System Test Plan

For

Microwave Tracking Ground Station

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Version/Author	Date
V1 - All team members	10/24/2023
V2 - IW, CE, JO	12/05/2023
V3 - JO, CO, IW	2/25/2024
V4 - JO	4/14/2024

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Introduction

1.1 Purpose

This document presents the test plan for the Microwave Tracking Ground Station System. The purpose of this test plan, crafted by the System Testing team, is to establish a comprehensive testing strategy and approach that systematically evaluates the entire system's functionality and performance. Our primary objective is to rigorously verify that the system aligns with the defined business requirements, ensuring its readiness for deployment. This test plan serves as a guiding framework for testing activities, ensuring that the ground station receiver and the broader system meet the standards expected by our organization and its stakeholders.

1.2 Objectives

- Meets the requirements, specifications and the Business rules.
- Supports the intended business functions and achieves the required standards.
- Satisfies the Entrance Criteria for User Acceptance Testing.

2. Functional Scope

The Modules in the scope of testing for the Microwave Tracking Ground Station System Testing are listed as such:

The functional scope of the receiver system encompasses the following components and their interactions, which collectively work to maintain the alignment of an antenna with a satellite using azimuth and elevation control:

1. **Antenna Control System**
The system includes two motors responsible for controlling the azimuth and elevation angles of the dish antenna. The antenna control system maintains alignment with a target satellite by adjusting the angles based on incoming tracking data.

2. **Software Interface**
A software application on a connected computer serves as the central control unit. It facilitates the following functionalities:

a. Input Handling
The software accepts user inputs for the ground station location and satellite tracking information, including orbital data, satellite coordinates, and tracking algorithms.

b. Data Processing
The software processes the input data to calculate the required azimuth and elevation angles for the antenna to stay aligned with the target satellite.

c. Signal Generation
It generates signals that are sent to the motor controller to adjust the antenna's position.

3. **SDR (Software-Defined Radio)**
The SDR serves as an intermediary component responsible for receiving signals picked up by the dish antenna. It connects to the computer and enables signal reception and data transmission between the antenna and the software application.

4. **Motor Controller**
The motor controller receives control signals from the software application and translates them into motor movements. It is responsible for physically adjusting the azimuth and elevation angles of the dish antenna

in real-time.

5. **Alignment Maintenance**
The core functionality of the system is to ensure the continuous alignment of the antenna with the target satellite. This is achieved through precise control of the two motors based on tracking data and real-time feedback.

6. **User Interaction**
The system provides user interfaces for inputting ground station location and satellite tracking information, allowing users to configure and monitor the alignment process. User-friendly interfaces enable easy setup and adjustment.

7. **Communication**
The system facilitates the exchange of data and control signals between the computer software, SDR, and motor controller to ensure accurate and efficient antenna alignment.

8. **Feedback Mechanism**
A feedback loop mechanism is incorporated to monitor and report the status of the antenna's alignment. Any discrepancies or deviations from the target satellite's position trigger adjustments in real-time.

9. **Safety Mechanisms**
The system includes safety features to prevent collisions or damage to the antenna, motors, or any other components in the event of unexpected events or errors.

10. **Logging and Reporting**
The system generates logs and reports to document its operation, including any deviations, errors, or adjustments made during the alignment process. These logs aid in troubleshooting and maintenance.

This functional scope encompasses the key elements and interactions of the receiver system, which collectively enable the precise alignment of a dish antenna with a satellite through azimuth and elevation control, utilizing software, an SDR, and motor control mechanisms.

3. Overall Strategy and Approach

3.1 Testing Strategy

Microwave Tracking Ground Station System Testing will include testing of all functionalities that are identified in the functional scope (Section 2). System testing activities will include the testing of new functionalities, modified functionalities, screen level validations, work flows, functionality access, testing of internal & external interfaces.

The testing for the ground station encompasses a comprehensive approach to validate the system's functionality, performance, and safety. This strategy includes a range of testing types, such as functional, integration, user interface, safety, and performance testing, to ensure the seamless operation of key components, including the antenna, software interface, SDR, and motor controller. Real-time tracking capabilities and frequency versatility are thoroughly examined to ensure the system's reliability in various operational scenarios. With a strong focus on safety mechanisms, error handling, and user acceptability, the strategy aims to deliver a thoroughly tested system that maintains alignment with moving satellites while safeguarding against unexpected events. The use of a carefully curated set of test data and a representative test environment ensures that the system is evaluated under conditions closely resembling actual operational setups. Through meticulous documentation, issue tracking, and compliance with predefined test completion criteria, this testing strategy aims to guarantee a high level of confidence in the ground station's readiness for operational use.

3.2 System Testing Entrance Criteria

In order to start system testing, certain requirements must be met for testing readiness. The readiness can be classified into:

1. **Antenna Readiness**
   The antenna testing readiness requirement is defined as the stage at which all necessary preparations, including the assembly and calibration of the antenna equipment and establishment of a stable testing environment have been successfully completed. It signifies that the antenna is fully equipped and configured for testing, and all prerequisites for conducting functional, performance, and safety testing have been met.
2. **Positioning Motors Readiness**
   The positioning motors readiness requirement is defined as the phase in the testing process where the positioning motors, responsible for controlling the antenna's azimuth and elevation angles, have been meticulously inspected, calibrated, and integrated. The motors are considered fully prepared for testing, and all necessary arrangements, including electrical connections and safety measures, are in place. This readiness state signals that the motors are poised for operational testing, where they will be evaluated for their accuracy, responsiveness, and reliability in maintaining the antenna's alignment with a satellite.
3. **Motor Controller Readiness**
   The motor controller readiness requirement is defined as the point at which the motor controller unit is fully configured, interconnected, and prepared for operational testing. In this state, the motor controller has undergone comprehensive calibration, is successfully communicating with the software interface, and is capable of translating control signals into precise motor movements. The motor controller is ready for comprehensive testing to validate its functionality and accuracy in responding to commands, thereby ensuring its role in maintaining antenna alignment with a satellite.
4. **SDR Receiver Readiness**
   The SDR Receiver readiness requirement is where the receiver component is fully prepared for operational testing. This encompasses the verification of the SDR's proper integration into the system, successful establishment of communication with the connected computer, and confirmation of its ability to receive signals from the dish antenna. The SDR receiver is calibrated, configured, and checked to ensure that it accurately and efficiently captures incoming signals. This signals that the SDR receiver is ready for thorough testing, where its signal reception capabilities and data transmission to the computer software can be evaluated.
5. **SDR Software Readiness**
   The SDR Software readiness requirement indicates that the SDR software is fully prepared for operational testing. In this state, the SDR software has been successfully installed and configured on the connected computer. It is capable of receiving signals from the SDR receiver and processing these signals for further analysis. This also encompasses the validation of communication between the SDR software and the SDR receiver, ensuring that data is transmitted and received accurately.
6. **Satellite Tracking Software Readiness**
   The Satellite Tracking Software readiness requirement requires that the software responsible for tracking and controlling antenna alignment is fully prepared for operational testing. In this state, the tracking software is installed, configured, and interconnected with the motor controller. It successfully processes input data related to ground station location and satellite tracking information, generating accurate control signals. This requirement encompasses the validation of communication between the tracking software and the motor controller, ensuring that control commands are transmitted and executed correctly.
7. **Tracking System Readiness**
   The Tracking System readiness requirement represents a pivotal phase in the testing process, indicating the full preparedness of the entire tracking system, consisting of the tracking software, motor controller, and positioning motors, to function cohesively as an integrated unit. In this state, all components are configured and interconnected to ensure seamless operation. The tracking software processes data for satellite tracking, generates precise control signals, and successfully communicates with the motor controllers, which, in turn, accurately guide the positioning motors to adjust the antenna's azimuth and elevation angles. This readiness state ensures that the tracking system works harmoniously together and is ready for comprehensive testing, verifying its collective ability to track satellites and maintain precise alignment, instilling confidence in the system's

operational reliability.

8. **Receiving System Readiness**
The Receiving System readiness requirement signifies the complete preparedness of the entire receiving system, comprising the antenna, Software-Defined Radio, and SDR software, to function cohesively as an integrated unit. All components are configured and interconnected to ensure seamless operation. The antenna captures signals, the SDR efficiently receives and processes these signals, and the SDR software communicates with the SDR to ensure accurate signal processing. This readiness requirement ensures that the receiving system works harmoniously together and is prepared for comprehensive testing, verifying its collective ability to receive, process, and interpret signals from the antenna.

9. **Full System Readiness**
The Full System readiness requirement marks the ultimate phase in our testing process, demonstrating that the integrated system, combining both the tracking and receiving systems, is fully prepared for comprehensive testing. At this point, both systems are configured and interconnected to function together seamlessly. The tracking system handles all processes for maintaining antenna alignment, and the receiving system captures and processes satellite signals. This readiness state ensures that the entire system is set for rigorous testing, confirming its collective capability to simultaneously track and receive satellite signals, with the ultimate objective of reliable satellite signal reception.

3.3 Testing Types

3.3.1 Usability Testing

Software Ease of Use

Usability testing on the software side of the project primarily focuses on assessing the user-friendliness and efficiency of the tracking and receiving system's interfaces. This involves evaluating the ease with which users can input ground station locations, satellite tracking data, and other parameters. The goal is to ensure that the software components offer an intuitive and seamless experience, allowing users to interact with the system effortlessly. Test scenarios will include typical user tasks, such as inputting coordinates, initiating tracking, and adjusting system settings. Any difficulties or points of confusion will be identified, leading to refinements in the software to enhance user-friendliness and overall system usability.

System Requirements Specification, 4.2.3.1: The system shall use inputted TLE elements to calculate orbit along with azimuth and elevation.

System Requirements Specification, 4.2.3.3: The system shall use inputted longitude and latitude to calculate azimuth and elevation relative to the current location of the ground station on Earth.

System Requirements Specification, 4.2.3.4: The software shall update the satellite's position in real-time based on the current date and time.

System Requirements Specification, 4.2.3.7: The software shall provide an interface for users to input satellite data, view calculated positions, and configure system settings.

System Requirements Specification, 4.2.3.9: Implement error detection and reporting mechanisms to alert users in case of invalid input data, calculation errors, or communication issues with external data sources.

Physical System Attributes

Usability testing for the physical aspects of the system encompasses evaluating the practicality of deploying and operating the tracking and receiving system in real-world conditions. This entails assessing factors like system size, weight, and overall ergonomics to ensure that the system is manageable and safe for users to install and operate. Test scenarios will include tasks related to system setup, motor movement, and emergency stop procedures to assess whether users can handle the system comfortably and safely. Any identified issues related to size, weight, or physical usability will be addressed through design modifications or recommendations, aiming to optimize the system's overall user experience and safety during deployment and operation.

System Requirements Specification, 4.1.3.1: The system shall be capable of activating and deactivating the Antenna and Dish based on user initiation.

System Requirements Specification, 4.1.3.2: The Antenna shall be adjustable based on user input for direction and angle.

System Requirements Specification, 4.1.3.5: In case of signal loss, the system shall provide feedback to the user and attempt to reconnect.

System Requirements Specification, 4.1.3.6: The Antenna and Dish shall be weather-resistant to ensure reliable operation under varying conditions.

System Requirements Specification, 4.1.3.7: The system shall have a manual override for the Antenna in case of automated system failure.

3.3.2 Functional Testing

Functional testing encompasses a meticulous evaluation of all six subsystems, ensuring that the groundstation aligns with the product owner's specified requirements. This rigorous process confirms that the system effectively performs its fundamental functions in a synchronized and precise manner. It encompasses testing the antenna alignment system to ascertain accurate azimuth and elevation adjustments for satellite tracking, validating the tracking software's capacity to calculate and transmit precise control signals, examining motor controllers for the accurate interpretation of control signals and safe motor movements, and testing the antenna, SDR Receiver, and Software for reliable signal reception and processing. At the system level, functional testing evaluates the collective functionality of all subsystems, guaranteeing that the entire system works cohesively to meet the product owner's specifications, providing accurate satellite tracking, reliable signal reception, and all necessary safety measures. Any identified discrepancies are addressed to ensure that the system delivers the necessary functionality and safety for dependable operational use.

System Requirements Specification, 4.3.3.1: The system shall have an angle of resolution smaller than 1 degree.

System Requirements Specification,4.3.3.2: The system shall have an accuracy greater than +/- 0.06 degrees within the set angle.

System Requirements Specification, 4.3.3.5: The system shall be able to hold 30kg of vertical load at all angles of elevation between 0-1800.

System Requirements Specification, 4.3.3.6: The system shall be able to rotate 360 degrees of azimuth.

System Requirements Specification, 4.3.3.7: The system shall be able to rotate 180 degrees of elevation.

3.4 Suspension Criteria and Resumption Requirements

This section will specify the criteria that will be used to suspend all or a portion of the testing activities on the items associated with this test plan.

3.4.1 Suspension Criteria

Testing will be suspended if the incidents found will not allow further testing of the system/application under-test. If testing is halted, and changes are made to the hardware, software or database, it is up to the Testing Manager to determine whether the test plan will be re-executed or part of the plan will be re-executed.

3.4.2 Resumption Requirements

Resumption of testing will be possible when the functionality that caused the suspension of testing has been retested successfully.

4. Execution Plan

4.1 Execution Plan

The execution plan details the test cases to be executed, ensures that all the requirements are covered, and can accommodate some changes if necessary. All the test cases of the projects under test in this release are arranged in a logical order depending upon their inter dependency.

Requirement (From SRS)	Test Case Identifier	Input	Expected Behavior	Pass/Fail
4.2.3.1: The system shall use inputted TLE elements to calculate orbit along with azimuth and elevation.	2.3.1.1	Stored TLE Elements, run orbit algorithm	Output coordinates of the satellite along its entire visible orbit.	Pass
4.2.3.2: The system shall send the chosen satellite’s degrees of azimuth and elevation to the positioner every 0.1 seconds.	2.3.2.1	Run orbit algorithm	Updated azimuth and elevation sent at at least 10 Hz refresh rate.	Pass
4.2.3.3: The system shall use inputted GPS coordinates to calculate azimuth and elevation relative to the current location of the ground station on Earth.	2.3.3.1	GPS coordinates, run orbit algorithm	Output azimuth and elevation of satellite along its entire visible orbit.	Pass
4.2.3.4: The software shall update the satellite's position in real-time based on the current date and time.	2.3.4.1	Algorithm is ran	Exact position of the satellite with current date and time are outputted to the user.	Pass
4.2.3.5: The system shall	2.3.5.1	Algorithm is ran	Algorithm outputs are within	Pass

employ algorithms to accurately predict the satellite's future positions over a specified time range.			.05% of verified true values.	
4.2.3.6: The system shall determine the voltage levels required for the antenna positioner motors to achieve the calculated azimuth and elevation angles.	2.3.6.1	Desired azimuth and elevation	System makes calculations and determines the necessary signals to correct the antenna alignment.	N/A due to computer controller connecti-on error
4.2.3.7: Provide a user-friendly interface for users to input satellite data, view calculated positions, and configure system settings.	2.3.7.1	Open tracking software	Display a menu with options to input new TLE elements, view orbits, and view and change settings.	Pass
4.2.3.8: The system shall display real-time information such as current satellite position, azimuth, and elevation.	2.3.8.1	Algorithm is ran	GUI displays current satellite position, azimuth, and elevation refreshed at atleast 10 Hz.	Pass
4.2.3.9: Implement error detection and reporting mechanisms to alert users in case of invalid input data, calculation errors, or communication issues with external data sources.	2.3.9.1	User inputs invalid data such as “AJFHS” for a TLE element	Error message is displayed to the user and data for that entry is not stored. No orbit path is displayed.	Pass
4.1.3.1: The system shall be capable of activating and deactivating the Antenna and Dish based on user initiation.	1.3.1.1	User inputs activation and deactivation codes for antenna operation	The antenna activates when told to and deactivates when told to.	Pass
4.1.3.2: The Antenna shall be adjustable based on user input for direction and angle.	1.3.2.1	User inputs desired angle and direction for antenna operation	The antenna aligns with the input parameters within 0.5 degree	N/A due to computer controller connecti-on error
4.1.3.3: The system shall have built-in algorithms to automatically optimize the Antenna position for signal reception.	1.3.3.1	Tracking algorithm is run	System corrects to the optimal direction when the signal becomes weaker at the directed location.	Pass

4.1.3.4: The system shall monitor signal quality in real-time and adjust Antenna parameters to mitigate interference.	1.3.4.1	Input signal	System displays input signal waveforms. Certain tracking parameters can be adjusted by the user.	N/A due to computer controller connecti-on error
4.1.3.5: In case of signal loss, the system shall provide feedback to the user and attempt to reconnect.	1.3.5.1	System sends error message to display and sends code to start reconnection process	The system displays an error message on screen and informs the user that the reconnection process has begun.	Pass
4.1.3.6: The Antenna and Dish shall be weather-resistant to ensure reliable operation under varying conditions.	1.3.6.1	User deploys ground station in multiple weather conditions	The ground station performs as expected under all deployed weather conditions.	Untested
4.1.3.7: The system shall log and report any issues related to the Antenna and Dish for maintenance purposes.	1.3.7.1	Input signal	Extreme signal issues and errors saved in .txt log file.	Untested
4.3.3.1: The system shall have an angle of resolution smaller than 1 degree.	3.3.1.1	Attach a laser to the system and command it to point at a wall, increment command and measure change.	Use multiple points and math to determine the angle of resolution is smaller than a degree.	Untested
4.3.3.2: The system shall have an accuracy greater than +/- 0.06 degrees within the set angle.	3.3.2.1	Attach laser to system and command it to point at a specific point multiple times	The laser is always within +/- 0.06 degrees of the desired point	Untested
4.3.3.3: The system shall have an azimuth rotation speed greater than 6.2 deg./sec.	3.3.3.1	Max azimuth speed signal	Timed revolution shall be less than 58.1 sec.	Pass
4.3.3.4: The system shall have an elevation rotation speed greater than 2.69 deg./sec.	3.3.4.1	Max elevation speed signal	Timed 180 degree rotation shall be less than 67.1 sec.	Pass
4.3.3.5: The system shall be able to hold 30kg of vertical load at all angles of elevation between 0-180 degrees.	3.3.5.1	A dummy load that weighs 30 kg is loaded onto the positioner and then moved between all angle of elevation	The system withstands the stress of 30 kg in all positions of elevation and azimuth while moving at required speeds	Pass

4.3.3.6: The system shall be able to rotate 360 degrees of azimuth.	3.3.6.1	The user rotates the system through all 360 degrees of azimuth	The system is accurately able to cycle all 360 degrees of azimuth in either direction	Pass
4.3.3.7: The system shall be able to rotate 180 degrees of elevation.	3.3.7.1	The user rotates the system through all 180 degrees of elevation	The system is accurately able to cycle all 180 degrees of elevation in either direction	Pass
4.3.3.8: The system shall weigh less than 20kg.	3.3.8.1	The system is weighed	The scale shall read less than 20kg.	Pass
4.3.3.9: The system shall remain still against 5kg of horizontal force.	3.3.9.1	A horizontal force of 5kg shall be applied to the antenna mount	Any significant deflection or shifting shall result in failure	Pass
4.3.3.10: The system shall have a manual override for the positioner in case of automated system failure.	3.3.10.1	User initiates the manual override for the positioner.	The positioner responds to manual inputs for positioning	Pass

5. Traceability Matrix & Defect Tracking

5.1 Traceability Matrix

List of requirement, corresponding test cases

Requirement **CRITICAL**: System requirements Specification, 4.3.3.10: “The system shall have a manual override for the positioner in case of automated system failure.”

Test Cases: Check that the manual override function responds immediately to manual inputs

Requirement **CRITICAL**: System requirements Specification, 4.2.3.4: “The software shall update the satellite's position in real-time based on the current date and time.”
Test Cases: The algorithm is run and the exact position of the satellite with current date and time are outputted to the user.

Requirement **CRITICAL**: System requirements Specification, 4.3.3.6: “The system shall be able to rotate 360 degrees of azimuth.”
Test Cases: The user inputs are run and and system actively cycles through all 360 degrees of azimuth

Requirement **CRITICAL**: System requirements Specification, 4.3.3.7: “The system shall be able to rotate 180 degrees of elevation.”
Test Cases: The user inputs are run and and system actively cycles through all 180 degrees of elevation

Requirement **CRITICAL**: System requirements Specification, 4.2.3.1: “The system shall use inputted TLE elements to calculate orbit along with azimuth and elevation.”
Test Cases: Input TLE Elements into orbit algorithm and validate correct timing, azimuth, and elevation coordinates of the satellite along its entire visible orbit.

***Requirement* MEDIUM**: System requirements Specification, 4.2.3.3: The system shall use inputted GPS coordinates to calculate azimuth and elevation relative to the current location of the ground station on Earth.
Test Cases: Using GPS coordinates the orbit algorithm accounts for location of the station in determining the visible path of the satellite..

***Requirement* MEDIUM**: System requirements Specification, 4.3.3.5: "The system shall be able to hold 30kg of vertical load at all angles of elevation between 0-180 degrees."
Test Cases: 30 kg is loaded on the positioner and cycled between all angles of elevation and azimuth. The system is stable throughout all of these conditions

5.2 Defect Severity Definitions

Critical	The defect causes a catastrophic or severe error that results in major problems and the functionality rendered is unavailable to the user. A manual procedure cannot be either implemented or a high effort is required to remedy the defect. Examples of a critical defect are as follows: ● System abends ● Data cannot flow through a business function/lifecycle ● Data is corrupted or cannot post to the database
Medium	The defect does not seriously impair system function can be categorized as a medium Defect. A manual procedure requiring medium effort can be implemented to remedy the defect. Examples of a medium defect are as follows: ● Form navigation is incorrect ● Field labels are not consistent with global terminology
Low	The defect is cosmetic or has little to no impact on system functionality. A manual procedure requiring low effort can be implemented to remedy the defect. Examples of a low defect are as follows: ● Repositioning of fields on screens ● Text font on reports is incorrect

6. Environment

6.1 Environment

An open area Environment in Daytona Beach, Fl will be used for System Testing.

6.2 Environment constraints

Time should not be a constraint when running the systems tests but for data all tests will be run within the timeframe of 1-5pm EST.
The open area used for testing must be free of signal blocking material such as very thick concrete.
The open area must have line of sight to sky from the Microwave Ground Tracking station.

7. Assumptions

These are assumptions made directly for this project

AS 7.1: The user is authorized to operate the system
AS 7.2: All data being fed to the GUI for positioning is correct and in the correct file format(.txt)
AS 7.3: The SDR software for signal interpretation is up to date
AS 7.4: The Ground station is receiving the full and correct signal

8. Risks and Contingencies

Define risks and contingencies.

Risk #	Risk	Impact	Contingency plan
1	Signal received is incorrect and or not fully received	High	Ensure the antenna has the correct gain needed to receive the signal and verify the tracking data is being updated accurately and correctly. This would be done before implementation of the system
2	Ground station and positioner are not stable during operation	Moderate	Weight balances will be tested on paper and physically over its full range of motion to ensure the system is stable before use.
3	Unauthorized user operates the system to track satellites	Moderate	All authorized users will be given a secure username and password only known to the said authorized user to ensure its security.