Satellite Antenna Tracking Mount

Hunter Britton
Michael Raabe
David Santos

CONCEPT OF OPERATIONS

REVISION – Final
7 February 2023

Concept of Operations
for
Satellite Antenna Tracking Mount

Team <35>

Approved by:

Project Leader Date

Prof. Kalafatis Date

T/A Date

Change Record

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1. Executive Summary

HAM radio systems require specialized equipment and software to operate. Rather than manually adjusting the antenna with dials or computer software, our objective is to provide remote operation that will control the antenna rotator and display data for communication. The Satellite Antenna Tracking Mount will address this issue with a web application and microcontroller that will interface with the mount over the wireless internet. SATM will also provide secure user authentication via hashing account data. This will allow for low-cost remote operation and web browser accessibility.

2. Introduction

The purpose of this document is to provide an overview of the Satellite Antenna Tracking Mount (SATM) system. The SATM is designed to accurately target and track satellites as they orbit the Earth. The user interface allows for the selection of the desired satellite for communication, after which the SATM will perform automated tracking to ensure the antenna is correctly pointed at the selected satellite as it passes overhead. This feature enables the user to concentrate solely on their communication without having to manually track the satellite.

2.1. Background

The majority of legacy systems for moving satellite antennas are semi-manually controlled, with a user having to press a switch to move the antennas in different directions or input data for software. This outdated system tracks satellites across the sky, but requires the operator to be physically present with a laptop. Few strides have been taken to provide control wirelessly and even fewer allow access through web browsers. The SATM intends to replace this manual control system scheme with an automated one, where a Satellite can be selected out of a set catalog, and the tracking mount seamlessly follows it in the sky. This automatic system would allow for more flexibility when operating the antenna, as well as include less error since the data would be instantly updated.

2.2. Overview

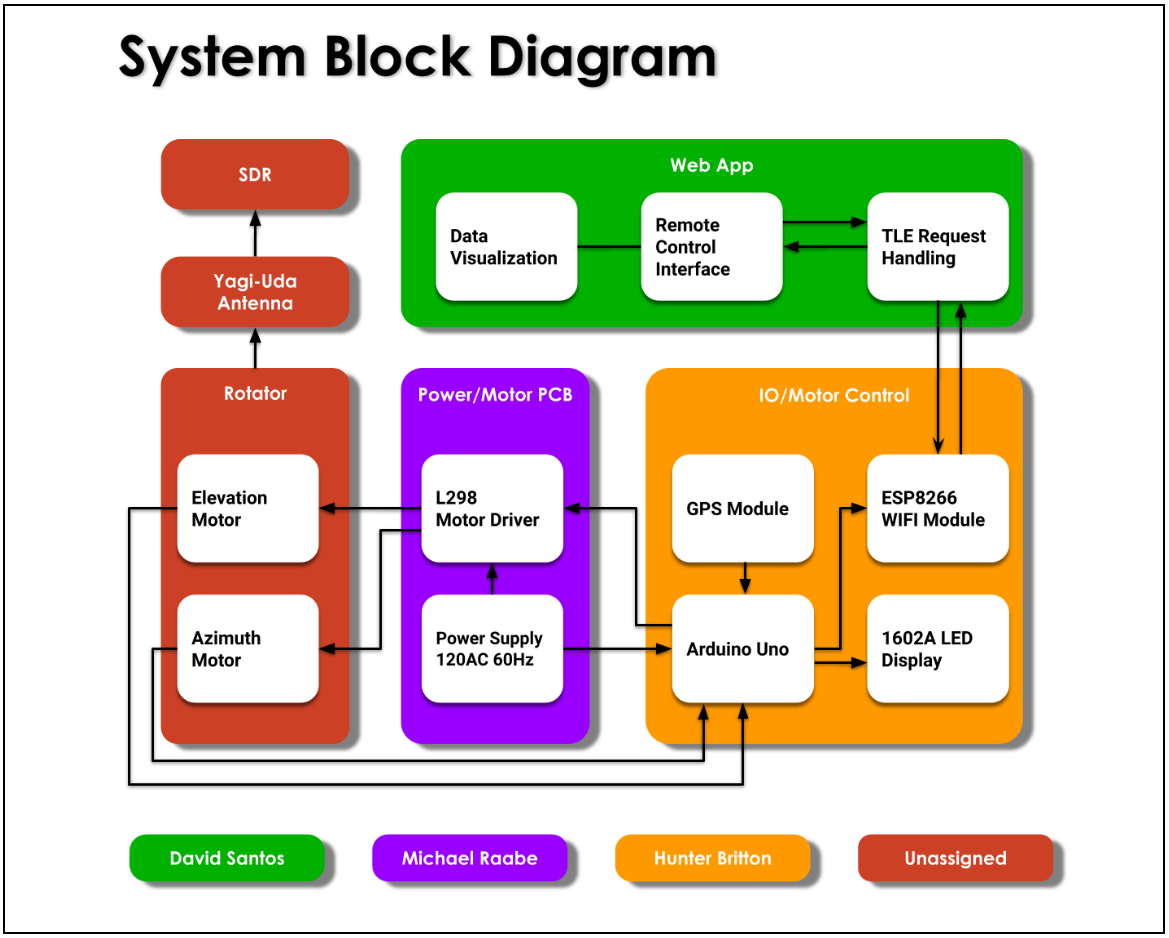

Figure 1: *Satellite Antenna Tracking Mount Block Diagram*

The SATM system is designed to automate the process of tracking satellites as they traverse the overhead region, eliminating the requirement for manual tracking by the operator using azimuth and elevation controls. The location data of the targeted satellite will be obtained from a pre-existing database that will be continuously updated to ensure accurate and persistent tracking of the satellite. The system is equipped with a web-based user interface, allowing the operator to input the desired satellite to be tracked. This information will be transmitted to the microcontroller, which will drive the motors within the antenna mount, enabling continuous tracking until the satellite descends below the horizon.

2.3. Referenced Documents and Standards

- IEEE Wi-Fi communication standards: IEEE 802.11
- C95.1-2005 - IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz
- CCSDS 502.0-B-2 - Orbit Data System Standards
- FCC 97.213 - Telecommand of an amateur station
- CFR P97T47 - Amateur Radio Service

3. Operating Concept

3.1. Scope

The SATM will provide wireless connectivity to amateur radio operators that seek to enhance their current manual setups. They will initially configure the device to provide the necessary information to the web application. When the operator accesses the website on any browser, they will login and select a satellite. The next thing they will see is the relative location of the satellite along with the orientation of the antenna in degrees. The microcontroller will handle the intermediate processes that are usually completed by the user or computer software. These include calculating orbital paths, as well as setting the motor to the appropriate motion sequence. The SATM will immediately benefit operators, but may also be used for other IOT projects with slight alterations such as telescope mounts or weaponry.

3.2. Operational Description and Constraints

The Satellite Antenna Tracking Mount (SATM) is intended to be used by amateur radio enthusiasts to be able to communicate with satellites without having to manually control the azimuth and elevation controls to track the satellite. The SATM system will take the information from a pre-existing database of satellite locations and use it to track a satellite as it passes overhead.

The resulting constraints are from this operational description are as follows:

- The SATM system must have access to a WIFi connection.
- The SATM system should be placed in an area without obstructions to the sky. This will allow the system to communicate with the satellite.
- The system should be placed on fairly level ground to allow the rotator to track the satellite fully.
- The budget for the whole project is $300 so that limits the components that we will be able to use in the system.
- The system components must be strong enough to operate in most weather conditions.

3.3. System Description

- Web Application: The user-friendly web application enables the operator to select the desired satellite for communication. The application can be accessed remotely with an internet connection, and it will retrieve satellite location data from a constantly updated database. This information will then be transmitted to the microcontroller.
- Microcontroller: The microcontroller calculates the relative position of the satellite based on the data obtained from the database and drives the motors within the antenna mount to point the antenna towards the satellite.
- Antenna Mount: The antenna mount is equipped with two motors that regulate the azimuth and elevation angles, allowing precise orientation towards the target satellite. The mount is pre-existing and will be controlled by the SATM system through the microcontroller. An antenna is mounted on the mount, making it ready for satellite communication.

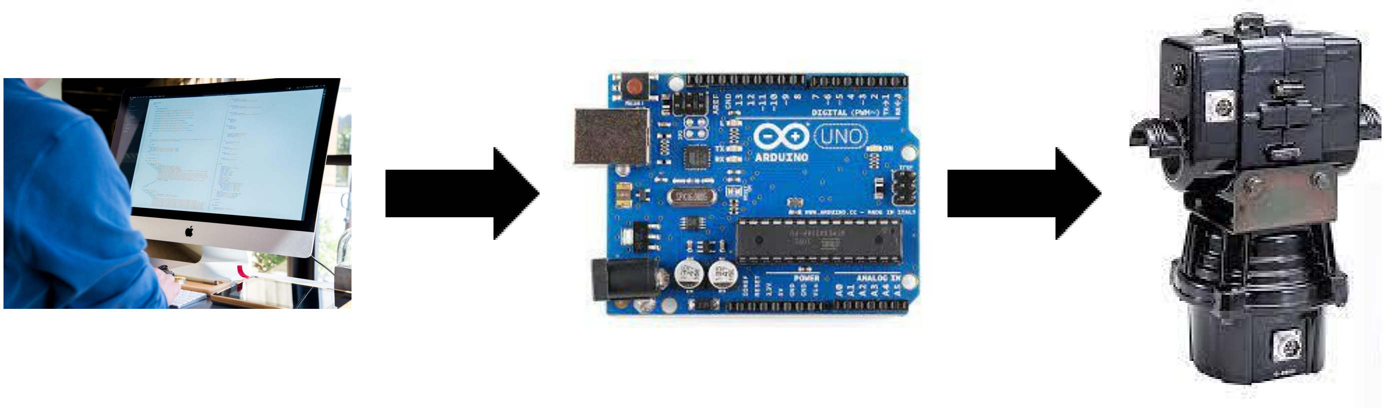

Figure 2: *SATM Flow Chart*

3.4. Modes of Operations

There will be two main modes of operations: automatic mode and manual mode.
In the automatic mode, the user will select a satellite from a list provided to them and the device will automatically track the satellite.
In the manual mode, the user will be able to control the device and point it in the direction that they choose.

3.5. Users

The main users of the system would be David Gent, W5AC, and the Aggie Radio Club. This system should only be used by those who have a ham radio license and call sign due to the fact that this system would be interfacing with antennas and will be transmitting and receiving information that is protected by the American Radio Relay League. The level of training for this system would be minimal since the use is mainly for those who have a ham radio license, but for those that are not licensed the basic knowledge of antennas, radio waves, and satellite movements are necessary.

3.6. Support

The support for the SATM will be provided by a user's manual that includes all modes of operation, as well as schematics and diagrams for the internals of the device. The source code for the device would be provided as well in order for the users to debug any issues that happen in corner cases. The user manual would describe how to operate the SATM, as well as walk the user through the main modes of operation.

4. Scenario(s)

4.1. Emergency

Radios are utilized in a lot of different emergency situations since they are not as limited in their scope and broadcast range as mobile phones. The SATM could potentially be utilized in an emergency situation where the only way to communicate with someone would be via a radio. A big part of using radio communication is that many areas have a lot of amateur radio stations that are fail resistant, leading to no choke points or overloading from use.

4.2. Recreation

Operators typically use their setups to simply meet other people and form clubs. The remote operation system will increase access for people with limited mobility or insufficient geography conditions like inclement weather or high rf interference.

4.3. Competition

Amateur radio contesting or radiosport, is an organized activity where operators try to have the most two-way interactions as possible. The SATM will potentially allow anyone to participate in these activities without physically being there.

5. Analysis

5.1. Summary of Proposed Improvements

This system will take a legacy system that is already built that has manual controls, and convert it to a system that can be remote controlled and automatically points the antenna in the direction of the chosen satellite. This allows for a higher level of precision and a better connection to the target over manual controls.

5.2. Disadvantages and Limitations

One major limitation of the system is that it requires you to be connected to wifi to operate, as well as the device being connected to wifi to pull the data for the satellite tracking.
Another disadvantage of the device is that this is specifically designed for the legacy system that is already in place, and cannot be used for different rotators.

5.3. Alternatives

The other alternatives to this project are to manually control the system by hand, or to find an off the shelf remote controlled system. Both of these alternatives have their own disadvantages. The manual control loses the remote control aspect, and sacrifices the precision from the computer controlled system. The off the shelf component does not directly mount on the legacy system and can cost money, as well as require a license or very specific equipment.

5.4. Impact

The main impact this project would have on the environment is to increase the amount of radio signals that are active in the community. The main ethical concern can be related to increasing the amount of signals in the environment which potentially could slow down the wifi in the area.

Satellite Antenna Tracking Mount

Hunter Britton
Michael Raabe
David Santos

FUNCTIONAL SYSTEM REQUIREMENTS

REVISION – 1.0
16 February 2023

FUNCTIONAL SYSTEM REQUIREMENTS
FOR
Satellite Antenna Tracking Mount

APPROVED BY:

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Hunter Britton Date

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Prof. S. Kalafatis Date

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Pranav Dhulipala Date

Change Record

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1.0	2/15/2023	David Santos		Draft Release

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1. Introduction

1.1. Purpose and Scope

This document provided detailed system requirements for a HAM radio remote operation system. Amateur radio systems require specialized equipment and software to operate automatically. Typically a controller is used in conjunction with computer software to control the antenna rotator, but our objective is to provide a remote operation system that will allow a user to control the antenna from a web browser. The Satellite Antenna Tracking Mount (SATM) will be formed from a legacy rotator with two motors, additional control and communication hardware, and a web application. SATM will also display pertinent data and provide secure user authentication via hashing account data, allowing for low-cost remote operation. The improved system will provide users greater flexibility and ease-of-use through web accessibility.

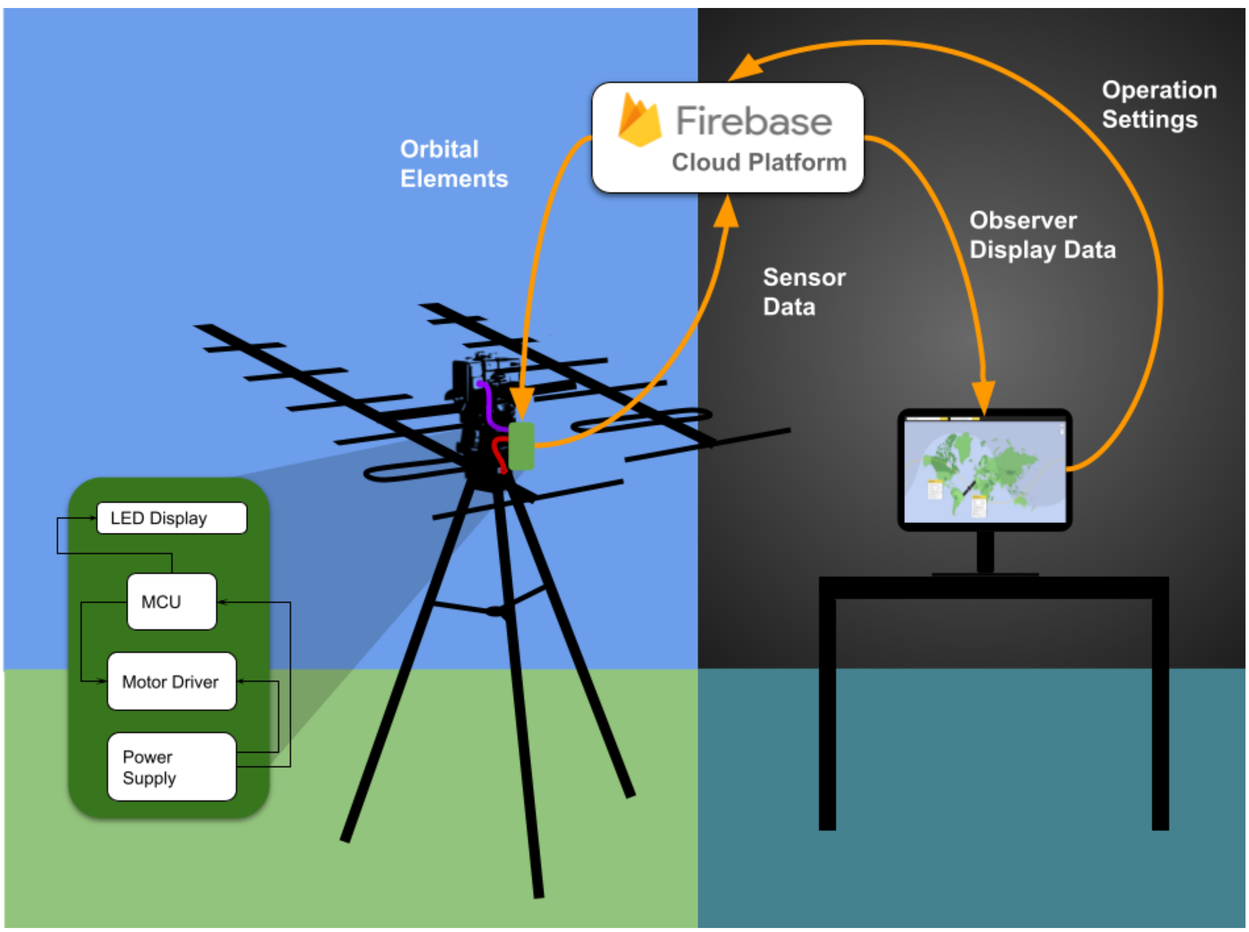

Figure 1. Browser-Based Satellite Antenna Tracking System

The following definitions differentiate between requirements and other statements.

Shall:	This is the only verb used for the binding requirements.
Should/May:	These verbs are used for stating non-mandatory goals.
Will:	This verb is used for stating facts or declaration of purpose.

1.2. Responsibility and Change Authority

The team leader, Hunter Britton, will be responsible for verifying all requirements are satisfied and the verification plan. Performance requirements are only to be changed by David Gent or by the consensus of the team members with the approval of David Gent. Each owner is responsible for the fulfillment of the functional requirements for their subsystem shown below.

Table 1. Subsystem Responsibility

Subsystem	**Owner**
MCU / IO	Hunter Britton
Power Supply / Motor Driver	Michael Raabe
Web Application	David Santos

2. Applicable and Reference Documents

2.1. Applicable Documents

The following documents, of the exact issue and revision shown, form a part of this specification to the extent specified herein:

Table 2. Standards

Document Number	Revision/ Date	Document Title
IPC A-610E	Revision E – 4.1.2010	Acceptability of Electronic Assemblies
IEEE 802.11ba	Revision ba - 2021	Wake-Up Radio Operation
CCSDS 502.0-P-2.1	Revision 2.1 - 10.21	Orbit Data Messages
FCC 97.213	Revision 213 - 6.20.1989	Telecommand of an Amateur Station

2.2. Reference Documents

The following documents are reference documents utilized in the development of this specification. These documents do not form a part of this specification and are not controlled by their reference herein.

Table 3. Reference Documents

Document Number	Revision/ Date	Document Title
CFR P97T47	6.20.1989	Amatuer Radio Service
C95.6	10.23.2022	IEEE Standard for Safety Levels With Respect to Human Exposure to Electromagnetic Fields

2.3. Order of Precedence

In the event of a conflict between the text of this specification and an applicable document cited herein, the text of this specification takes precedence without any exceptions.

All specifications, standards, exhibits, drawings or other documents that are invoked as “applicable” in this specification are incorporated as cited. All documents that are referred to within an applicable report are considered to be for guidance and information only, except ICDs that have their relevant documents considered to be incorporated as cited.

3. Requirements

This section defines the minimum requirements that the development item(s) must meet. The requirements and constraints that apply to performance, design, interoperability, reliability, etc., of the system, are covered.

3.1. System Definition

The SATM system is divided into three subsystems to manage complexity: Microcontroller and Peripherals, Power Supply and Motor Driver, and Web Application Interface. The microcontroller is responsible for taking data from the rotator motors, gps, and web application settings and using it to control the LED display, antenna positioning, and relaying that back to the web application with a WIFI module. The Power Supply Subsystem will convert power from the standard wall outlet 120v 60Hz to power the motor driver and microcontroller. Finally the Web Application will be used to interface with the rotator through the Firebase Platform. The web application will feature search capabilities for the rotator and satellite, data visualization, and a map visualizer.

A user will first connect their rotator via Wifi. The web app will then request GPS location, as well as the current position of the antenna from the microcontroller to determine where to place the marker on the map. Once a satellite is selected, the web app will access the NASA satellite catalog to relay the orbital elements. The microprocessor can then calculate the path of the satellite as well as the motor controls. The user can choose to manually enter the elevation and azimuth positioning.

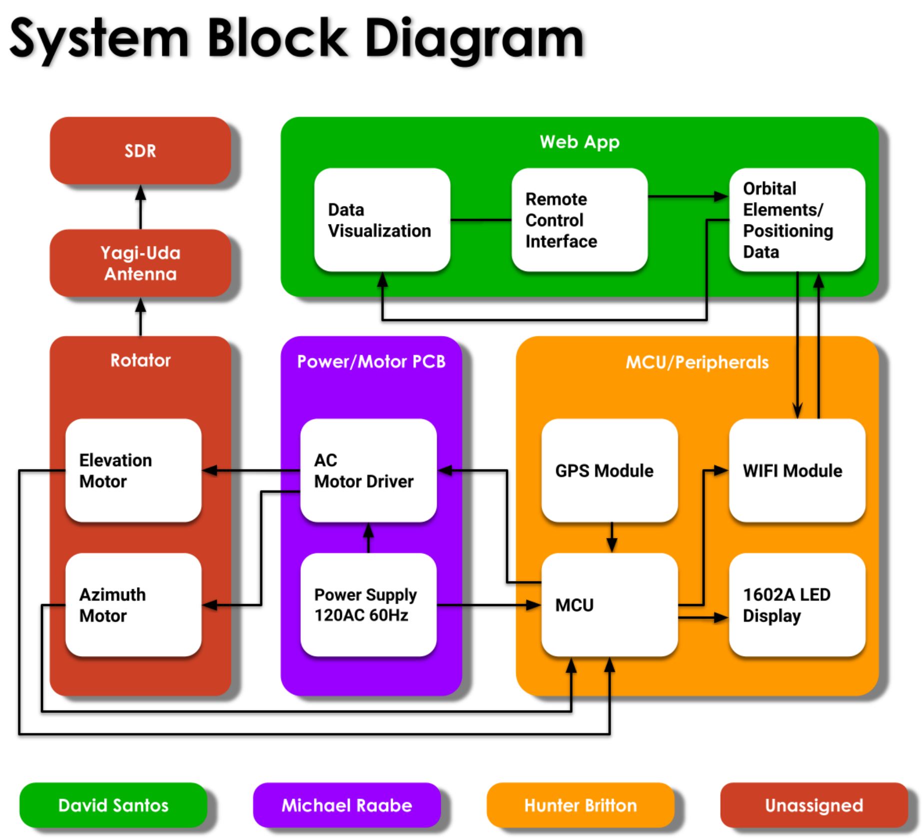

Figure 2. System Block Diagram

The block diagram in Figure 2 illustrates the subsystem added to legacy systems as well and their sub components. The MCU acts as an intermediate controller between the web application and rotator system. This PCB along with the power supply and driver will be mounted onto the upper part of the rotator with enough slack that it can move freely.

3.1.1 Web App Hosting

Firebase is a collection of web services developed by Google and will serve as the web application hosting platform. Similar to Amazon Web Services (AWS), it provides functions typically handled by the server, such as real-time databases and user authentication, through the cloud. It was designed to enable rapid prototyping and scalability, making it perfect for IoT applications that use web hosting. Firebase works on multi-tier payments to cater to the diverse users, ranging from hobbyists to professionals.The “Spark Plan” is the free version and provides all the necessary features for this project with the option to upgrade. Firebase incorporates the REST API, which is a software architecture that uses HTTP requests, such as “GET”, “POST”, “PUT”, and “DELETE”, to interact with resources on the server. HTTP can use URLs to access resources with a variety of formats like JSON or XML. The lightweight, user-friendly interface of the Google Cloud Platform will allow for easy web development.

3.1.2 Web App Framework

The front-end will use Vue.js because it is lightweight and versatile. This will enable an implementation of a satellite search bar, a connection port for the microcontroller, and an interactive map with the Esri JavaScript API. The satellite catalog will be made available through REST API.

3.1.4 Microcontroller

[TODO]

3.1.5 Power Supply

There will be a power supply board, separate from the Arduino UNO board, that will take in a 120 V, 60 Hz input from a standard wall outlet, and have two outputs. One output will go directly to the Arduino UNO board, which requires 7-12 VDC and ≤200 mA. The other output from the power supply board will go to a separate input on the Arduino UNO board for the L298N motor driver. The L298N requires 24 VDC and ≤2.5 A.

3.2. Characteristics

3.2.1. Functional / Performance Requirements

3.2.1.1 Signal Strength and Quality

Antenna shall have a Signal-to-Noise Ratio (SNR) >= 30dB and a RST Report of R5S5T5 or better indicating perfect readability, good signals, and rectified AC signals but strongly ripple-modulated.

Rationale: Together, signal strength and quality provide a good indication of how intelligible the audio signals are in amateur radio communication. A strong and high-quality signal can ensure that the audio is clear and audible, even under challenging conditions such as interference, noise, or path loss. Conversely, a weak or poor-quality signal may result in distorted, garbled, or unintelligible audio, making it difficult to communicate effectively.

3.2.1.2 Azimuth and Elevation Accuracy

Antenna shall point to the selected satellite within 4 percent, the error of the motor gearbox.

Rationale: The directional nature of satellite transmitters and antennas can have implications for satellite tracking and communication. To establish a reliable communication link with a satellite, the ground station antenna must be pointed accurately towards the satellite's position and must use an antenna that is capable of receiving the specific frequency and direction of the satellite's signal. Additionally, changes in the satellite's position or orientation can affect the strength and direction of the signal, requiring adjustments to the tracking system and communication parameters.

3.2.1.3 Tracking Speed

The antenna should have a tracking speed of at least 2 degrees/s to ensure that the center of the antenna is within 2 degrees for every second of movement of the satellite.

Rationale: As a satellite moves across the sky, its position changes rapidly, and a tracking system must be able to keep up with this movement to maintain a stable signal. If the tracking speed is too slow, the antenna may fall out of alignment with the satellite, resulting in a loss of signal or poor *signal quality. This can be especially problematic for applications that require a continuous or high-quality signal, such as satellite communication or Earth observation.*

3.2.2. Physical Characteristics

3.2.2.1 Form Factor

The hardware added to the rotator shall be minimized to 5 kg and a total volume of 0.75 m^3

Rationale: If the hardware is too large, it may interfere with the antennas or the rotators, limiting the functionality.

3.2.2.2 Weather Resistance

The hardware enclosure should withstand non-freezing temperatures and limited precipitation.

Rationale: The additional hardware should be as durable as the rotator and antenna

3.2.3. Web App Requirements

3.2.3.1 Interactive Map

The Web Application will have an interactive map of earth as a mercator projection. Day/Night Terminator, Ground Track, Labels, and a grid may also be added to the map.

Rationale: The map allows the user to easily see where the rotator is in relation to the satellite.

3.2.3.2 Satellite Selection

The Web Application shall have a search bar to select a satellite to track

Rationale: The satellite to be tracked needs to be defined or the web app does not know what orbital elements to request

3.2.3.3 Rotator Connection Port

The Web Application should have a connection method for the microcontroller. It should allow the user to disconnect, search, or reconnect.

Rationale: The web application has to initially contact the microcontroller for the GPS Location, and Motor Position data.

3.2.4. Electrical Characteristics

3.2.4.1 Inputs

a. The presence or absence of any combination of the input signals in accordance with ICD specifications applied in any sequence shall not damage the Satellite Antenna Tracking Mount, reduce its life expectancy, or cause any malfunction, either when the unit is powered or when it is not.

b. No sequence of command shall damage the Satellite Antenna Tracking Mount, reduce its life expectancy, or cause any malfunction.

Rationale: By design, should limit the chance of damage or malfunction by user/technician error.

3.2.4.2 Power Consumption

a. The maximum peak power of the system shall not exceed 50 watts.

Rationale: This is because the motors will consume a maximum of 48 watts. The Arduino board will consume a maximum of 1.8 watts.

3.2.4.3 Input Voltage Level

The input voltage level for the Satellite Antenna Tracking Mount will be +9 VDC for the Arduino UNO board and +24 VDC for the L298N motor driver input.

Rationale: The Arduino UNO board has an input voltage operating range of 7-12 VDC and the L298N motor driver has an input voltage operating range of 7-35 VDC. The motors themselves require 24 VDC in order to operate.

3.2.4.4 Input Noise and Ripple

The input noise and ripple for the Satellite Antenna Tracking Mount shall operate while in the presence of a 1.5 Volt RMS ripple superimposed on the steady-state voltage over the frequency range of 0 Hz to AC.

Rationale: Aircraft bus specification compatibility, MIL-STD-704F

3.2.4.5 External Commands

The Satellite Antenna Tracking Mount shall document all external commands in the appropriate ICD.

Rationale: The ICD will capture all interface details from the low level electrical to the high-level packet format.

3.2.5 Outputs

3.2.5.1 Data Output

The Satellite Antenna Tracking Mount outputs the azimuth and elevation of the antenna to the web application, as well as the GPS location of the system.

Rationale: The Satellite Antenna Tracking Mount information passes directly to the customer's system.

3.2.5.2 Diagnostic Output

The Satellite Antenna Tracking Mount outputs the azimuth and elevation information in order to show any errors in the tracking output.

Rationale: Provides the customer with the information to adjust the antenna's mounting location.

3.2.5.3 Connectors

The Satellite Antenna Tracking Mount will use external connectors to interface with the customers Yaesu-G5500.

Rationale: This is a requirement specified by our customer due to constraints of their system in which the Satellite Antenna Tracking Mount is integrating into.

3.2.5.4 Wiring

The Satellite Antenna Tracking Mount shall follow the guidelines outlined in MIL-HDBK-5400 paragraph 4.3.35 Wire and cable.

Rationale: Conform to aircraft standard.

3.2.6 Failure Propagation

The Satellite Antenna Tracking Mount System shall not allow propagation of faults beyond the Satellite Antenna Tracking Mount System interface.

3.2.6.1 Failure Detection, Isolation, and Recovery (FDIR)

3.2.6.2 Built In Test (BIT)

The Satellite Antenna Tracking Mount will have a heartbeat signal talking to the web application so verification can be made if any packets are dropped in communication.

3.2.6.3 BIT Critical Fault Detection

The BIT shall be able to detect a critical fault in the Satellite Antenna Tracking Mount 95 percent of the time.

> *Rationale: This is a requirement specified by our customer due to constraints of their system in which the Satellite Antenna Tracking Mount is integrating.*

3.2.6.4 BIT Log

The BIT shall save the results of each run into a log so the customer can view previous data points and keep a track of the satellites they have tracked.

> *Rationale: This is a requirement specified by our customer due to constraints of their system in which the Satellite Antenna Tracking Mount is integrating.*

4. Support Requirements

4.1 Web Browser

Modern web browser with support for JavaScript, CSS, HTML5, and web graphics.

4.2 Wifi Connection

Minimum Download Speed: 10Mbps
Minimum Upload Speed: 5Mbps
Latency < 100ms

4.3 120V 60Hz Power Outlet

Standard NEMA 5-15 outlet with 15 A capacity and maximum power delivery of 1800 watts. GFCI protection for outlets near water sources. Electrical standards and codes can vary by state or local jurisdiction, so it is important to check the specific regulations in the area where the wall outlet will be installed.

Appendix A: Acronyms and Abbreviations

BIT	Built-In Test
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
GPS	Global Positioning System
Hz	Hertz
ICD	Interface Control Document
kHz	Kilohertz (1,000 Hz)
LCD	Liquid Crystal Display
LED	Light-emitting Diode
mA	Milliamp
MHz	Megahertz (1,000,000 Hz)
mW	Milliwatt
PCB	Printed Circuit Board
SATM	Satellite Antenna Tracking Mount
MCU	Micro Control Unit
NASA	National Aeronautics and Space Administration
HTTP	Hypertext Transfer Protocol
API	Application Programming Interface
AWS	Amazon Web Services
VDC	Voltage Direct-Current
RST	Readability Strength Tone
SNR	Signal to Noise Ratio

Satellite Antenna Tracking Mount

Hunter Britton
Michael Raabe
David Santos

INTERFACE CONTROL DOCUMENT

REVISION – 1.0
17 February 2023

Interface Control Document
for
Satellite Antenna Tracking Mount

Prepared by:

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Author Date

Approved by:

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Hunter Britton Date

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Prof. S. Kalafatis Date

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Pranav Dhulipala Date

Change Record

Rev.	Date	Originator	Approvals	Description
-1.0	2/21/2023	David Santos		Draft Release

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1. Overview

This document will show how the web application, power supply, and MCU subsystems will interface with each other. It will list all possible inputs, outputs, and how the system will manage each. First, an explanation of the inputs from the web application and how it is transferred to the MCU will be detailed. A description of how the power supply will be implemented, and how the MCU interfaces with the power supply subsystem will follow.

2. References and Definitions

2.1. References

Refer to section 2.2 of the Functional Systems Requirement document.

2.2. Definitions

W	Watt
A	Amp
mA	Milliamp
mW	Milliwatt
TBD	To Be Determined
g	Grams

3. Physical Interface

3.1. Weight

3.1.1 Main Control Unit

Component	Weight	Number of Items	Total Weight
Arduino Uno Board	25 g	1	25 g
ESP8266	1.72 g	1	1.72 g
NEO-6M	22 g	1	22 g
4x20 LCD Display	76 g	1	76 g

Table 1: Main Control Unit Weight

3.1.2 Power Supply Unit

Component	Weight	Number of Items	Total Weight
Power Supply Board	TBD	1	TBD
AC-DC Converter	TBD	1	TBD
DC-DC Boost Converter	TBD	1	TBD
Output Port	TBD	2	TBD

Table 2: Power Supply Unit Weight

3.2. Dimensions

Dimensions are in millimeters.

3.2.1. Dimensions of MCU Subsystem

Component	Length	Width	Height
Arduino UNO Board	68.6 mm	53.4 mm	24.9 mm
LCD Display	20 mm	4 mm	N/A

Table 3: MCU Dimensions

3.2.2 Dimensions of Power Supply Subsystem

Component	Length	Width	Height
Power Supply Board	TBD	TBD	TBD

Table 4: Power Supply Dimensions

3.3. Mounting Locations

The Satellite Antenna Tracking Mount (SATM) should be able to be used anywhere on Earth, but will most likely be deployed in various locations around College Station, Texas. The MCU will be attached by wires to the antenna mount, but the MCU box itself will be mounted directly below the antenna mount. The power supply will be plugged into a wall outlet (most likely with an extension cord), and then the outputs of the power supply will plug directly into the MCU box.

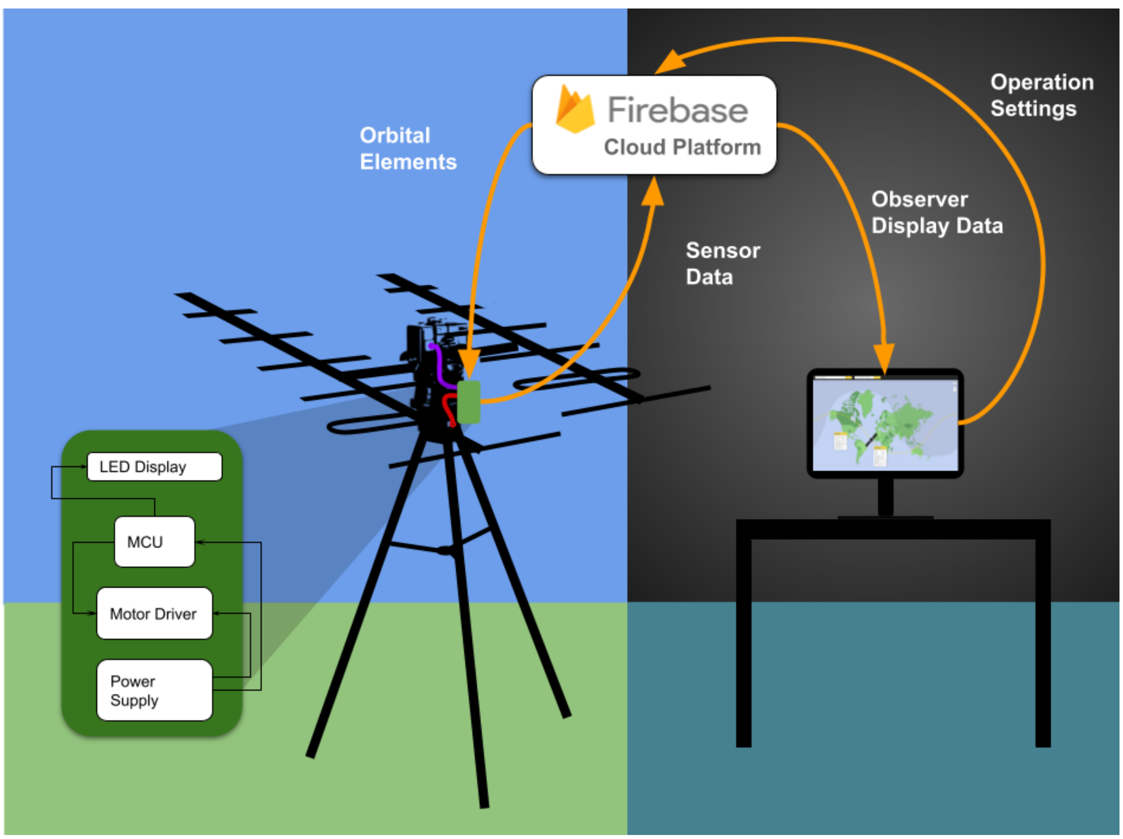

Figure 1: Satellite Antenna Tracking Mount System

4. Thermal Interface

The L298N motor driver has a built-in heat sink. There is also a built-in heat sink for the MCU (Arduino UNO). Also, to prevent overheating of the antenna mount, the gearbox will need to be lubricated.

5. Electrical Interface

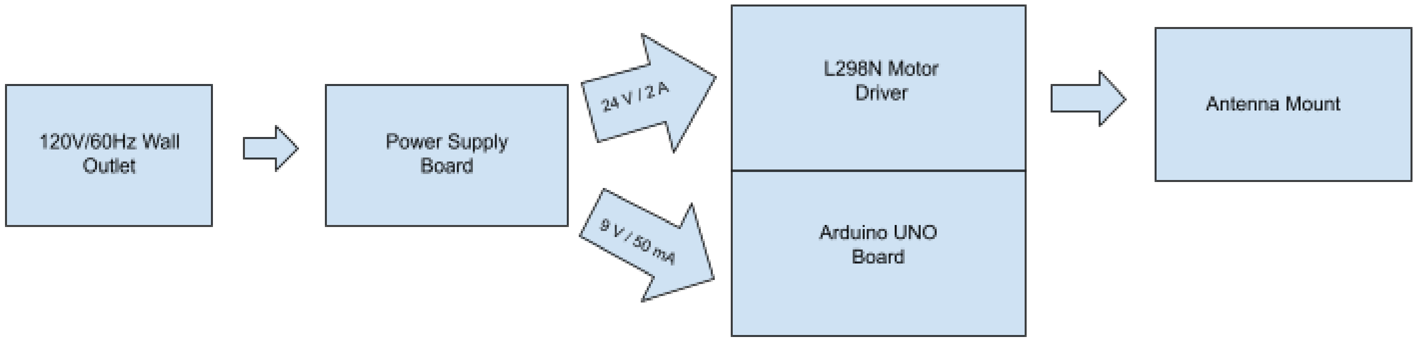

Figure 2: Electrical Interface Diagram

5.1. Primary Input Power

5.1.1 Main Control Unit

The MCU will be powered by the power supply board and will take 9V at 50 mA. It will consume a maximum of 1.8 watts of power.

5.1.2 L298N Motor Driver

The motor driver will be powered by the power supply board and will take 24V at 2A. The two motors together will consume a maximum of 48 watts of power.

5.2. Voltage and Current Levels

5.2.1 Maximum Values

Component	**Voltage**	**Current**	**Power**
Arduino UNO	9 V	≤ 200 mA	1.8 W
L298N Motor Driver	24 V	≤ 2 A	48 W

Table 5: Maximum Electrical Values

The values in table 5 allow for gauging how much power the system will use, per second, at peak power consumption. It is estimated that the system will be at peak power most of the time because the motors will be running constantly to track the satellite.

6. Communications / Device Interface Protocols

6.1. Wireless Communications (WiFi)

Using IEEE 802.11ac the Satellite Antenna Tracking Mount will connect to a user's device and network to upload and download data.

6.2. Device Peripheral Interface

The device will have custom connectors to send a digital signal to the customers existing system in order to control the motors on the existing system.

Satellite Antenna Tracking Mount

Hunter Britton
Michael Raabe
David Santos

Schedule And Validation

REVISION – Final
7 February 2023

Schedule:

Work	**End Date**	**Owner**	**Status**	**Date Completed**
Concept of Operations	02/13/2023	All		
Functional System Requirements	02/22/2023	All		
Interface Control Document	02/22/2023	All		
Midterm Presentation	03/01/2023	All		
Sponsor Specification Approval	03/01/2023	All		
Parts ordered	03/01/2023	Hunter, Michael		
First Milestone	03/03/2023	All		
Subsystem Circuit Design	03/05/2023	All		
Learn Arduino IDE	03/06/2023	Hunter		
Web App Wireframe	03/06/2023	David		
Setup Satellite Catalog Database	03/08/2023	David		
Arduino as Access Point	03/10/2023	Hunter		
Create Interactive Mercator Projection	03/15/2023	David		
GPS Location Services working	03/15/2023	Hunter		
Second Milestone	03/20/2023	All		
Status Update	03/29/2023	All		

Completed circuit drawing for power supply	03/30/2023	Michael		
Microcontroller/GPS location to satellite Math	03/30/2023	Hunter		
Web App Microcontroller Connection		Hunter/David		
Web App Data Visualization		David		
Power Supply PCB Assembled	03/31/2023	Michael		
Validate Power Supply Output	04/01/2023	Michael		
Verify Web App is Iron Clad	4/01/2023	David		
Validate Microcontroller can send output signals	04/03/2023	Hunter		
Third Milestone	04/03/2023	All		
LED display done	04/05/2023	Hunter		
Microcontroller PCB Done	04/05/2023	Hunter		
Finalize Web App Interface/Features	4/10/2023	David		
Microcontroller PCB Assembled	04/12/2023	Hunter		
Finish final presentation preparation	04/17/2023	All		

Work on Subsystem presentations	04/17/2023	All		
Work on Report	04/17/2023	All		
Final Presentation	04/17/2023	All		
Finish Subsystem presentations	04/23/2023	All		
Subsystem Presentation	04/24/2023	All		
Finish Final Report	04/26/2023	All		
Final Report	04/29/2023	All		

Validation Plan:

Task	**Specification**	**Result**	**Owner**
Signal Strength	SNR >= 30dB		All
RST Report	R5S5T5		All
Azimuth Accuracy	+- 4%		All
Tracking Speed	2 deg/sec		All
Power Supply to Motors	48 Watts		Michael
Power Supply to Microcontroller	1.8 Watts		Michael
Microcontroller Motor Control output	Continuous Signal for 6 minutes		Hunter

Microcontroller GPS location	Accurate location within 20 meters		Hunter
Microcontroller as Access Point	Be accessible to various devices		Hunter
Web Application pull Satellite data	Satellites listed		David