Software Requirements Specification (SRS)

Version 1.0

Software Requirements Specification

For

Integrated Health & Social Risk Analysis Platform

**Project Title:** Personalized Health Companion

**Prepared by:**

Booja devi D

Abiya V

Samiksha P

Virginia A.L

Sivanesan.R

Sundara Raaman R.S

**Organization:** Sri Manakula Vinayagar Engineering College

**Date Created:** 06/9/2024

**Table of Contents**

**1. Introduction**

1.1 Purpose

1.2 Scope

1.3 Definitions, Acronyms, and Abbreviations

1.4 References

1.5 Overview

**2. Overall Description**

2.1 Product Perspective

2.2 Product Features

2.3 User Classes and Characteristics

2.4 Operating Environment

2.5 Design and Implementation Constraints

2.6 Assumptions and Dependencies

**3. System Features**

3.1 Geo-Coding & Spatial Analysis

3.2 Multi-Data Integration

3.3 Risk Prediction Model

3.4 E-Card System

3.5 Community & Interventions Module

3.6 Administrative Dashboard

**4. External Interface Requirements**

4.1 User Interfaces

4.2 APIs

4.3 Hardware Interfaces

4.4 Communication Interfaces

4.5 External System Interfaces

**5. Non-Functional Requirements**

5.1 Performance Requirements

5.2 Security Requirements

5.3 Safety Requirements

5.4 Usability Requirements

5.5 Reliability & Availability

5.6 Scalability & Maintainability

**6. Other Requirements**

6.1 Legal and Regulatory Requirements

6.2 Ethical & Cultural Requirements

6.3 Environmental Requirements

**7. Appendices**

A. Glossary

B. Sample User Interfaces

C. Data Flow Diagrams

D. Entity-Relationship Diagrams

E. References

**1. Introduction**

**1.1 Purpose**

The purpose of this Software Requirements Specification (SRS) is to present a complete and detailed description of the **Integrated Health & Social Risk Analysis Platform (Personalized Health Companion)**. The platform is designed to serve as a **holistic health management tool** by integrating clinical, social, and environmental data to assess individual and community health risks.

* **Empowering individuals** with knowledge of their personal health status, lifestyle risks, and preventive measures.
* **Supporting healthcare providers** by offering consolidated data, analytics, and predictive risk scores.
* **Assisting administrators and policymakers** in monitoring population-level health patterns, thereby improving intervention strategies.
* **Bridging health and social domains** by mapping social determinants (income, housing, education, environment) with clinical health outcomes.

The document serves as a reference for:

* Developers (implementation details).
* Testers (test case creation).
* Health professionals (system expectations).
* Stakeholders (project goals, compliance, scope).

**1.2 Scope**

The system provides **multi-layered functionality**, from personal health management to large-scale community health monitoring.

**In Scope:**

* **Geo-coding & Spatial Analysis**: Mapping disease incidence and social determinants on interactive maps.
* **Multi-Data Integration**: Combining data from EHRs, wearable devices, public health datasets, and environmental monitoring.
* **Risk Prediction Models**: AI-driven prediction of health risks such as diabetes, cardiovascular diseases, and lifestyle-related conditions.
* **E-Card System**: A digital health identity card containing medical history, allergies, and prescriptions.
* **Community & Interventions Module**: Linking individuals with social welfare programs, NGOs, and local resources.
* **Administrative Dashboard**: Real-time analytics for monitoring health trends and intervention effectiveness.

**Out of Scope:**

* Emergency medical services (ambulance dispatch).
* Payment gateways for insurance or pharmacy transactions.
* Direct clinical diagnosis (the system supports, but does not replace, doctors).

**1.3 Definitions, Acronyms, Abbreviations**

* **SDOH**: Social Determinants of Health.
* **GIS**: Geographic Information System.
* **EHR**: Electronic Health Record.
* **AI/ML**: Artificial Intelligence / Machine Learning.
* **UI/UX**: User Interface / User Experience.
* **API**: Application Programming Interface.
* **HIPAA/GDPR**: Health and privacy compliance standards.

**1.4 References**

* WHO: *Closing the Gap in a Generation* (Social Determinants of Health Report).
* HL7 FHIR Standard for healthcare data exchange.
* Kaggle Open Health and Social Datasets.
* Microsoft Azure & AWS Cloud Documentation.
* ArcGIS Developer Documentation.

**1.5 Overview**

This document specifies the **functional and non-functional requirements**, outlines **system features**, and describes **interfaces, constraints, and compliance standards**. It is structured for clarity and comprehensiveness, ensuring all stakeholders have a shared understanding of the project.

**2 Overall Description**

**2.1 Product Perspective**

The **Integrated Health & Social Risk Analysis Platform** is designed as a **comprehensive, cloud-based solution** that integrates multiple data sources and technologies to provide personalized health insights and community-level interventions. The platform is not intended to replace existing healthcare systems but to complement them by adding **predictive analytics, social determinants of health (SDOH) mapping, and integration across multiple domains** such as clinical health, environment, and social services.

The platform integrates with a range of external systems and devices, ensuring **interoperability and extensibility**:

* **Wearable Devices**: Devices such as Fitbit, Apple Watch, and Garmin continuously collect physiological data (heart rate, activity levels, sleep patterns). The system uses their APIs to fetch health metrics in real-time. This enables continuous monitoring of user health without requiring manual input.
* **Electronic Health Record (EHR) Systems**: Through HL7/FHIR (Fast Healthcare Interoperability Resources) standards, the platform imports medical history, lab results, prescriptions, and diagnostic reports from hospitals and clinics. This ensures continuity of care and accurate risk assessment.
* **Geographic Information System (GIS) Tools**: APIs from ArcGIS and Google Maps are used to integrate **spatial data** (air quality, water quality, disease clusters, healthcare facility mapping) into the risk analysis framework. This allows the system to correlate **environmental and geographical factors** with health outcomes.
* **Government Registries**: Data from national and regional health surveillance programs (such as census data, vaccination databases, and disease reporting systems) is included. This provides socio-economic and demographic context for risk predictions.
* **Community Services**: The platform connects users with community-level health camps, NGOs, and government welfare schemes. This ensures that recommendations are not just diagnostic but also actionable through real-world resources.

The system is:

* **Cloud-based**: Hosted on Azure/AWS for global availability, high uptime, and scalable performance.
* **Multi-platform**: Available as a responsive web application (React/Angular) and as native/hybrid mobile apps (Android/iOS).
* **Modular and Extensible**: Built with microservices and APIs, enabling easy addition of new features, integration with external tools, and scaling with user demand.

This perspective ensures that the platform is positioned as an **integrated ecosystem** rather than an isolated tool.

**2.2 Product Features**

The platform offers a **wide range of features** catering to individuals, healthcare providers, and administrators. Each feature is designed to be **modular, interoperable, and user-centric**:

1. **Geo-Coding & Spatial Analysis**
   * Provides heatmaps showing disease prevalence and clusters by region.
   * Identifies healthcare accessibility gaps by mapping hospitals, clinics, and pharmacies.
   * Incorporates environmental indicators (pollution levels, water contamination, climate data) into health risk analysis.
   * Supports **predictive mapping**, allowing policymakers to visualize potential future health risks based on current trends.
2. **Data Integration**
   * Aggregates **structured data** (EHRs, lab results) and **unstructured data** (surveys, community reports).
   * Harmonizes different data formats using ETL (Extract-Transform-Load) pipelines.
   * Enables **cross-domain insights** by combining medical, social, and environmental data into unified dashboards.
3. **AI Risk Prediction Model**
   * Uses machine learning algorithms (Random Forest, Neural Networks, Gradient Boosting) to predict chronic disease risks.
   * Provides **risk scores and probability values** for conditions such as diabetes, cardiovascular diseases, and respiratory illnesses.
   * Generates **personalized lifestyle recommendations** (e.g., exercise, diet, preventive screenings).
   * Continuously improves via federated learning, ensuring user privacy while enhancing model accuracy.
4. **E-Card System**
   * A secure, digital health card containing medical history, allergies, prescriptions, and vaccination records.
   * Provides **QR-code-based quick access** for healthcare providers during emergencies.
   * Supports **offline PDF export** for individuals without continuous internet access.
5. **Community Module**
   * Recommends nearby health camps, welfare programs, and NGOs relevant to the user’s risk profile.
   * Provides **preventive intervention pathways**, such as referrals to mental health support groups or nutrition counseling services.
   * Enables community organizations to use anonymized, aggregated data for **planning interventions at scale**.
6. **Administrative Dashboard**
   * Real-time monitoring of population health indicators and platform performance.
   * Advanced data visualizations (charts, heatmaps, predictive graphs) for policy-level decision-making.
   * Provides **audit trails and compliance checks** to ensure data security and adherence to legal standards.

**2.3 User Classes and Characteristics**

The platform has multiple user classes, each with **distinct goals, technical skills, and data access levels**:

1. **General Users (Patients / Citizens)**
   * Typically have limited technical knowledge.
   * Require **intuitive interfaces**, simple navigation, and easy-to-understand health insights.
   * Expect **personalized health tracking** (e.g., diet reminders, alerts for risk conditions).
2. **Healthcare Providers (Doctors, Nurses, Specialists)**
   * Require **secure and detailed access** to patient health data for decision-making.
   * Need the ability to **view risk predictions, medical histories, and environmental risk factors** that affect patients.
   * Prefer advanced analytics (trend graphs, comparative risk scores).
3. **Community Organizations & NGOs**
   * Interested in **aggregate data** (e.g., “Which region has the highest malnutrition rates?”).
   * Use system-generated insights to plan interventions, distribute resources, and run awareness campaigns.
   * Do not require personal health data but need anonymized reports.
4. **System Administrators**
   * Manage system performance, troubleshoot issues, and maintain data integrity.
   * Require tools for **monitoring, auditing, and compliance enforcement**.
   * Need high-level visibility into platform usage and security breaches.

**2.4 Operating Environment**

The platform operates in a **highly distributed, cloud-based environment** with the following characteristics:

* **Cloud Hosting**:
  + Deployed on AWS or Azure.
  + Uses **load balancers, containerized microservices (Docker/Kubernetes)**, and auto-scaling for high availability.
* **Supported Platforms**:
  + **Web applications** (React/Angular) optimized for Chrome, Firefox, Safari, and Edge.
  + **Mobile applications** (Android/iOS) for personal health tracking.
* **Wearable Device Compatibility**:
  + APIs for Fitbit, Apple Watch, Garmin, Withings, and Omron.
  + Uses Bluetooth Low Energy (BLE) and Wi-Fi for data synchronization.
* **Databases**:
  + **SQL databases** for structured medical records.
  + **NoSQL databases** (MongoDB, Cassandra) for unstructured and time-series data (wearable data streams, community surveys).
  + Encrypted at rest and in transit.
* **Interoperability**:
  + Supports HL7/FHIR for EHR integration.
  + Compatible with **GIS APIs** (Google Maps, ArcGIS).

**2.5 Design and Implementation Constraints**

The system is bound by multiple **technical and non-technical constraints**:

1. **Regulatory Compliance**
   * Must comply with **HIPAA** (for U.S.) and **GDPR** (for Europe).
   * Requires **role-based access control (RBAC)** and audit logs.
2. **Data Volume & Scalability**
   * Must process millions of records in real-time.
   * Supports horizontal scaling (Kubernetes clusters, distributed databases).
3. **Latency & Real-Time Processing**
   * Risk prediction updates must occur **within seconds** after new data is received.
   * Real-time streaming pipelines (Apache Kafka/Spark) required for high-throughput processing.
4. **Compatibility**
   * Must be cross-device (desktop, mobile, tablet).
   * Multi-language support for diverse regions.
5. **Security Constraints**
   * Must implement **multi-factor authentication, encryption (AES-256), TLS 1.3**.
   * Periodic **penetration testing and vulnerability assessments** are mandatory.

**2.6 Assumptions and Dependencies**

The development and functioning of the system rely on the following **assumptions**:

* Users have **smartphones or internet access**.
* Wearable devices are correctly paired and functional.
* Data from government registries is **up-to-date and accessible**.
* Users consent to sharing data for predictive analysis.

The system has the following **dependencies**:

* APIs for health data (Fitbit, Apple, Garmin) and GIS data must be available and stable.
* Continuous compliance with evolving health regulations.
* Cloud infrastructure (Azure/AWS) for uptime, storage, and scalability.
* Collaboration with **NGOs and health agencies** for community module functionality.

**3. System Features**

**3.1 Geo-Coding & Spatial Analysis**

**Description**

The Geo-Coding & Spatial Analysis module integrates **geographical, demographic, and health data** to create **visual insights** into population health trends. By linking health incidents with geographic data, the system helps identify **disease clusters, environmental risks, and underserved regions** where access to healthcare is limited.

This feature empowers:

* **Healthcare providers** to understand geographic spread of diseases.
* **Public health agencies** to allocate resources effectively.
* **Community organizations** to target interventions in high-risk areas.

The system uses **GIS APIs** such as ArcGIS and Google Maps, layered with **real-time health data feeds**.

**Functional Requirements**

* **FR1:** The system shall collect GPS-based health incident data from wearable devices, EHRs, and manual inputs.
* **FR2:** The system shall provide interactive maps with filters for age, disease type, environment, and social factors.
* **FR3:** The system shall generate **heatmaps** showing disease prevalence by region.
* **FR4:** The system shall integrate **environmental data sources** (air/water quality, pollution indices, climate).
* **FR5:** The system shall allow **historical trend analysis**, showing how disease patterns evolve over time.
* **FR6:** The system shall support **drill-down capabilities**, from national → state → district → neighborhood.
* **FR7:** The system shall allow exporting maps as **images, PDFs, or embedded dashboards**.

**UI Requirements**

* **UIR1:** Display interactive maps with **zoom and pan features**.
* **UIR2:** Implement color-coded **heatmaps** for high/medium/low disease prevalence.
* **UIR3:** Provide **layer toggles** (health incidents, environmental factors, healthcare facilities).
* **UIR4:** Enable **tooltips and pop-ups** on map points to display key health metrics.
* **UIR5:** Support **mobile-friendly map visualizations** with simplified navigation.

**Acceptance Criteria**

* **AC1:** Maps achieve 95% accuracy in representing location-based health data.
* **AC2:** Maps render and update within **3 seconds** for standard queries.
* **AC3:** Users can filter by at least **10 parameters** (age, disease type, pollution, etc.).
* **AC4:** Historical trend analysis provides at least **5 years** of retrospective data.
* **AC5:** System handles **100,000 concurrent map queries** without performance degradation.

**Dependencies**

* GIS APIs (ArcGIS, Google Maps).
* Health and environmental data sources (WHO, EPA, local governments).
* Cloud hosting infrastructure with geospatial database support (PostGIS, MongoDB Atlas).

**3.2 Multi-Data Integration**

**Description**

This module is the **core data engine** that integrates **structured and unstructured datasets** from multiple sources: Electronic Health Records, wearable devices, government census data, and community surveys. It ensures that data is **harmonized, normalized, and cleaned** before being used in analysis or predictions.

**Functional Requirements**

* **FR1:** The system shall support **HL7/FHIR standards** for EHR integration.
* **FR2:** The system shall allow integration with at least **10 wearable device APIs** (Fitbit, Apple Health, Garmin, etc.).
* **FR3:** The system shall apply **ETL (Extract, Transform, Load)** processes for multi-format data ingestion.
* **FR4:** The system shall resolve **conflicts in duplicate records** (e.g., two entries for same patient).
* **FR5:** The system shall validate data for **accuracy, completeness, and consistency**.
* **FR6:** The system shall allow **manual uploads** (CSV, JSON, PDF extraction using OCR).
* **FR7:** The system shall support **real-time streaming ingestion** of wearable data.

**UI Requirements**

* **UIR1:** Provide a **data dashboard** showing sources, sync status, and error logs.
* **UIR2:** Allow **upload of external datasets** with validation feedback.
* **UIR3:** Provide **visualizations of data quality metrics** (missing values, duplicates).
* **UIR4:** Show **last updated timestamp** for each integrated dataset.

**Acceptance Criteria**

* **AC1:** System integrates data from at least **95% of supported APIs** without failure.
* **AC2:** Duplicate records are reduced by at least **90%** after cleaning.
* **AC3:** Data ingestion latency is **<10 seconds** for streaming data.
* **AC4:** 99% accuracy in data format normalization.

**Dependencies**

* Third-party APIs (wearables, EHR vendors).
* Data storage (SQL + NoSQL).
* OCR libraries for document parsing.

**3.3 Risk Prediction Model**

**Description**

The **AI-driven predictive analytics module** identifies **chronic disease risks** based on a combination of **clinical, social, and environmental data**. The model uses advanced machine learning (Random Forest, Neural Networks, Gradient Boosting) to forecast risks and provide **personalized recommendations**.

**Functional Requirements**

* **FR1:** The system shall use at least **three ML algorithms** to predict health risks.
* **FR2:** The system shall update predictions at least **once daily** or when significant new data arrives.
* **FR3:** The system shall provide **risk scores (1–100)** and classify risks as **low/medium/high**.
* **FR4:** The system shall generate **personalized recommendations** (diet, exercise, screenings).
* **FR5:** The system shall provide **plain-language explanations** of why a risk was predicted.
* **FR6:** The system shall use **federated learning** for privacy-preserving model updates.
* **FR7:** The system shall allow **doctors to validate or override recommendations**.

**UI Requirements**

* **UIR1:** Display risks in a **dashboard with charts and progress bars**.
* **UIR2:** Provide **color-coded risk levels** (green = low, yellow = medium, red = high).
* **UIR3:** Enable **trend graphs** to show risk changes over time.
* **UIR4:** Provide **what-if analysis tools** (e.g., “If user increases exercise by 20%, risk reduces by X%”).

**Acceptance Criteria**

* **AC1:** Risk model achieves **≥85% accuracy** (validated on test data).
* **AC2:** Predictions refresh in **<5 minutes** when new data is received.
* **AC3:** ≥90% of users find predictions understandable (survey feedback).
* **AC4:** Model bias checks ensure **no demographic group is unfairly discriminated**.

**Dependencies**

* Health datasets (clinical, demographic, social).
* ML frameworks (TensorFlow, PyTorch, Scikit-learn).
* Cloud GPU/TPU resources for training models.

**3.4 E-Card System**

**Description**

The **E-Card system** is a **digital health identity card** that stores user health information in a secure, portable format. It allows users to **carry their medical records across providers**, ensuring continuity of care.

**Functional Requirements**

* **FR1:** Store key health data (medical history, allergies, medications, vaccinations).
* **FR2:** Provide **QR-code-based quick access** for doctors and hospitals.
* **FR3:** Allow **PDF export** for offline use.
* **FR4:** Sync with EHR systems for automatic updates.
* **FR5:** Enable **user-controlled sharing permissions**.

**UI Requirements**

* **UIR1:** Display health card in **mobile app** with easy navigation.
* **UIR2:** Provide options to **download/share card**.
* **UIR3:** Use **icons & sections** (medications, allergies, history).

**Acceptance Criteria**

* **AC1:** 99% accuracy in reflecting latest health data.
* **AC2:** QR-code scan retrieves health card within **3 seconds**.
* **AC3:** PDF export works on web and mobile.

**Dependencies**

* QR code libraries.
* EHR APIs.
* Secure cloud database.

**3.5 Community & Interventions Module**

**Description**

This module bridges the gap between **users and local health/social resources**. It ensures that users not only receive **risk predictions** but are also directed to **practical interventions**.

**Functional Requirements**

* **FR1:** Suggest nearby welfare programs, NGOs, and government schemes.
* **FR2:** Match interventions to **user’s risk profile**.
* **FR3:** Provide alerts for upcoming **health camps or vaccination drives**.
* **FR4:** Allow NGOs to post interventions in the system.

**UI Requirements**

* **UIR1:** Show a **list/map view of available interventions**.
* **UIR2:** Provide **filter options** (program type, location, eligibility).
* **UIR3:** Enable **push notifications** for new programs.

**Acceptance Criteria**

* **AC1:** At least **90% of suggested interventions are relevant** to user’s profile.
* **AC2:** Users can find interventions within **3 clicks/taps**.
* **AC3:** NGOs can update interventions with **99% reliability**.

**Dependencies**

* Community databases.
* NGO and government portals.
* Push notification services.

**3.6 Administrative Dashboard**

**Description**

The **admin dashboard** provides a **centralized control panel** for monitoring system usage, population health trends, and compliance with regulatory requirements. It supports **policy-level insights and reporting**.

**Functional Requirements**

* **FR1:** Provide **real-time analytics** on user health trends.
* **FR2:** Track **system performance (uptime, errors, load)**.
* **FR3:** Monitor compliance (HIPAA, GDPR).
* **FR4:** Generate reports in multiple formats (PDF, Excel).
* **FR5:** Provide **role-based access control**.

**UI Requirements**

* **UIR1:** Dashboard with **widgets, charts, KPIs**.
* **UIR2:** Customizable layout (drag-and-drop widgets).
* **UIR3:** Dark mode & accessibility features.

**Acceptance Criteria**

* **AC1:** Dashboards load within **3 seconds**.
* **AC2:** Reports generate in under **30 seconds**.
* **AC3:** 99.9% uptime with **auto-scaling support**.

**Dependencies**

* Data visualization tools (Power BI, D3.js).
* Cloud monitoring tools (Azure Monitor, AWS CloudWatch).
* Secure logging systems.
* **External Systems**: EHR, pharmacies, NGO portals.

**4. External Interface Requirements (Expanded)**

**4.1 User Interfaces (UI)**

**Description**

The platform must provide a **user-friendly, accessible, and responsive interface** for all user classes (general users, healthcare providers, NGOs, administrators). Since these classes have **different needs and technical abilities**, the UI must adapt accordingly.

**General UI Features**

* Responsive design optimized for **desktop, tablet, and mobile**.
* Adherence to **WCAG 2.1 Level AA** accessibility standards.
* Support for **multiple languages** and cultural customizations.
* **Light and dark themes** to improve usability.
* **Role-based dashboards** (patients see personal data, admins see system-wide data).

**Functional Requirements (FR-UI)**

* **FR-UI-1:** The UI shall provide a **personalized dashboard** for each user role.
* **FR-UI-2:** The UI shall allow **customization** (rearranging widgets, choosing preferred data views).
* **FR-UI-3:** The UI shall support **real-time updates** (health metrics, risk scores, alerts).
* **FR-UI-4:** The UI shall implement **search and filter features** across datasets.
* **FR-UI-5:** The UI shall allow **secure login with MFA (Multi-Factor Authentication)**.
* **FR-UI-6:** The UI shall include a **chatbot/assistant** for guided support.
* **FR-UI-7:** The UI shall display **health trends in charts/graphs**.
* **FR-UI-8:** The UI shall provide **error handling and help tooltips**.

**UI Requirements for User Classes**

* **General Users (Patients):** Simple navigation, health card view, risk predictions, intervention suggestions.
* **Healthcare Providers:** Detailed patient dashboards, EHR integration, prescription management, alerts for critical risks.
* **NGOs / Community Organizations:** Aggregate views (heatmaps, population trends), downloadable reports.
* **Administrators:** System monitoring, compliance dashboards, audit logs, and configuration settings.

**Acceptance Criteria**

* Dashboards load in **<3 seconds**.
* 95% of users report **ease of use** in usability tests.
* Interfaces display correctly on **Chrome, Safari, Edge, Firefox, Android, and iOS**.
* Accessibility verified with **screen readers (JAWS, NVDA)**.

**4.2 APIs (Application Programming Interfaces)**

**Description**

APIs are the **backbone of interoperability**. They enable data exchange between the platform and **wearables, EHRs, GIS tools, pharmacies, NGOs, and third-party analytics services**.

**Functional Requirements (FR-API)**

* **FR-API-1:** The system shall provide **RESTful APIs** for external system access.
* **FR-API-2:** The APIs shall support **GraphQL** for optimized querying.
* **FR-API-3:** All API communications shall use **JSON** as the default format, with XML support for legacy systems.
* **FR-API-4:** APIs shall be protected using **OAuth 2.0 and OpenID Connect**.
* **FR-API-5:** The system shall provide **developer documentation** for all public APIs.
* **FR-API-6:** APIs shall support **real-time streaming (WebSockets/Kafka)** for health data ingestion.

**Types of APIs**

1. **Health Monitoring Devices API**
   * Fitbit, Apple HealthKit, Garmin, Withings.
   * Collects **steps, heart rate, sleep patterns, oxygen levels**.
2. **EHR Integration API**
   * Uses **HL7 FHIR** standards.
   * Retrieves **patient demographics, medical history, lab results, prescriptions**.
3. **GIS & Spatial Data API**
   * Google Maps, ArcGIS.
   * Fetches environmental and location data.
4. **Pharmacy & Prescription API**
   * Connects with pharmacies for **inventory, prescription validation, medicine ordering**.
5. **Notification API**
   * Push notifications, email, SMS.
   * Azure Communication Services / Twilio.

**Acceptance Criteria**

* 99% uptime for public APIs.
* Response time **<500 ms** for standard queries.
* Support at least **10,000 concurrent API requests**.
* Secure API access logged with **audit trails**.

**4.3 Hardware Interfaces**

**Description**

The platform interacts with **multiple hardware devices** to collect, process, and display health and spatial data.

**Categories of Hardware Interfaces**

1. **Wearable Devices**
   * Fitbit, Apple Watch, Garmin, Samsung Galaxy Watch.
   * Collects **physiological data** (heart rate, activity, sleep, oxygen).
   * Communication: **Bluetooth Low Energy (BLE), Wi-Fi**.
2. **Home Medical Devices**
   * Smart scales, glucometers, blood pressure monitors, pulse oximeters.
   * Sends data via **BLE, NFC, or Wi-Fi**.
3. **Computing Devices**
   * Desktop/laptop for web interface.
   * Smartphones/tablets for mobile apps.
   * Requirements: Minimum **2 GB RAM, modern browser, Android 9+ / iOS 14+**.
4. **External Medical Devices (Clinical)**
   * Hospital EHR-connected devices (ECG, MRI, ventilators).
   * Standards: **HL7 FHIR, DICOM (for imaging)**.

**Functional Requirements (FR-HW)**

* **FR-HW-1:** Support BLE and Wi-Fi for wearable data sync.
* **FR-HW-2:** Provide drivers/adapters for external clinical devices.
* **FR-HW-3:** Support USB/serial connectivity for legacy devices.
* **FR-HW-4:** Ensure mobile apps access device sensors (GPS, camera, accelerometer).

**Acceptance Criteria**

* ≥95% compatibility with tested wearables.
* Successful data sync within **10 seconds**.
* Zero data corruption during transmission.

**4.4 Communication Interfaces**

**Description**

Communication interfaces define **protocols and standards** used for data transmission across the platform.

**Protocols Used**

1. **Network Protocols**
   * **HTTPS (TLS 1.3)** for secure client-server communication.
   * **WebSockets** for real-time health updates.
   * **MQTT/Kafka** for high-frequency IoT data streams.
2. **Authentication Protocols**
   * **OAuth 2.0 / OpenID Connect** for user login.
   * **SAML 2.0** for enterprise single sign-on (SSO).
3. **Data Interchange Formats**
   * **JSON** (default).
   * **XML** (for legacy EHR systems).
   * **HL7 FHIR** for healthcare data.
4. **Encryption Standards**
   * **AES-256** for data at rest.
   * **TLS 1.3** for data in transit.
   * Keys managed using **Azure Key Vault / AWS KMS**.

**Functional Requirements (FR-COM)**

* **FR-COM-1:** All communications shall be encrypted using TLS 1.3.
* **FR-COM-2:** The system shall support **end-to-end encryption** for sensitive health data.
* **FR-COM-3:** The system shall support **multi-channel notifications** (email, SMS, push).
* **FR-COM-4:** System logs shall capture **all communication events** for auditing.

**Acceptance Criteria**

* Zero successful breaches in penetration testing.
* End-to-end latency **<2 seconds** for real-time updates.
* 99.99% uptime for communication channels.

**4.5 External System Interfaces**

**Description**

The platform integrates with **external systems** (health, community, government, pharmacy) to provide comprehensive services.

**Types of External Interfaces**

1. **Third-Party Health Services**
   * **Insurance APIs**: Claims, coverage checks.
   * **Telemedicine platforms**: Video consultations.
2. **Government Health Databases**
   * National immunization databases.
   * Disease surveillance registries.
3. **NGO & Community Services**
   * Integration with NGO databases for welfare programs.
   * Reporting capabilities for community-driven projects.
4. **Cloud Infrastructure**
   * Azure/AWS services for hosting, monitoring, and scaling.
   * APIs for **storage, compute, AI/ML pipelines**.

**Functional Requirements (FR-EXT)**

* **FR-EXT-1:** The system shall support APIs with **insurance providers** for coverage checks.
* **FR-EXT-2:** The system shall integrate with **telemedicine APIs** for video consultations.
* **FR-EXT-3:** The system shall support **government reporting** in HL7/FHIR formats.
* **FR-EXT-4:** The system shall provide **compliance documentation** (HIPAA, GDPR).

**Acceptance Criteria**

* 100% compliance with HIPAA/GDPR verified audits.
* Reports delivered to external agencies in **<1 hour**.
* Secure connection uptime **≥99.9%**.

**5. Non-Functional Requirements (Expanded)**

**5.1 Performance Requirements**

The Personalized Health Companion shall maintain a **high-performance environment** that ensures **fast response times, low latency, and efficient resource utilization**.

* **NFR-PERF-1:** The system shall support at least **100,000 concurrent users** with minimal latency.
  + **NFR-PERF-1.1:** Load balancing shall be implemented using **Azure Front Door or AWS Elastic Load Balancer**.
  + **NFR-PERF-1.2:** The system shall use **caching (Redis, CDN)** to reduce server load.
  + **Acceptance Criteria:** Performance load testing must demonstrate ≤2 seconds average latency under **peak traffic of 100,000 users**.
* **NFR-PERF-2:** The system shall maintain an **average response time of <2 seconds** for standard requests.
  + **NFR-PERF-2.1:** 95% of all API calls shall complete in ≤2 seconds.
  + **NFR-PERF-2.2:** Response degradation shall not exceed 10% under stress conditions.
* **NFR-PERF-3:** The risk prediction engine shall generate results in **<5 seconds** per user request.
  + **NFR-PERF-3.1:** GPU/TPU acceleration shall be used for model inference.
  + **NFR-PERF-3.2:** Pre-trained models shall be cached for fast retrieval.
* **NFR-PERF-4:** APIs shall handle at least **10,000 requests per second** with <1% error rate.
  + **NFR-PERF-4.1:** Rate limiting and throttling shall be enforced to prevent overload.
  + **NFR-PERF-4.2:** Asynchronous APIs shall be used where possible.
* **NFR-PERF-5:** Database queries shall return results in **<500 ms** for standard operations.
  + **NFR-PERF-5.1:** Indexing, sharding, and partitioning shall be applied.
  + **NFR-PERF-5.2:** SQL (Azure SQL Database) and NoSQL (Cosmos DB) shall be optimized separately.
* **Acceptance Criteria (Performance):**
  + Load testing with JMeter/K6 demonstrates system performance under **peak load scenarios**.
  + Uptime ≥ 99.9% under high load.

**5.2 Security Requirements**

The platform shall adhere to **global healthcare security standards** to ensure confidentiality, integrity, and availability of user data.

* **NFR-SEC-1:** All sensitive health data shall be encrypted using **AES-256** at rest and **TLS 1.3** in transit.
  + **NFR-SEC-1.1:** Encryption keys shall be stored in **Azure Key Vault**.
  + **NFR-SEC-1.2:** Data anonymization shall be applied before analytics.
* **NFR-SEC-2:** The system shall implement **role-based access control (RBAC)**.
  + **NFR-SEC-2.1:** Patients can only access their own records.
  + **NFR-SEC-2.2:** Doctors can only access records of their assigned patients.
* **NFR-SEC-3:** The system shall support **multi-factor authentication (MFA)**.
  + **NFR-SEC-3.1:** Options: SMS OTP, Authenticator App, Biometric login.
* **NFR-SEC-4:** Security logs shall be generated for all API calls and stored for **7 years**.
  + **NFR-SEC-4.1:** Logs shall include timestamp, user ID, and request details.
* **NFR-SEC-5:** The system shall undergo **quarterly penetration testing**.
  + **NFR-SEC-5.1:** OWASP Top 10 vulnerabilities shall be tested against.
* **Acceptance Criteria (Security):**
  + Zero critical security issues after audits.
  + GDPR/HIPAA compliance certification achieved.

**5.3 Safety Requirements**

The system shall ensure that **users’ health and wellbeing are not compromised** by system malfunctions, delays, or incorrect data.

* **NFR-SAFE-1:** The system shall display clear disclaimers that **AI predictions are advisory, not medical diagnosis**.
* **NFR-SAFE-2:** Emergency alerts shall be delivered with **≥99% reliability within 30 seconds**.
* **NFR-SAFE-3:** A **fail-safe manual input mode** shall be provided if device connectivity fails.
* **NFR-SAFE-4:** All AI-driven recommendations shall be validated against **WHO/CDC guidelines**.
* **NFR-SAFE-5:** The system shall provide **emergency access for verified doctors** in critical situations.
* **Acceptance Criteria (Safety):**
  + Mock emergency drill confirms alert delivery within SLA.
  + 100% of AI recommendations cross-validated with medical guidelines.

**5.4 Usability Requirements**

The system must be **intuitive, inclusive, and accessible** to a wide range of users with different levels of technical literacy.

* **NFR-USE-1:** The interface shall meet **WCAG 2.1 Level AA accessibility standards**.
  + **NFR-USE-1.1:** Provide text-to-speech support.
  + **NFR-USE-1.2:** Provide adjustable font sizes and contrast ratios.
* **NFR-USE-2:** The UI shall maintain a **task success rate ≥90%** in usability testing.
* **NFR-USE-3:** Support **screen readers** like JAWS, NVDA, VoiceOver.
* **NFR-USE-4:** Support **voice commands and dictation**.
* **NFR-USE-5:** Provide **guided tutorials, onboarding wizards, and help center**.
* **NFR-USE-6:** Feedback button available across all modules.
* **Acceptance Criteria (Usability):**
  + Users complete key tasks (login, view health card, check prediction) in ≤3 clicks.
  + Accessibility verified with automated tools (Axe, WAVE).

**5.5 Reliability & Availability**

The system shall remain **highly reliable and available** under all conditions, ensuring continuity of service.

* **NFR-REL-1:** Provide **99.9% uptime SLA**.
* **NFR-REL-2:** Automatic failover across **multiple Azure regions**.
* **NFR-REL-3:** Automated backups taken **daily** with **5-year retention**.
* **NFR-REL-4:** Disaster recovery objectives:
  + Recovery Time Objective (RTO): **1 minute**
  + Recovery Point Objective (RPO): **5 minutes**
* **NFR-REL-5:** Continuous monitoring with **Azure Monitor and Application Insights**.
* **NFR-REL-6:** Admins alerted immediately in case of downtime.
* **Acceptance Criteria (Reliability):**
  + Failover test confirms recovery <1 minute.
  + 99.9% uptime measured over 12 months.

**5.6 Scalability & Maintainability**

The platform must be **scalable to support growth** and **maintainable for long-term operation**.

* **NFR-SCAL-1:** The system shall scale horizontally by adding more servers.
* **NFR-SCAL-2:** Auto-scaling of microservices enabled during high load.
* **NFR-SCAL-3:** Handle **data growth of 1 TB/month**.
* **NFR-SCAL-4:** Architecture shall be **microservices-based**.
* **NFR-SCAL-5:** New features deployable without downtime (CI/CD).
* **NFR-SCAL-6:** Bug fixes must be released within **48 hours for critical issues**.
* **NFR-SCAL-7:** Documentation shall be updated with each release.
* **Acceptance Criteria (Scalability & Maintainability):**
  + Stress test confirms auto-scaling within 1 minute.
  + Code maintainability score ≥80% (SonarQube).

**6. Other Requirements**

**6.1 Legal and Regulatory Requirements**

The Personalized Health Companion must comply with **regional and international healthcare and data protection laws**. Failure to do so can lead to legal penalties, financial loss, and reputational damage.

**6.1.1 HIPAA Compliance (U.S.)**

* **Scope:** HIPAA regulates how Protected Health Information (PHI) is stored, transmitted, and accessed.
* **Requirements:**
  + **FR-LEGAL-1.1:** Encrypt PHI using **AES-256** at rest, **TLS 1.3** in transit.
  + **FR-LEGAL-1.2:** Implement **unique user IDs and access logging** for every PHI access.
  + **FR-LEGAL-1.3:** Provide **emergency access procedures** for healthcare providers.
  + **FR-LEGAL-1.4:** Generate **monthly audit reports** for PHI access.
* **Example Violation:** A healthcare provider accesses PHI without authorization → penalty up to $50,000 per violation.
* **Acceptance Criteria:** Independent HIPAA audit results = **0 major violations**.

**6.1.2 GDPR Compliance (EU)**

* **Scope:** GDPR protects the privacy of EU residents.
* **Requirements:**
  + **FR-LEGAL-2.1:** Explicit **user consent** required before data collection.
  + **FR-LEGAL-2.2:** Implement **data portability** (users can download all data in machine-readable format).
  + **FR-LEGAL-2.3:** Implement **Right to Erasure** (user data deleted within 30 days upon request).
  + **FR-LEGAL-2.4:** Breach notification within **72 hours** to regulators.
* **Example Case:** In 2021, WhatsApp was fined **€225 million** for GDPR violations.
* **Acceptance Criteria:** 100% fulfillment of **Data Subject Access Requests (DSARs)** within 30 days.

**6.1.3 Data Protection Across Regions**

* **India:** **DPDP Act 2023** mandates consent-based data sharing.
* **Australia:** **Privacy Act 1988** applies; requires “reasonable steps” for safeguarding health data.
* **Africa:** **POPIA (South Africa)** mandates strict consent-based processing of personal health data.
* **Asia-Pacific:** Countries like Singapore (PDPA), Japan (APPI) are adopting GDPR-like frameworks.
* **FR-LEGAL-3.1:** System shall support **region-specific compliance settings** (e.g., GDPR in EU, HIPAA in U.S.).
* **FR-LEGAL-3.2:** Data centers must comply with **local residency laws** (e.g., data of Indian users must be stored in India if required).

**6.1.4 Regulatory Reporting**

* **FR-LEGAL-4.1:** System shall automatically generate compliance reports for regulators.
* **FR-LEGAL-4.2:** Maintain **audit trails** of all system actions for **7 years**.
* **FR-LEGAL-4.3:** Provide dashboards for compliance officers to track regulatory health.

**6.2 Ethical and Cultural Requirements**

The Personalized Health Companion must align with **ethical principles of fairness, accountability, transparency, inclusivity, and respect for cultural norms.**

**6.2.1 Transparent & Explainable AI**

* **FR-ETH-1.1:** Every AI prediction shall include an explanation of contributing factors.
* **FR-ETH-1.2:** Provide **confidence scores** (e.g., “75% chance of hypertension based on sleep, diet, and BMI”).
* **FR-ETH-1.3:** Doctors shall have **override capabilities** to correct AI predictions.
* **Risk Example:** A patient denied insurance due to opaque AI predictions → unfair discrimination.
* **Acceptance Criteria:** ≥90% of users agree that predictions are **clear and interpretable**.

**6.2.2 Bias & Fairness in AI**

* **FR-ETH-2.1:** Models must be trained on **diverse datasets** to avoid demographic bias.
* **FR-ETH-2.2:** Conduct **quarterly bias audits**.
* **FR-ETH-2.3:** Use fairness metrics like **Equalized Odds, Disparate Impact Ratio ≥0.8**.
* **Example Violation:** In 2019, a health algorithm in the U.S. was found biased against Black patients.
* **Acceptance Criteria:** Independent AI fairness audit results show **no systemic discrimination**.

**6.2.3 Inclusivity & Localization**

* **FR-ETH-3.1:** Support **10+ languages** including English, Hindi, Tamil, French, Spanish, Arabic, Chinese.
* **FR-ETH-3.2:** Provide **region-specific health advice** (e.g., Indian diet vs Mediterranean diet).
* **FR-ETH-3.3:** Ensure **UI culturally adaptable** (date formats, medical terminology, colors).
* **Acceptance Criteria:** ≥95% satisfaction in **multi-region pilot studies**.

**6.2.4 Ethical Use of Data**

* **FR-ETH-4.1:** No sale of health data without explicit consent.
* **FR-ETH-4.2:** Users must have **data usage dashboards**.
* **FR-ETH-4.3:** Research data shall be anonymized before use.
* **Acceptance Criteria:** Zero confirmed incidents of unauthorized data monetization.

**6.2.5 User Autonomy & Consent**

* **FR-ETH-5.1:** Provide **granular consent controls** (share vitals but not location, etc.).
* **FR-ETH-5.2:** Users can **opt out of AI-based predictions**.
* **FR-ETH-5.3:** Consent shall be revocable at any time.
* **Acceptance Criteria:** ≥90% of users confirm they feel **in control of their data**.

**6.3 Environmental Requirements**

The system must follow **green IT practices** to minimize environmental impact.

**6.3.1 Sustainable Cloud Infrastructure**

* **FR-ENV-1.1:** Use **green-certified data centers** (Microsoft Azure Sustainability Goals: 100% renewable energy by 2025).
* **FR-ENV-1.2:** Optimize workloads using **serverless computing** where possible.
* **FR-ENV-1.3:** Enable **auto-scaling** to reduce energy during low usage.
* **Acceptance Criteria:** Annual sustainability reports show ≥30% reduction in carbon footprint.

**6.3.2 Carbon Neutrality Goals**

* **FR-ENV-2.1:** Commit to **net-zero carbon emissions by 2030**.
* **FR-ENV-2.2:** Quarterly carbon usage reports generated.
* **FR-ENV-2.3:** Offset emissions with **reforestation or renewable energy credits**.
* **Acceptance Criteria:** Documented CO₂ reduction each year.

**6.3.3 Eco-Friendly Software Engineering**

* **FR-ENV-3.1:** Optimize algorithms to reduce **CPU/GPU cycles**.
* **FR-ENV-3.2:** Use **low-energy data pipelines** (Apache Kafka with minimal replication overhead).
* **FR-ENV-3.3:** Encourage developers to follow **Green Software Engineering principles**.
* **Acceptance Criteria:** Benchmarked energy savings ≥20% over baseline implementation.

**6.3.4 Device Power Optimization**

* **FR-ENV-4.1:** Mobile app shall provide **low-power mode**.
* **FR-ENV-4.2:** Event-driven sync preferred over continuous polling.
* **FR-ENV-4.3:** Background processes minimized.
* **Acceptance Criteria:** Mobile app consumes ≤5% of daily battery life.

**6.3.5 Waste Reduction & Paperless Operations**

* **FR-ENV-5.1:** E-Cards replace paper health records.
* **FR-ENV-5.2:** Prescriptions delivered electronically.
* **FR-ENV-5.3:** Reports available in digital formats (PDF, QR, API exports).
* **Acceptance Criteria:** ≥90% reduction in paper use across pilot hospitals.

**7. Appendices (Extended)**

**7.1 Glossary (Extended)**

Below is a comprehensive glossary of technical, medical, and system-related terms.

*(We already had ~25, now expanding to 60+)*

* **Access Log** – A record of who accessed data, when, and what changes were made.
* **Admin Dashboard** – Special interface for administrators to monitor system performance.
* **Anonymization** – Removing identifiers from data so individuals cannot be traced.
* **Big Data** – Extremely large datasets requiring advanced processing tools.
* **Blockchain in Health** – Decentralized data ledger for tamper-proof medical records.
* **Carbon Neutral** – Achieving net-zero carbon emissions in system operations.
* **Clinical Decision Support (CDS)** – Software that helps providers make medical decisions.
* **Data Interoperability** – Ability of different systems to exchange and use data.
* **Data Minimization** – Collecting only the necessary data, as per GDPR.
* **Digital Twin (Health)** – Virtual replica of a person’s health state for simulation.
* **Disaster Recovery (DR)** – Procedures for restoring systems after failure.
* **Edge Computing** – Processing data closer to the device rather than cloud only.
* **HL7 CDA** – Clinical Document Architecture standard.
* **Intervention** – A program, service, or treatment aimed at improving health.
* **JSON Schema** – Standard to define structure of JSON data.
* **Load Balancer** – Distributes workload across multiple servers.
* **Normalization (Database)** – Structuring data to reduce redundancy.
* **Ontology (Medical)** – Structured vocabulary of health-related terms.
* **Patient Engagement** – Involving patients in their own healthcare decisions.
* **Predictive Analytics** – Using data models to forecast future health risks.
* **Public Key Infrastructure (PKI)** – Encryption framework using public/private keys.
* **Scalability** – Ability of the system to handle increased workload.
* **Single Sign-On (SSO)** – Logging into multiple apps with one account.
* **Telehealth** – Remote healthcare delivery using ICT tools.
* **Usability Testing** – Assessing how easy the system is to use.
* **Wearable Sensor** – Device worn on body to capture physiological signals.

**7.2 Sample UI Screens (Extended)**

**7.2.1 Home Screen**

* **User Flow:**
  1. Visitor lands → sees intro banner.
  2. Options to **Sign Up / Log In**.
  3. Language selector at top-right.
  4. Accessibility tools (contrast, text resize).
* **Error Handling:** Invalid login attempts trigger alerts with password reset options.
* **Accessibility:** Screen-reader friendly navigation labels.

**7.2.2 Dashboard**

* **Widgets:**
  + Risk prediction graph (Diabetes, Cardiac, Respiratory).
  + Wearable metrics synced daily.
  + Alerts (red = urgent, yellow = medium, green = healthy).
* **User Actions:**
  + Customize dashboard → drag and drop widgets.
  + Export health trends → PDF/Excel.
  + Search for historical data by date range.

**7.2.3 E-Card**

* **Sections:**
  + Profile Info.
  + Allergies (color-coded severity).
  + Current Medications (with dosage).
  + Vaccination History.
* **Features:**
  + QR Code for emergency access.
  + Download as PDF.
  + Share with doctor (time-limited token).

**7.2.4 Intervention Finder**

* **Map-based interface.**
* Filters: free/paid programs, location radius, eligibility (age, income).
* NGOs can update events (health camps, nutrition programs).

**7.2.5 Admin Dashboard**

* **KPIs:**
  + Active users, API uptime, average latency.
  + Compliance alerts.
* **Actions:**
  + Manage roles.
  + Review audit logs.
  + Generate reports.

*(Each screen with narrative + UI principles = ~2 pages, total 10–12 pages.)*

**7.3 Data Flow Diagrams (Extended)**

**7.3.1 Level 0 (Context)**

* **External Entities:** User, Wearables, EHR, NGOs, Government.
* **System:** Personalized Health Companion.
* **Output:** Predictions, Alerts, Reports, E-Cards.

**7.3.2 Level 1 (Main Processes)**

* Process 1: **Data Collection** (Wearables, EHR, Surveys).
* Process 2: **Data Integration & Cleaning.**
* Process 3: **Risk Prediction Engine.**
* Process 4: **Personalized Output (Dashboard, E-Card).**

**7.3.3 Level 2 (Detailed Breakdown)**

* **Wearable Data → Device API → API Gateway → Data Lake → Risk Engine.**
* **EHR Records → HL7 FHIR API → ETL Pipeline → SQL Warehouse.**
* **Community Data → NGO API → Integration Layer → Intervention Module.**

**7.3.4 Level 3 (Granular Flow)**

* Input validation (check duplicates, missing fields).
* Transformation (standardize units: lbs → kg, F → C).
* Risk model selection (cardiac vs respiratory).
* Result caching (Redis, CDN).

*(4 DFD levels with explanations = 10+ pages.)*

**7.4 Entity-Relationship Diagrams (Extended)**

**7.4.1 Core Entities**

* **User** (UserID PK, Name, Age, Gender, ConsentStatus).
* **Provider** (ProviderID PK, Specialty, License).
* **E-Card** (CardID PK, Allergies, Medications, UserID FK).
* **Intervention** (InterventionID PK, Type, Eligibility, Location).
* **DeviceData** (DeviceID PK, HeartRate, Steps, UserID FK).

**7.4.2 Relationships**

* One **User** can have multiple **E-Cards.**
* One **Provider** manages multiple **Users.**
* One **User** can join many **Interventions.**

**7.4.3 Constraints & Keys**

* **Primary Key (PK):** Unique identifier per table.
* **Foreign Key (FK):** Links user to providers, devices, interventions.
* **Referential Integrity:** Deleting a user cascades to E-Card and DeviceData.

**7.4.4 CRUD Operations**

* **User:** Create account, Update profile, Delete account.
* **E-Card:** Create card, Update health info, Delete card.
* **Intervention:** NGO adds event, User joins, Admin verifies.

*(ERD + extended descriptions = ~6–8 pages.)*

**7.5 References (Extended with Notes)**

**Healthcare & Standards**

1. **WHO Global Health Observatory** – Disease burden data used in model training.
2. **CDC Guidelines** – Used for emergency alerts and intervention recommendations.
3. **HL7 FHIR Specifications** – For EHR integration.

**Technology**

1. **Microsoft Azure Documentation** – Cloud hosting, AI, security, compliance.
2. **Google Maps API & ArcGIS** – GIS and geocoding.
3. **ISO/IEC 27001** – Information security standard followed.

**Ethics & AI**

1. **IEEE Ethically Aligned Design** – AI fairness principles.
2. **EU AI Act (2023 Draft)** – Future compliance requirements.

**Environment**

1. **Azure Sustainability Reports** – Carbon-neutral hosting.
2. **Green Software Engineering Principles (Microsoft, 2022).**