIX |
18. - Requirement Mapping

In order to verify that certain customer and performance requirements are satisfied, Team MASS used requirement mapping. Requirement mapping is done by generating a table, which specifies the layers that fulfill certain requirements.

<table>
<thead>
<tr>
<th>No.</th>
<th>Requirement</th>
<th>IRBS</th>
<th>IRBS</th>
<th>IRBS</th>
<th>IRBS</th>
<th>IRBS</th>
<th>RRM</th>
<th>RRM</th>
<th>RRM</th>
<th>RRM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>DI</td>
<td>UI</td>
<td>DP</td>
<td>Network</td>
<td>HI</td>
<td>Network</td>
<td>DI</td>
<td>DP</td>
<td>HI</td>
</tr>
<tr>
<td>3.1</td>
<td>Rocket lands where it was launched from</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3.4</td>
<td>IRBS - Standby Mode</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>IRBS – Preparation Mode</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3.6</td>
<td>IRBS – Launch Mode</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3.9</td>
<td>IRBS – Rotation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3.10</td>
<td>IRBS – Pad Pitch</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.11</td>
<td>RRS – Abort Countdown</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.12</td>
<td>IRBS – Wind Speed Detection</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td>IRBS Modes – Time</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>5.6</td>
<td>RRM – Microcontroller instructions per cycle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

**RRS** – Rocket Recovery System; **IRBS** – Intelligent Rotating Base Station; **RRM** – Rocket Recovery Module; **DI** – Data Input; **UI** – User Interface; **DP** – Data Processing; **HI** – Hardware Interface

TABLE 18.1 - REQUIREMENT MAPPING
19. - Testing Considerations

19.1 - Overview
Testing consideration provides the guide for validation and verification of the architectural designs specified in the document. The section will provide the accurate metrics needed to determine if the layers, subsystems, and components of the system meet the requirements as defined in the System Requirements Specification.

19.2 - Testing Approach
Team Mass will start by testing each component required independently to verify that it works correctly before coupling together. When the components work perfectly, they will be coupled together to form subsystems. Each subsystem will be tested independently for proper performance and functionality. Upon success of the subsystem testing, Team Mass will proceed by integrating the subsystems into layers and each layer will also be tested independently. When each layer works successfully, the layers will then be attached together for the system to work as one.

19.2.1 - User Interface
The User Interface layer must be able to make use of its subsystems to display processed information and data. Since the layer is to be user friendly, all components needed for display function will be adequately tested to ensure correct result and data are displayed.

19.2.2 - Data Input
Data Input layer is responsible for interacting with user and accepting any data or information inserted by the user in the operation of the system. The layer will transport data to the Data Process layer and User Interface layer. The layer accept input from user in form of the button, we will ensure that the button works perfectly without any hitch. Also this layer takes in the wind speed from Anemometer and normal speed data from the accelerometer. All this data will be tested independently to be sure that accurate data will be processed by the layers and subsystems that depend on layer for proper functioning.

19.2.3 - Data Process
The Data Process layer is responsible for obtaining, verifying, encapsulating, and storing data from anemometer and accelerometer. The team will ensure that all the data obtained will be thoroughly verified and correctly stored for a smooth transition to the needed layers and subsystems.

19.2.4 - Hardware Interface
The Hardware Interface functions as hardware processor and storage. The team will examine the servo and electric motor independently to ensure that each works correctly. Also the layer will insure that the command receives from the Data Process layer is properly transported to the Hardware Process subsystem.
19.2.5 - IRBS Network
The subsystems of the layer will be tested independently for perfection because the IRBS Network layer is responsible for transporting packets to the RRM Network layer which in turn send the wind speed data to be used for the final mode of the system.

19.2.6 - RRM Network
Team Mass will ensure that each subsystem of the layer performs the required function expected before proceed to the next phase because the layer will be reliably connect both the RRM and IRBS systems together for proper operation.

19.2.7 - RRM Data Input
The RRM Data Input layer is liable for accepting wind data from the IRBS Data Input layer. The layer will also transport data to the Data Process layer. We will ensure that the wind data is verified and analyzed for proper functioning of the system. Also this layer takes in the wind speed from Network layer, normal speed data from the accelerometer, and air pressure data from barometer. All this data will be tested independently to be sure that accurate data will be processed by the layers and subsystems that depend on layer for proper functioning.

19.2.8 - RRM Data Process
RRM Data Process layer is responsible for obtaining, verifying, stabilizing, and storing data from barometer and accelerometer. The team will ensure that all the data obtained will be thoroughly verified and correctly stored for easy movement to the needed layers and subsystems.

19.2.9 - RRM Hardware Interface
The Hardware Interface functions as hardware processor and storage. The team will examine the servo to ensure that it works correctly. Also the layer will insure that the command receives from the Data Process layer is correctly carried to the Hardware Process subsystem.