SOFTWARE REQUIREMENTS SPECIFICATION

NASA Psyche Mission Simulator

CSE 397 Team 3

Requirement specification for the proposed NASA Psyche mission simulator application.
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Contents

Software Requirements Specification (SRS) Document for NASA Psyche Mission Simulator

1. Introduction

1.1 Purpose

This Software Requirements Specification (SRS) document outlines the requirements for a web-based spacecraft simulator designed to imitate the approach to, landing on, and mining of the asteroid Psyche. The simulator aims to facilitate mission planning for scientists and engineers while providing educational resources for a broader audience.

1.2 Scope

The simulator will allow users to visualize spacecraft dynamics, landing strategies, and mining operations on Psyche. It will cater to various user groups, including NASA personnel and the general public, to enhance understanding and support future sample mining mission planning.

1.3 Definitions, Acronyms, and Abbreviations

- **SRS:** Software Requirements Specification
- **NASA:** National Aeronautics and Space Administration
- **UI:** User Interface
- **API:** Application Programming Interface

1.4 References

- NASA's Psyche mission documentation
- Academic papers on asteroid mining and spacecraft dynamics
- Web Content Accessibility Guidelines (WCAG) for usability standards

1.5 Overview

The remaining sections of this document detail the overall product description, specific requirements (functional and non-functional), use cases, and other necessary details to guide the development and implementation of the spacecraft simulator.

1.6 Elicitation Identifiers

The following identifiers signify which elicitation methods were used to determine requirements and will follow the requirement in parentheses:

- B – Brainstorming
- CS – Card Sorting
- I – Introspection
- P – Profiles
- SC – Scenarios
- TA – Task Analysis

1.7 Feature priority

Each requirement will have one of the following priority levels. The priority reflects the feature's implementation need. The priority level will follow the elicitation techniques after each requirement in square brackets.

- Critical – It is vital the feature be implemented for application functionality.
- High – The feature implementation may be delayed, but must be functional prior to first release build.
- Normal – This feature may be delayed for a future release build.
- Low – The feature is not necessary for full functionality, but is a requested feature for a future release.

2. Overall Description

2.1 Product Perspective

The NASA Psyche Type-M asteroid mission simulator will be a standalone web application accessible through modern web browsers. It will ultimately utilize advanced physics and graphics engines to provide realistic simulations of spacecraft operations and mining techniques on Psyche.

2.2 Product Functions

- Simulate approach trajectories, landing maneuvers, and sample mining operations.
- Visualize mining operations and evaluate extraction techniques.
- Allow users to manipulate spacecraft parameters such as thrust, angle, and speed.
- Provide real-time data feedback and analysis based on user-defined scenarios.

2.3 User Classes and Characteristics

NASA Engineers: Require precise simulations for mission planning and design validation.

NASA Managers: Seek insights into project feasibility and resource allocation.

NASA Public Affairs Personnel: Need to communicate mission objectives to the public effectively.

Spacecraft Industry Engineers: Focus on design assessments and technology evaluation.

Scholars and Researchers: Require data for studies on asteroid characteristics and mining feasibility.

Mining Experts: Assess potential resource extraction methods and efficiencies.

Science Teachers: Use the simulator as an educational tool for teaching space science concepts.

General Public: Engage with simplified simulations for educational and recreational purposes.

2.4 Constraints

- A stable internet connection is required to access the simulator.
- The application must be compatible with major web browsers (Chrome, Firefox, Edge).
- Compliance with NASA’s security and data management protocols is mandatory.

3. Specific Requirements

This requirements section outlines the necessary functionalities and user interactions for the simulation tool, based on the data derived from the elicitation techniques of brainstorming sessions, introspection, card sorting, profiles, scenarios, and task analysis, ensuring a comprehensive and engaging user experience.

3.1 Functional Requirements

3.1.1 Home Page and User Authentication

3.1.1.1 The system shall provide a home page that serves as the main entry point for users. *(B, I) [Critical]*

3.1.1.2 An authentication window shall allow users to enter a username and password for secure access, shown after a user selects the "Login" button. *(B, I, TA) [Critical]*

3.1.1.3 The system shall display an error message and allow retry if the login credentials are incorrect. *(TA) [Critical]*

3.1.1.4 The system shall provide a "Guest" button for users who wish to access the application without logging in. *(B, TA) [Critical]*

3.1.1.5 The system shall disable unsupported features if the user proceeds as a Guest. *(TA) [High]*

3.1.1.6 The system shall grant access to the main menu upon successful authentication. *(TA) [Critical]*

3.1.2 Cookie Management

3.1.2.1 The system shall allow users to open a card for managing cookie settings, displaying details of data being tracked. *(TA) [Normal]*

3.1.2.2 Users shall have the ability to opt in or out of tracking by selecting toggle options. *(TA) [Normal]*

3.1.2.3 The system shall provide "Accept" and "Decline" buttons for users to confirm their cookie preferences. *(TA) [Normal]*

3.1.3 Error Handling

3.1.3.1 If the web server is down, the system shall notify the user that the application is unavailable and suggest trying again later. *(TA) [Critical]*

3.1.3.2 If login fails, the system shall display an error message with an option to retry. *(TA) [Critical]*

3.1.3.3 If the cookie management card is ignored, the system shall auto-set the user's selection as accepted or declined. *(TA) [High]*

3.1.4 User Interaction Features

3.1.4.1 The system shall support touch control for mobile devices to enhance user interaction. *(B, TA) [Low]*

3.1.4.2 The application shall include QR code scanning capabilities to access space-related photos and resources. *(B, CS) [Low]*

3.1.4.3 The system shall offer different levels of interactivity, ranging from simple to complex, to accommodate varying user preferences. *(B, P) [Low]*

3.1.4.4 The system shall support user's recording and transfer of data whether that be to internal or external storage. *(I, TA) [Low]*

3.1.5 Data Visualization and Simulation

3.1.5.1 The running simulator shall include two visualization windows, one to display data and the second to image the simulated visuals of the spacecraft or rover operations. *(I, B) [Critical]*

3.1.5.2 The system shall include a data readout window displaying the following parameters during the simulation:

- Relative gravity in relation to Psyche
- Distance to Psyche
- Rate of descent
- Angle of descent
- Speed of the spacecraft
- Rate of ascent
- Angle of ascent
- Time elapsed since the beginning of descent
- Current and interim orbit data
- Simple indicators for:
    - Takeoff failure
    - Liftoff failure
    - Sampling failure
    - Landing success
    - Takeoff success
    - Sampling success *(B, I, S, CS) [Critical]*

3.1.5.3 The system shall provide realistic rendering for spaceflight, approach maneuvering, landing, and takeoff simulations, including an animation sequence for more casual visual engagement. *(B, I, CS, TA) [High]*

3.1.5.4 The simulation shall incorporate physics simulation features, enabling 3D movement and rendering of the spacecraft. *(B, TA) [High]*

3.1.5.5 The system shall provide options to toggle graphics settings to optimize performance. *(TA) [Normal]*

3.1.6 Visual Performance

3.1.6.1 All visual components shall operate at a frame speed range of 15-30 frames per second to ensure smooth rendering of a 3D environment across all intended devices. *(I, TA) [Normal]*

3.1.7 Simulation Controls

3.1.7.1 The application shall display a main menu after authentication or guest login occurs, or when a user attempts to save a mission. This will include:

- Load Mission (to load an earlier saved data set)
- Write Mission (to save simulation data - both visuals and parameters)
- Exit
- Dropdown menu having interaction options from simple to expert
- Configure button
- Start button *(TA) [Critical]*

3.1.7.1 The settings menu shall appear if the configuration button is pressed. This will display all simulation parameters, allowing data to be entered by the user. *(TA) [Critical]*

3.1.7.2 Pressing the start button shall begin the simulation using input data if the configure button was selected, otherwise a default data set is used. *(TA) [Critical]*

3.1.7.3 The system shall provide controls for spacecraft or rover operations whenever maneuvering, landing, ascending, descending, or takeoff simulations are being run. *(I) [High]*

3.1.7.4 The system shall provide controls for starting, pausing, stopping, and resuming the simulation. *(B, I, CS, TA) [Critical]*

3.1.7.5 The application shall include spacecraft controls such as thrust, rotation, and other settings, allowing users to program or manipulate the spacecraft prior to beginning or during the simulation. *(B, I, TA) [High]*

3.1.7.6 The system shall feature diverse sampling controls to enable users to select different sampling types and instruments. *(B, I) [Critical]*

3.1.7.7 The system shall support batch simulation control, enabling users to run multiple simulation scenarios in succession. *(I) [Normal]*

3.1.8 Error Handling for Configuration

3.1.8.1 If any input parameters are invalid, the system shall display an error message and ignore the invalid options. *(TA) [Critical]*

3.1.8.2 If the survey mission program is invalid, the system shall display an error message prompting the user to rewrite it. *(TA) [High]*

3.1.9 Error Handling for Simulation

3.1.9.1 If the spacecraft sustains fatal damage, the simulation shall stop with options to restart or adjust parameters. *(TA) [High]*

3.1.9.2 If the survey mission is inoperable due to timing or other issues, the system shall display an error message with adjustment options. *(TA) [High]*

3.1.10 Mission Success and Research Contribution

3.1.10.1 The system shall support users in successfully executing and contributing to the planning of future Psyche missions, from launch to the collection and analysis of samples on the asteroid Psyche. *(P) [High]*

3.1.10.2 The simulation shall provide resources for publishing research findings in high-impact journals and contributing to future NASA missions or programs. *(P) [Low]*

3.1.10.3 The tool shall facilitate engagement with the public and academic communities through science outreach initiatives. *(P) [Normal]*

3.1.11 Engagement and Learning

3.1.11.1 The simulation shall aim to spark curiosity and critical thinking about physical concepts, accommodating various learning styles to maintain student engagement or satisfy a general user's curiosity. *(P) [Low]*

3.1.11.2 The simulation tool shall include resources for publishing research in undergraduate journals and gaining hands-on experience with telescopes and other equipment. *(P) [Low]*

3.1.11.3 The system shall offer educational content designed to deepen students' understanding of physics concepts, metallurgy, and the scientific method of data collection. It should aid in preparing them for standardized exams (e.g., AP, SAT, ACT). *(P, S) [Low]*

3.1.11.4 The system shall include features that allow teachers to customize lessons and track student progress. *(S) [Low]*

3.1.11.5 The simulation shall provide accessible, easy-to-understand explanations of scientific concepts related to the Psyche mission. *(P, S) [Low]*

3.1.12 Collaboration Features

3.1.12.1 The tool shall include features that enable users to share their enthusiasm for space exploration with family, friends, or online communities. *(P, S, TA) [Low]*

3.1.13 Data Compatibility

3.1.13.1 The system shall be compatible with existing NASA software tools to streamline workflows and communication among team members. *(S) [Normal]*

3.2 Non-Functional Requirements

3.2.1 Performance Requirements

3.2.1.1 The system should be responsive and able to handle multiple simultaneous users without performance degradation. *(B) [Normal]*

3.2.1.2 The home page shall load within 3 seconds. *(TA) [High]*

3.2.1.3 Settings adjustments shall update in real-time and save without noticeable delay. *(TA) [Critical]*

3.2.2 Usability Requirements

3.2.2.1 The interface shall be intuitive and user-friendly, accommodating users with varying levels of understanding regarding scientific topics. *(S) [Critical]*

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.

5. Use Cases

The Software Requirements Specification (SRS) document for the NASA Psyche Mission Simulator outlines a wide range of use cases that cater to different user groups. Here are some typical use cases derived from the provided SRS:

Use Case 1: Mission Planning for NASA Engineers

Scenario: Engineers use the simulator to model various approach trajectories and landing strategies for the Psyche mission.

Goal: Optimize spacecraft dynamics to ensure a successful landing and sample collection.

Use Case 2: Project Feasibility Assessment by NASA Managers

Scenario: Managers analyze simulation results to evaluate mission feasibility and resource allocation.

Goal: Make informed decisions on budget and resource deployment for the mission.

Use Case 3: Public Engagement and Education

Scenario: General public users engage with a simplified version of the simulator to learn about asteroid mining and space exploration.

Goal: Increase public interest and understanding of NASA's missions.

Use Case 4: Research and Data Collection for Scholars and Researchers

Scenario: Researchers utilize the simulator to gather data on asteroid characteristics and mining techniques.

Goal: Support academic studies and contribute to scientific literature.

Use Case 5: Design Assessment by Spacecraft Industry Engineers

Scenario: Industry engineers test and evaluate design concepts for spacecraft and mining technologies.

Goal: Enhance the development of innovative solutions for space missions.

Use Case 6: Educational Tool for Science Teachers

Scenario: Teachers incorporate the simulator into their curriculum to teach concepts of physics, space science, and engineering.

Goal: Provide an interactive learning experience that reinforces classroom lessons.

Use Case 7: Collaboration and Data Sharing

Scenario: Users share simulation outcomes and strategies with peers, family, or online communities to foster discussion and collaboration.

Goal: Promote a collaborative approach to learning and exploration.

Use Case 8: Error Handling and Recovery

Scenario: A user encounters an error during a simulation and uses the error handling features to rectify the issue and continue.

Goal: Ensure a smooth user experience by allowing for easy recovery from errors.

Use Case 9: Customizing Simulation Parameters

Scenario: Users adjust various parameters such as thrust, angle, and speed to explore different mission scenarios.

Goal: Understand the effects of different variables on mission success.

Use Case 10: Real-Time Data Analysis and Feedback

Scenario: Users monitor real-time data during simulations, assessing performance metrics and making adjustments as needed.

Goal: Enhance decision-making through immediate feedback on simulation outcomes.

These use cases highlight the versatility of the simulator, addressing the needs of diverse stakeholders, from engineers and managers to educators and the general public. Each use case not only supports mission objectives but also promotes education and engagement with space science.