4. Validation

This structured validation approach will ensure that the simulation tool meets its requirements and provides an effective user experience. This section outlines the methods and criteria for validating that the requirements of the simulation tool have been met. The validation process ensures that the system fulfills its intended purpose, providing a comprehensive and engaging user experience.

4.1 Validation Approach

The validation of functional and non-functional requirements will be conducted through a combination of techniques, including:

- **Requirements Review**: Systematic examination of the requirements against the actual implementation to ensure completeness and correctness.
- **Functional Testing**: Execution of test cases derived from the functional requirements to verify that the system behaves as expected.
- **Usability Testing**: Evaluation of the user interface and user experience through user feedback and observation during testing.
- **Performance Testing**: Assessment of system performance under load conditions to ensure it meets the specified performance requirements.

4.2 Validation Criteria

4.2.1 Functional Requirements

Each functional requirement will be validated as follows:

4.2.1.1 Home Page and User Authentication:

- Verify the home page is accessible and visually aligned with design specifications (3.1.1.1).
- Test the authentication window for secure login functionality (3.1.1.2).
- Validate error messages for incorrect login attempts (3.1.1.3) and the functionality of the Guest button (3.1.1.4).

4.2.1.2 Cookie Management:

- Ensure users can manage cookie settings and successfully opt in or out (3.1.2.1-3).

4.2.1.3 Error Handling:

- Simulate server downtime to check the application's response (3.1.3.1).
- Test all specified error conditions to ensure appropriate messaging and functionality (3.1.3.2-3).

4.2.1.4 User Interaction Features:

- Test touch control capabilities on mobile devices (3.1.4.1) and QR code scanning functionality (3.1.4.2).

4.2.1.5 Data Visualization and Simulation:

- Validate the functionality of visualization windows and data readouts during simulations (3.1.5.1-5).
- Ensure realistic rendering and physics simulations work as intended (3.1.5.3-4).

4.2.1.6 Simulation Controls:

- Test the main menu and all control options (3.1.7.1-5) to ensure they function correctly.

4.2.1.7 Error Handling for Configuration and Simulation:

- Validate that appropriate error messages are displayed for invalid inputs (3.1.8.1-2) and simulation errors (3.1.9.1-2).

4.2.1.8 Mission Success and Research Contribution:

- Assess the support for mission execution and research publication features (3.1.10.1-3).

4.2.1.9 Engagement and Learning:

- Evaluate educational features and their impact on user understanding and engagement (3.1.11.1-5).

4.2.1.10 Collaboration Features and Data Compatibility:

- Verify the functionality of sharing features and data compatibility with NASA tools (3.1.12.1, 3.1.13.1).

4.2.2 Non-Functional Requirements

4.2.2.1 Performance Requirements:

- Conduct load testing to confirm responsiveness under multiple simultaneous users (3.2.1.1).

- Measure the home page loading time (3.2.1.2) and real-time updates of settings (3.2.1.3).

4.2.3 Usability Requirements

4.2.3.1 Perform usability testing sessions with diverse user groups to validate that the interface is intuitive and user-friendly (3.2.2.1).

4.3 Validation Activities

1. **Test Planning**: Develop a comprehensive test plan detailing test case, test data, and success criteria based on the requirements outlined.
2. **Test Execution**: Conduct the tests as per the test plan, documenting outcomes and identifying any discrepancies from expected behavior.
3. **Review and Reporting**: Compile a validation report summarizing findings, including any issues encountered, resolutions, and areas for improvement.
4. **User Feedback**: Gather feedback from actual users during usability testing to refine the application further based on their experiences and suggestions.

4.4 Acceptance Criteria

The simulation tool will be considered validated and ready for deployment when:

- All critical and high-priority functional requirements are successfully verified.
- Non-functional requirements regarding performance and usability are met.
- User feedback indicates a satisfactory level of engagement and understanding of the system's functionalities.