Software Requirements Specification

for

Astronomy Data Management & Analysis System

Version 1.0

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Table of Contents

Revision History

Name	***Date***	***Reason For Changes***	***Version***
Disha,Saumyaa,Sinjini	*19/3/25*	*Initial draft*	*1.0*

1. Introduction

1.1 Purpose

This Software Requirements Specification (SRS) document specifies the requirements for the Astronomy Data Management & Analysis System, version 1.0. This document describes the complete system, including the database management system, backend API, frontend user interface, and data analysis components.

1.2 Document Conventions

The following conventions have been used throughout this document:

- *Requirements are organized hierarchically with a unique identifier for each requirement*
- *Priority levels are indicated as High, Medium, or Low for each feature*
- *"TBD" indicates items that are yet to be determined*
- *Important terms are highlighted in italics when first introduced*

1.3 Intended Audience and Reading Suggestions

This document is intended for:

- ***Development Team**: To understand the complete set of requirements for implementation*
- ***Project Managers**: To plan project phases and resource allocation*
- ***Database Administrators**: To design and optimize the database schema*
- ***Testers**: To develop test cases and validation criteria*
- ***End Users**: To understand system capabilities (astronomers, researchers, students)*

For developers and technical team members, it is recommended to start with Sections 2 and 3 to understand the overall architecture, followed by Section 4 for detailed functional requirements. Project managers should focus on Sections 1, 2, and 5 for scope and non-functional requirements. End users may focus on Sections 2.2 and 4.

1.4 Product Scope

The Astronomy Data Management & Analysis System is designed to store, manage, analyze, and visualize astronomical data for various celestial objects including stars, exoplanets, galaxies, and asteroids. The system aims to provide astronomers, researchers, and students with a comprehensive platform to:

- *Maintain structured records of celestial objects and their properties*
- *Log observation data from telescopes*
- *Perform spectral analysis of celestial objects*
- *Generate visual representations of astronomical data*
- *Import and export data from/to standard astronomical databases*

The system will enhance research capabilities by providing efficient data management and analysis tools, supporting both educational and research objectives in the field of astronomy

1.5 References

1. *NASA Exoplanet Archive API Documentation: https://exoplanetarchive.ipac.caltech.edu/docs/program_interfaces.html*
2. *Sloan Digital Sky Survey (SDSS) Data Model: https://www.sdss.org/dr16/data_access/*
3. *International Astronomical Union (IAU) Standards: https://www.iau.org/*
4. *Oracle 19c Documentation: https://docs.oracle.com/en/database/oracle/oracle-database/19/index.html*
5. *React.js Documentation: https://reactjs.org/docs/getting-started.html*

2. Overall Description

2.1 Product Perspective

The Astronomy Data Management & Analysis System is a new, self-contained application designed to serve as a comprehensive platform for astronomical data management. It will operate independently but has the capability to import data from external astronomical databases such as NASA's exoplanet archive, SDSS, and JPL.
The system consists of four main components:

1. *Database System (Oracle 19c) - Core data storage*
2. *Backend API (Flask/Python or Node.js) - Business logic and data processing*
3. *Frontend UI (React.js) - User interface and data presentation*
4. *Data Visualization Tools (Matplotlib, Plotly, D3.js) - Graphical representation![System Architecture Diagram]*

2.2 Product Functions

The major functions of the Astronomy Data Management & Analysis System include:

- *User authentication and role-based access control*
- *Celestial object cataloging and management (stars, planets, galaxies, asteroids)*
- *Detailed exoplanet data management with host star relationships*
- *Spectral data classification and analysis*
- *Telescope observation logging and tracking*
- *Graphical visualization of astronomical data through charts and celestial maps*
- *Data import and export functionality with major astronomical databases*
- *User and permission management for administrators*

2.3 User Classes and Characteristics

The system accommodates three primary user classes:

1. ***Administrators***
    - *Technical expertise: High*
    - *System access: Full access to all system features and administrative functions*
    - *Usage frequency: Regular (weekly)*
    - *Functions: User management, system configuration, database maintenance*
2. ***Researchers/Astronomers***
    - *Technical expertise: Medium to High*
    - *System access: Full access to data entry, analysis, and visualization features*
    - *Usage frequency: High (daily)*

- *Functions: Data entry, analysis, visualization, import/export*

3. ***Guest Users (Students/Public)***

    - *Technical expertise: Low to Medium*
    - *System access: Read-only access to public datasets and basic visualizations*
    - *Usage frequency: Occasional*
    - *Functions: Data browsing, basic queries, predefined visualizations*

2.4 Operating Environment

The Astronomy Data Management & Analysis System will operate in the following environment:

- ***Server Environment**:*
    - *Operating System: Linux (Ubuntu 22.04 LTS) or Windows Server 2022*
    - *Database: Oracle 19c*
    - *Web Server: Apache or Nginx*
    - *Memory: Minimum 16GB RAM*
    - *Storage: Minimum 1TB with expandability options*
- ***Client Environment**:*
    - *Modern web browsers (Chrome 90+, Firefox 88+, Safari 14+, Edge 90+)*
    - *Minimum screen resolution: 1366 x 768*
    - *Internet connection: Minimum 5 Mbps*

2.5 Design and Implementation Constraints

The following constraints apply to the design and implementation of the system:

- *The system must use Oracle 19c as the primary database management system*
- *Frontend must be implemented using React.js*
- *Data visualization components must be compatible with both desktop and mobile browsers*
- *System must adhere to IAU naming conventions and standards for astronomical objects*
- *Development tools limited to VS Code and Oracle SQL Developer*
- *Database queries must be optimized for handling large astronomical datasets*
- *User interface must follow accessibility guidelines (WCAG 2.1 Level AA)*

2.6 User Documentation

The following user documentation will be delivered with the system:

- *System Administration Guide (PDF)*
- *User Manual for Researchers (PDF and online help)*

- *Quick Start Guide for Guest Users (PDF and online help)*
- *API Documentation for developers (interactive web-based)*
- *Database Schema Documentation (PDF)*
- *Video tutorials for common tasks (online)*

2.7 Assumptions and Dependencies

- *The system assumes continuous internet connectivity for real-time data import from external astronomical databases*
- *The system depends on availability of NASA, SDSS, and JPL APIs for data import*
- *It is assumed that users have basic knowledge of astronomical terminology*
- *Development assumes availability of Oracle 19c licenses*
- *System performance assumptions are based on datasets not exceeding 10TB in size*

3. External Interface Requirements

3.1 User Interfaces

The user interface will be web-based, responsive, and adhere to the following specifications:

- ***Dashboard Interface**:*
    - *Main navigation menu with access to all modules*
    - *Summary statistics and recent activity feed*
    - *Quick access to frequently used functions*
    - *Customizable widgets for personalized view*
- ***Celestial Object Management Interface**:*
    - *List view with filtering and sorting capabilities*
    - *Detailed view showing all object properties*
    - *Form-based data entry with field validation*
    - *Integrated search functionality*
- ***Data Visualization Interface**:*
    - *Interactive charts with zoom and pan capabilities*
    - *Customizable plotting options*
    - *Toggle between different visualization types*
    - *Export options for generated visualizations*
- ***Administrative Interface**:*
    - *User management console*
    - *System configuration panel*
    - *Log viewer and monitoring tools*

- *Backup and restore functionality*

All interfaces will follow a consistent design language with a dark theme optimized for astronomy applications, with high contrast for data visualizations.

3.2 Hardware Interfaces

The system will interface with the following hardware components:

- ***Storage Systems**:*
  - *Direct interface with SAN/NAS storage for large dataset handling*
  - *Support for automatic data backup to external storage devices*
- ***Telescopes**:*
  - *Optional interface with compatible digital telescopes via standard protocols*
  - *Support for importing observation data from telescope control systems*
- ***Compute Infrastructure**:*
  - *Interface with high-performance computing clusters for complex data analysis*
  - *Support for distributed computing for intensive calculations*

3.3 Software Interfaces

The system will interface with the following software components:

- ***Database Management System**:*
  - *Oracle 19c*
  - *Interface Type: Direct connection via Oracle SQL*Net*
  - *Data Format: SQL*
  - *Purpose: Primary data storage and retrieval*
- ***External Data Sources**:*
  - *NASA Exoplanet Archive*
    - *Interface Type: REST API*
    - *Data Format: JSON, CSV*
    - *Purpose: Import exoplanet data*
  - *Sloan Digital Sky Survey (SDSS)*
    - *Interface Type: REST API*
    - *Data Format: FITS, CSV*
    - *Purpose: Import galaxy and star data*
  - *JPL Small-Body Database*
    - *Interface Type: REST API*
    - *Data Format: JSON*

- *Purpose: Import asteroid and comet data*

- ***Data Analysis Libraries**:*
    - *Python Scientific Stack (NumPy, SciPy, Pandas)*
        - *Interface Type: Internal Python modules*
        - *Purpose: Data processing and analysis*
    - *Visualization Libraries (Matplotlib, Plotly, D3.js)*
        - *Interface Type: JavaScript/Python libraries*
        - *Purpose: Data visualization*

3.4 Communications Interfaces

The system will utilize the following communication interfaces:

- ***HTTP/HTTPS**:*
    - *For all web-based user interface communications*
    - *RESTful API communications*
    - *Port: 443 (HTTPS)*
    - *Security: TLS 1.3*
    - *Data format: JSON*
- ***WebSockets**:*
    - *For real-time data updates in the user interface*
    - *Port: 443 (WSS)*
    - *Security: TLS 1.3*
    - *Data format: JSON*

- ***SMTP**:*
    - *For email notifications*
    - *Port: 587*
    - *Security: STARTTLS*
    - *Data format: MIME*

4. System Features

4.1 User Authentication and Authorization

***Priority: High** Provides secure user authentication and role-based access control with three user roles: Administrator, Researcher, and Guest. Includes login, password reset, and permission validation features.*

Key Requirements:

- *Role-based access control*

- *Secure authentication with password complexity requirements*
- *Password reset mechanism*
- *Session timeout after 30 minutes*
- *Account lockout after 5 failed attempts*

4.2 Celestial Object Management

Priority: High *Enables management of celestial objects (stars, planets, galaxies, asteroids) with support for creation, search, update, and deletion.*

Key Requirements:

- *Storage of fundamental properties (object_id, name, type, discovery_date, distance_ly)*
- *IAU naming convention validation*
- *Advanced search capabilities*
- *Bulk import functionality*
- *Relationship management between objects*

4.3 Exoplanet Management

Priority: High *Specialized management for exoplanet data, including host star relationships and orbital characteristics.*

Key Requirements:

- *Storage of exoplanet-specific properties*
- *Host star relationship management*
- *Calculation of derived properties (gravity, density)*
- *Atmospheric composition data management*
- *NASA Exoplanet Archive synchronization*

4.4 Spectral Data Analysis

Priority: Medium *Supports storage, analysis, and visualization of spectral data for celestial objects.*

Key Requirements:

- *Standard stellar spectral classification*
- *Spectral feature analysis tools*
- *Data import from common formats*
- *Automatic classification algorithms*
- *Comparative analysis capabilities*

4.5 Observation Logging

Priority: Medium *Allows recording of observational data including conditions, equipment, and results.*

Key Requirements:

- *Comprehensive observation metadata storage*
- *Image attachment support*
- *Filtering and reporting features*
- *Observation scheduling and reminders*
- *Quality rating system*

4.6 Data Visualization

Priority: High *Provides interactive visualizations of astronomical data.*

Key Requirements:

- *Multiple visualization types (scatter plots, histograms, etc.)*
- *Interactive celestial maps*
- *Customization options*
- *Export capabilities*
- *Sharing features*

4.7 Data Import and Export

Priority: Medium *Enables data exchange with external sources in various formats.*

Key Requirements:

- *Integration with NASA, SDSS, and JPL databases*
- *Support for common file formats*
- *Data validation*
- *Audit logging of all operations*
- *RESTful API for external access*

4.8 System Administration

Priority: Medium *Provides administrative tools for system management.*

Key Requirements:

- *User and permission management*
- *Database backup and restoration*
- *System logging and monitoring*
- *Performance monitoring*
- *Data integrity tools*

5. External Interface Requirements

5.1 Performance Requirements

- *Support for 100 concurrent users*
- *Query response time under 2 seconds*
- *Import rate of 1000 records/minute*
- *Visualization generation within 5 seconds*
- *Support for 10TB database*
- *99.9% uptime*

5.2 Safety Requirements

- *Data integrity through validation and error handling*
- *Concurrency control mechanisms*
- *Comprehensive backup system*

- *Disaster recovery procedures*

5.3 Security Requirements

- *Password complexity enforcement*
- *TLS 1.3 encryption for data in transit*
- *AES-256 encryption for data at rest*
- *Role-based access control*
- *Protection against common web vulnerabilities*
- *IP-restricted administrative functions*

5.4 Software Quality Attributes

- *Reliability: MTBF of 720 hours*
- *Maintainability: Modular architecture*
- *Portability: Cross-platform compatibility*
- *Usability: Intuitive interfaces*
- *Scalability: Horizontal scaling capabilities*
- *Interoperability: Standard astronomical data format support*

5.5 Business Rules

- *Administrator approval for user accounts*
- *Comprehensive audit logging*
- *Source attribution for imported data*
- *IAU-compliant object naming*
- *Role-restricted administrative functions*

6. Other Requirements

6.1 Database Requirements

REQ-DB1: The database shall support spatial queries for celestial object positioning.
REQ-DB2: The database shall implement partitioning for tables containing large datasets.
REQ-DB3: The database shall support full-text search capabilities for object descriptions and notes.
REQ-DB4: The database shall implement proper indexing for optimized query performance.

6.2 Internationalization Requirements

REQ-I1: The system shall support UTF-8 character encoding for all textual data.
REQ-I2: The user interface shall be designed to support future localization to multiple languages.
REQ-I3: The system shall display numerical data in configurable formats (metric/imperial).

6.3 Legal Requirements

REQ-L1: The system shall comply with data protection regulations for user data storage.
REQ-L2: The system shall properly attribute data sources according to their licensing requirements.
REQ-L3: The system shall maintain appropriate open-source licensing for third-party components.

Appendix A: Glossary

- ***API**: Application Programming Interface*
- ***FITS**: Flexible Image Transport System, a standard format for astronomical data*
- ***IAU**: International Astronomical Union*
- ***JPL**: Jet Propulsion Laboratory*
- ***NASA**: National Aeronautics and Space Administration*
- ***SDSS**: Sloan Digital Sky Survey*
- ***Spectral Type**: Classification of stars based on their spectral characteristics (O, B, A, F, G, K, M)*
- ***TLS**: Transport Layer Security*
- ***UI**: User Interface*
- ***WCAG**: Web Content Accessibility Guidelines*

Appendix B: Analysis Models

- **B.1 Entity-Relationship Diagram**

[Entity-Relationship Diagram showing the relationships between Users, CelestialObjects, Exoplanets, Stars, Galaxies, Asteroids, ObservationLogs, and SpectralData entities]

- **B.2 System Architecture Diagram**

[System Architecture Diagram showing the relationships between the Database (Oracle), Backend API (Flask/Python), Frontend (React.js), and Data Visualization components]

- **B.3 Use Case Diagram**

[Use Case Diagram showing the interactions between Administrator, Researcher, and Guest users with the system functions]

Appendix C: To Be Determined List

1. *TBD-1: Specific hardware requirements for hosting the system (Section 2.4)*
2. *TBD-2: Detailed security implementation strategy (Section 5.3)*
3. *TBD-3: Exact API endpoints for external data sources (Section 3.3)*
4. *TBD-4: Specific performance benchmarks for data processing operations (Section 5.1)*
5. *TBD-5: Detailed backup and recovery procedures (Section 4.8)*
6. *TBD-6: Final list of supported export formats (Section 4.7)*
7. *TBD-7: Detailed user interface mockups (Section 3.1)*