Software Requirements Specification
CattleCare Pro

IEEE Std 830-1998 Compliant Document

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Chapter 1

Introduction

1.1 Purpose

1.1.1 Document Purpose

This Software Requirements Specification (SRS) document provides a complete and precise description of the requirements for the CattleCare Pro livestock monitoring and management system. This document has been prepared in strict accordance with IEEE Std 830-1998, "IEEE Recommended Practice for Software Requirements Specifications," to ensure clarity, completeness, and verifiability of all stated requirements.

The primary purposes of this document are to:

- Define all functional and non-functional requirements for the CattleCare Pro system

- Establish a contractual foundation between stakeholders and developers

- Provide a reference for validation and verification activities

- Serve as a basis for cost estimation and project planning

- Guide system design and implementation decisions

1.1.2 Intended Audience and Reading Suggestions

This SRS is intended for multiple stakeholders, each with specific interests:

1.1.2.1   Software Developers and Engineers

Developers will use this document as the primary reference for understanding what functionality must be implemented. Section 3 (Specific Requirements) contains detailed technical specifications that should be consulted throughout the development lifecycle.

1.1.2.2   Project Managers and Supervisors

Project managers will use this document to plan resources, estimate costs, and schedule development milestones. The product scope (Section 1.3) and constraints (Section 2.6) are particularly relevant for project planning purposes.

1.1.2.3   Quality Assurance and Testing Teams

QA teams will use this SRS to develop test plans, test cases, and validation criteria. Every requirement in this document is written to be verifiable, meaning that test procedures can be designed to objectively determine whether each requirement has been satisfied.

1.1.2.4   Academic Evaluators

Faculty members and academic evaluators will use this document to assess the completeness and quality of the requirements engineering process, as well as compliance with IEEE standards and software engineering best practices.

1.1.2.5   Farm Owners and Stakeholders

End users and farm management personnel will use sections 1 and 2 to understand the system's capabilities, limitations, and expected benefits.

1.1.3   Product Scope

1.1.3.1   Product Name and Identity

The software product specified in this document is named **CattleCare Pro**, a comprehensive livestock monitoring and management system designed specifically for cattle farming operations.

1.1.3.2 Product Benefits and Objectives

CattleCare Pro aims to revolutionize cattle farming through technology-enabled monitoring and data-driven decision making. The primary benefits include:

1.1.3.2.1 Enhanced Animal Welfare By providing real-time monitoring of cattle location and activity patterns, the system enables farmers to quickly identify animals in distress, detect health issues early, and respond promptly to emergency situations.

1.1.3.2.2 Operational Efficiency The system automates many time-consuming manual tasks such as counting animals, monitoring their locations, and tracking their movements, freeing farm workers to focus on higher-value activities.

1.1.3.2.3 Data-Driven Decision Making Historical data analytics and trend analysis empower farm managers to make informed decisions about feeding schedules, breeding programs, and veterinary interventions based on objective data.

1.1.3.2.4 Theft Prevention and Security GPS tracking and geofencing capabilities help prevent cattle theft, a significant problem in many agricultural regions. The system can alert owners immediately when animals move beyond designated boundaries.

1.1.3.3 Product Scope Boundaries

1.1.3.3.1 Within Scope

- Real-time GPS tracking of individual cattle

- Activity monitoring and behavior pattern analysis

- Automated anomaly detection and alert generation

- Cloud-based data storage and management

- Mobile application for Android platforms

- Analytics dashboards using Power BI

- User authentication and access control

- Historical data analysis and trend identification

1.1.3.3.2 Outside Scope

- Veterinary diagnosis or medical treatment recommendations

- Automated feeding systems or equipment control

- Financial management or accounting functions

- Integration with existing legacy farm management systems (initial version)

1.2 Document Conventions

1.2.1 Requirement Priority and Necessity

This SRS follows IEEE recommended conventions for expressing requirements:

1.2.1.1 Mandatory Requirements

Requirements expressed using the keyword **shall** are mandatory and must be implemented exactly as specified. For example: "The system shall authenticate users before granting access."

1.2.1.2 Desirable Requirements

Requirements expressed using **should** are highly desirable but not absolutely mandatory. For example: "The system should provide data export capabilities in multiple formats."

1.2.1.3 Optional Requirements

Requirements expressed using **may** are optional features that could enhance the system but are not required for basic operation.

1.2.2 Typographical Conventions

- **Bold text** is used for requirement keywords (shall, should, may) and emphasis

- *Italic text* is used for document references and technical terminology

- `Monospace font` is used for system messages and technical identifiers

- ALL CAPS is used for acronyms and abbreviations

1.2.3   Requirement Labeling Convention

Each specific requirement is assigned a unique identifier:

- FR-XX: Functional Requirements

- NFR-XX: Non-Functional Requirements

- IR-XX: Interface Requirements

- DR-XX: Design Constraint Requirements

1.3   Definitions, Acronyms, and Abbreviations

1.3.1   Definitions

1.3.1.0.1   Anomaly   Any deviation from normal cattle behavior patterns as determined by the system's algorithms.

1.3.1.0.2   Cloud Platform   Remote server infrastructure accessed via the internet that provides data storage and processing capabilities.

1.3.1.0.3   GPS Collar   GPS-enabled hardware device attached to cattle that collects location and movement data.

1.3.1.0.4   Dashboard   Visual interface displaying key metrics, charts, and summary information about cattle status.

1.3.1.0.5   Farm Administrator   Primary system user with full access privileges, typically the farm owner or manager.

1.3.1.0.6   Geofence   Virtual boundary defined by GPS coordinates that creates a designated area.

1.3.1.0.7   Real-time   Information processing and display occurring with minimal delay (typically less than 5 seconds).

1.3.2 Acronyms

Acronym	Definition
API	Application Programming Interface
GPS	Global Positioning System
HTTPS	Hypertext Transfer Protocol Secure
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
JSON	JavaScript Object Notation
SMS	Short Message Service
SRS	Software Requirements Specification
UI	User Interface
UX	User Experience

1.4 References

1. IEEE Std 830-1998, IEEE Recommended Practice for Software Requirements Specifications

2. Course Material — Software Engineering, Namal University, Fall 2025

1.5 Overview

The remainder of this SRS is organized as follows:

Chapter 2: Overall Description provides high-level context including product perspective, functions, user characteristics, constraints, and assumptions.

Chapter 3: Specific Requirements contains detailed functional and non-functional requirements with unique identifiers.

Chapter 4: System Models presents visual representations including use case diagrams, and context diagrams.

Chapter 5: Appendices contains supporting information and additional documentation.

Chapter 2

Overall Description

2.1 Product Perspective

CattleCare Pro is a new, self-contained software system designed specifically for livestock monitoring and management. The system integrates multiple technology components:

2.1.1 Hardware Components

- **GPS Collar Devices:** Wearable IoT devices attached to cattle that collect location and movement data

- **Mobile Devices:** Android smartphones and tablets used by farm personnel

- **Cameras:** Visual monitoring equipment for enhanced surveillance

2.1.2 Software Components

- **Cloud Backend Services:** Server applications that process data and manage storage

- **Mobile Application:** Native Android app providing user interface

- **Analytics Platform:** Power BI integration for data visualization

2.1.3 Communication Infrastructure

- **Cellular Networks:** 4G connectivity for data transmission

- **WiFi Networks:** Local wireless connectivity for mobile devices

- **Internet Connectivity:** Broadband connection for cloud service access

2.2   Product Functions

The major functions of CattleCare Pro include:

2.2.1   Real-Time Cattle Tracking

The system shall continuously monitor and display the current location of all cattle equipped with GPS collars, enabling:

- View cattle locations on interactive maps

- Track movement patterns throughout the day

- Identify exact positions during emergencies

- Verify animals remain within designated areas

2.2.2   Activity Monitoring and Analysis

The system shall analyze movement data to understand cattle behavior:

- Detect periods of activity versus rest

- Identify unusual behavior patterns indicating health issues

- Track grazing patterns and feeding behavior

- Monitor reproductive behavior indicators

2.2.3   Anomaly Detection and Alerting

The system shall automatically identify abnormal situations:

- Cattle leaving designated areas (geofence violations)

- Extended periods of inactivity suggesting illness

- Unusual movement patterns

- Device malfunctions or connectivity loss

2.2.4 Data Storage and Management

All collected data shall be securely stored in cloud infrastructure with:

- Redundancy to prevent data loss

- Encryption to protect privacy

- Retention of historical data for trend analysis

- Efficient retrieval mechanisms

2.2.5 Analytics and Reporting

The system shall provide sophisticated analysis capabilities:

- Historical trend analysis using Power BI

- Comparative analysis between animals or groups

- Customizable reports for different needs

- Visual dashboards showing key performance indicators

- Export capabilities for external analysis

2.2.6 User Management

The system shall provide secure authentication and authorization:

- User account creation and management

- Role-based access control

- Password management and recovery

- Audit logging of user actions

2.3   User Classes and Characteristics

2.3.1   Farm Owner / Administrator

2.3.1.1   Characteristics

- **Technical Skill Level:** Basic to intermediate

- **Age Range:** 30-60 years

- **Usage Frequency:** Daily, multiple times per day

- **Primary Device:** Mobile phone

2.3.1.2   Responsibilities

- Monitor overall herd health and status

- Make strategic decisions based on system data

- Respond to critical alerts

- Configure system settings

- Generate reports for business purposes

2.3.2   Farm Worker

2.3.2.1   Characteristics

- **Technical Skill Level:** Basic

- **Age Range:** 20-50 years

- **Usage Frequency:** Daily during work hours

- **Role:** Indirect - provides information to Farm Owner

2.3.2.2   Responsibilities

- Observe cattle during field rounds

- Report observations to administrator

- Assist in physical cattle management

2.3.3 System Administrator

2.3.3.1 Characteristics

- **Technical Skill Level:** Advanced

- **Age Range:** 25-45 years

- **Usage Frequency:** As needed for maintenance

2.3.3.2 Responsibilities

- System installation and configuration

- User account management

- Database maintenance and backups

- Security monitoring

- Performance optimization

- Technical support

Table 2.1: User Class Comparison

User Class	Skill Level	Primary Device	Key Requirements
Farm Owner/Admin	Basic-Intermediate	Mobile + Desktop	Easy interface, comprehensive data
Farm Worker	Basic	None (indirect)	Manual reporting to owner
System Admin	Advanced	Desktop	Full system access, technical tools

2.4 Operating Environment

2.4.1 Hardware Environment

2.4.1.1 Collar Devices

- Rugged, weatherproof construction (IP67 rating)

- Battery life: minimum 7 days

- GPS accuracy: ±5 meters

- Operating temperature: -20°C to +50°C

- Weight: Maximum 500 grams

- Cellular connectivity: 4G with 3G fallback

2.4.1.2 Mobile Devices

- Android devices: Android 10.0+ required

- Minimum screen size: 4.7 inches

- Cellular or WiFi connectivity required

- Minimum 2GB RAM, 32GB storage

2.4.1.3 Desktop Computers

- Windows 10+ or macOS 10.15+

- Modern web browser (Chrome, Firefox, Safari, Edge)

- Minimum 4GB RAM

- Internet connection: 5 Mbps minimum

2.4.2 Software Environment

2.4.2.1 Cloud Platform

- Microsoft Azure or Amazon Web Services

- Scalable compute and storage resources

- IoT Hub or equivalent service

- Database service (SQL or NoSQL)

2.4.2.2 Mobile Platform

- Native Android application (Kotlin)

- Minimum API level: Android API 29

2.4.2.3   Analytics Platform

- Microsoft Power BI Desktop and Service

- Power BI Mobile applications

- Data gateway for cloud connectivity

2.4.3   Network Environment

- **Cellular:** 4G coverage in grazing areas

- **Internet:** Broadband minimum 10 Mbps at farm office

- **Mobile:** Cellular data or farm WiFi

2.5   Design and Implementation Constraints

2.5.1   Regulatory Compliance

- Compliance with local data protection laws

- Animal welfare monitoring requirements

- Wireless communication regulations

2.5.2   Technology Constraints

- **Battery Life:** GPS readings must balance accuracy with power consumption

- **Network Coverage:** Limited cellular coverage in rural areas

- **GPS Accuracy:** Signal quality affected by terrain and weather

2.5.3   Development Constraints

- Fixed academic semester timeline

- Development team size: 3 developers

- Limited budget for cloud services

- Access to farm environments for testing

2.5.4 Security Constraints

- Multi-factor authentication for admin access

- End-to-end encryption for sensitive data

- Secure communication protocols (HTTPS)

2.6 Assumptions and Dependencies

2.6.1 Assumptions

- **A1:** Adequate cellular network coverage exists in grazing areas

- **A2:** Farm owner possesses Android smartphone

- **A3:** Reliable internet connectivity available at farm

- **A4:** GPS collars can be securely attached to cattle

- **A5:** Cloud service providers maintain service levels

- **A6:** Users have basic smartphone operation skills

- **A7:** Users willing to adopt technology-based practices

- **A8:** Collar devices will be regularly maintained

2.6.2 Dependencies

- **D1:** Cloud platform services availability

- **D2:** Cellular network infrastructure

- **D3:** GPS satellite system operation

- **D4:** Android operating system updates

- **D5:** Power BI platform licensing

- **D6:** GPS collar device manufacturer support

- **D7:** Cellular service provider coverage

Chapter 3

Specific Requirements

3.1 Functional Requirements

3.1.1 User Authentication and Authorization

3.1.1.0.1 FR-01: User Account Creation The system shall allow authorized administrators to create new user accounts by providing username, email address, password, full name, and role assignment. Account creation shall generate a unique user identifier.

3.1.1.0.2 FR-02: Secure Login The system shall authenticate users by verifying username/email and password credentials against the encrypted database. Upon successful authentication, the system shall create a secure session token valid for 24 hours.

3.1.1.0.3 FR-03: Password Security The system shall enforce password requirements: minimum 8 characters, at least one uppercase letter, one lowercase letter, one number, and one special character. Passwords shall be stored using bcrypt hashing.

3.1.1.0.4 FR-04: Password Recovery The system shall provide password reset functionality via email verification. Users shall receive a time-limited reset link (valid 1 hour) to set a new password.

3.1.1.0.5 FR-05: Role-Based Access Control The system shall implement two primary user roles:

- **Administrator:** Full system access including user management and system configuration

- **Viewer:** Read-only access to reports and dashboards

3.1.1.0.6   FR-06: Session Management   The system shall automatically terminate inactive user sessions after 30 minutes. Users shall receive a warning 5 minutes before automatic logout.

3.1.2   Cattle Registration and Management

3.1.2.0.1   FR-07: Add New Cattle Record   The system shall allow administrators to register new cattle by entering unique identification number (tag ID), collar device ID, breed, date of birth, gender, and optional notes. The system shall validate uniqueness of tag ID and collar ID.

3.1.2.0.2   FR-08: Update Cattle Information   The system shall allow authorized users to modify cattle profile information. All changes shall be logged with timestamp and user identification.

3.1.2.0.3   FR-09: Remove Cattle Record   The system shall allow administrators to deactivate cattle records when animals are sold or deceased. Historical data shall be retained for archived records.

3.1.2.0.4   FR-10: Search and Filter Cattle   The system shall provide search and filter capabilities by tag ID, collar ID, breed, age range, gender, and status. Results shall be displayed in sortable tables.

3.1.2.0.5   FR-11: Create Cattle Groups   The system shall allow administrators to define cattle groups (e.g., "Breeding Stock," "Calves 2024") and assign multiple cattle to each group.

3.1.3   Real-Time Location Tracking

3.1.3.0.1   FR-12: Receive GPS Coordinates   The system shall continuously receive GPS coordinates (latitude, longitude) from all active collar devices. Data reception

shall include timestamp, device ID, and accuracy estimate.

3.1.3.0.2 FR-13: Data Transmission Frequency GPS collar devices shall transmit location data at configurable intervals, with default setting of every 5 minutes during daytime and every 15 minutes during nighttime.

3.1.3.0.3 FR-14: Display Current Locations The system shall display current location of all tracked cattle on an interactive map. Each cattle location shall be represented by a marker showing tag ID.

3.1.3.0.4 FR-15: Map Interaction Features The map interface shall support zoom, pan, marker click for details, legend, and layer controls for geofences.

3.1.3.0.5 FR-16: Location Refresh The system shall automatically update displayed cattle locations when new GPS data is received without requiring manual refresh.

3.1.3.0.6 FR-17: Individual Cattle Tracking The system shall allow users to select a specific animal and view its current location, recent movement path (last 24 hours), and relevant details.

3.1.3.0.7 FR-18: Store Location History The system shall store all received GPS coordinates in the cloud database with associated metadata: timestamp, cattle ID, coordinates, accuracy, and battery level.

3.1.3.0.8 FR-19: Display Historical Paths The system shall allow users to query and display historical movement paths for any cattle over a specified date range. Paths shall be rendered as connected lines on the map.

3.1.4 Activity Monitoring

3.1.4.0.1 FR-20: Record Movement Data Collar devices shall record accelerometer data to detect animal movement and activity levels. Activity metrics shall be computed and transmitted with location data.

3.1.4.0.2   FR-21: Activity Classification   The system shall classify cattle activity into categories: Active (moving/grazing), Resting (lying down), Feeding (head-down position), and Unknown.

3.1.4.0.3   FR-22: Calculate Daily Activity Metrics   The system shall compute daily activity summaries for each animal: total active time, total rest time, activity percentage, and number of transitions.

3.1.4.0.4   FR-23: Activity Pattern Recognition   The system shall analyze activity patterns over time to establish baseline behavior profiles and detect deviations from normal patterns.

3.1.4.0.5   FR-24: Comparative Activity Analysis   The system shall allow users to compare activity levels between multiple cattle or between an individual and herd average.

3.1.5   Geofence Management

3.1.5.0.1   FR-25: Create Geofence Areas   The system shall allow administrators to define geofence boundaries by drawing polygons on a map or entering GPS coordinates. Each geofence shall have a unique name and description.

3.1.5.0.2   FR-26: Multiple Geofence Support   The system shall support creation of multiple geofence areas representing different pastures and restricted zones.

3.1.5.0.3   FR-27: Modify Geofences   The system shall allow administrators to edit geofence boundaries and active status without deleting historical violation records.

3.1.5.0.4   FR-28: Detect Geofence Violations   The system shall evaluate each GPS location against all active geofences and detect when cattle enter or exit boundaries. Violations shall be recorded with timestamp.

3.1.5.0.5   FR-29: Geofence Status Display   The system shall display current geofence compliance status for all cattle on the monitoring dashboard.

3.1.6   Alert and Notification System

3.1.6.0.1   FR-30: Geofence Violation Alerts   The system shall automatically generate high-priority alerts when cattle exit designated safe zones. Alerts shall include cattle identification, location, time, and geofence name.

3.1.6.0.2   FR-31: Inactivity Alerts   The system shall generate medium-priority alerts when cattle activity falls below threshold levels for extended periods (configurable, default 4 hours).

3.1.6.0.3   FR-32: Device Malfunction Alerts   The system shall generate alerts when collar device battery falls below 15

3.1.6.0.4   FR-33: Unusual Activity Alerts   The system shall generate alerts when cattle exhibit abnormal activity patterns significantly different from established baselines.

3.1.6.0.5   FR-34: Push Notifications   The system shall deliver alert notifications to mobile devices via push notification service within 30 seconds of alert generation.

3.1.6.0.6   FR-35: SMS Notification   The system shall support optional SMS text message delivery of critical alerts to designated phone numbers.

3.1.6.0.7   FR-36: In-App Alert Center   The mobile application shall maintain an Alert Center displaying all alerts with status (new, acknowledged, resolved).

3.1.6.0.8   FR-37: Acknowledge Alerts   The system shall allow users to acknowledge alerts to indicate awareness. Acknowledged alerts shall be marked with timestamp and user identity.

3.1.6.0.9   FR-38: Resolve Alerts   The system shall allow users to mark alerts as resolved with optional resolution notes.

3.1.6.0.10   FR-39: Configure Alert Preferences   The system shall allow administrators to configure alert thresholds, notification channels, and user assignments.

3.1.7   Data Analytics and Reporting

3.1.7.0.1   FR-40: Real-Time Dashboard   The system shall provide a main dashboard displaying total cattle count, cattle by status, active alerts count, geofence compliance summary, and recent activity highlights.

3.1.7.0.2   FR-41: Individual Cattle Dashboard   The system shall provide detailed dashboard for individual animals showing current location, activity graphs, alert history, and key metrics.

3.1.7.0.3   FR-42: Herd Overview Analytics   The system shall provide herd-level analytics including activity distribution charts, location heat maps, health status summary, and trend indicators.

3.1.7.0.4   FR-43: Power BI Integration   The system shall integrate with Microsoft Power BI for advanced data visualization, enabling users to create custom dashboards and reports.

3.1.7.0.5   FR-44: Daily Activity Reports   The system shall generate automated daily reports summarizing cattle locations, activity levels, alerts generated, and any incidents.

3.1.7.0.6   FR-45: Custom Report Builder   The system shall provide a report builder allowing users to create custom reports by selecting data sources, date ranges, and output format.

3.1.7.0.7   FR-46: Scheduled Reports   The system shall allow administrators to schedule automated report generation and delivery via email at specified intervals (daily, weekly, monthly).

3.1.7.0.8   FR-47: Trend Analysis   The system shall provide trend analysis tools showing activity patterns, location preferences, and behavior changes over selectable time periods.

3.1.7.0.9 FR-48: Comparative Analysis The system shall allow comparison of metrics between individual cattle, groups, and time periods to identify outliers and patterns.

3.1.8 System Administration

3.1.8.0.1 FR-49: User Account Management The system shall allow administrators to create new accounts, modify user details, change roles, reset passwords, and deactivate accounts. All actions shall be logged.

3.1.8.0.2 FR-50: Audit Logging The system shall maintain comprehensive audit logs recording user actions, system changes, data modifications, and security events with timestamps.

3.1.8.0.3 FR-51: General System Settings The system shall provide configuration interface for organization details, time zone, measurement units, and date/time formats.

3.1.8.0.4 FR-52: Device Management The system shall allow administrators to register new collar devices, assign devices to cattle, modify device settings, and view device status.

3.1.8.0.5 FR-53: Notification Configuration The system shall allow configuration of alert thresholds, notification channels, escalation rules, and quiet hours.

3.1.8.0.6 FR-54: Data Backup The system shall perform automated daily backups of all system data to secure cloud storage with retention period of 90 days.

3.2 Non-Functional Requirements

3.2.1 Performance Requirements

3.2.1.0.1 NFR-01: User Interface Response The system shall respond to 95% of user interface interactions within 2 seconds under normal load conditions.

3.2.1.0.2   NFR-02: Map Loading Time   The interactive map with cattle locations shall load and display within 3 seconds for herds up to 500 animals.

3.2.1.0.3   NFR-03: Alert Delivery Time   Critical alerts shall be delivered to user mobile devices within 30 seconds of alert trigger event.

3.2.1.0.4   NFR-04: Data Synchronization   The system shall synchronize new GPS data to the database within 10 seconds of data reception by cloud platform.

3.2.1.0.5   NFR-05: Report Generation   Standard reports shall be generated within 10 seconds for date ranges up to 30 days.

3.2.1.0.6   NFR-06: Concurrent GPS Processing   The system shall process GPS data from at least 1,000 collar devices simultaneously.

3.2.1.0.7   NFR-07: Concurrent User Support   The system shall support at least 50 concurrent users accessing the mobile or web applications simultaneously without performance degradation.

3.2.1.0.8   NFR-08: Database Query Performance   Database queries for current cattle status shall execute in under 1 second for herds up to 1,000 animals.

3.2.2   Reliability Requirements

3.2.2.0.1   NFR-09: System Uptime   The system shall maintain 99.5% uptime excluding planned maintenance windows, allowing maximum 43.8 hours of downtime per year.

3.2.2.0.2   NFR-10: Data Recovery Time   In the event of system failure, data recovery and system restoration shall be completed within 4 hours.

3.2.2.0.3   NFR-11: Backup Verification   System backups shall be verified weekly to ensure recoverability. Backup restoration testing shall be performed quarterly.

3.2.2.0.4   NFR-12: Error Handling   The system shall implement comprehensive error handling with graceful degradation and informative error messages to users.

3.2.2.0.5   NFR-13: Fault Tolerance   The system shall continue operating with degraded functionality if individual components fail, ensuring critical features remain available.

3.2.3   Security Requirements

3.2.3.0.1   NFR-14: Data Encryption   All sensitive data shall be encrypted both in transit (using TLS 1.2+) and at rest (using AES-256 encryption).

3.2.3.0.2   NFR-15: Password Storage   User passwords shall be hashed using bcrypt algorithm with salt before storage. Plain text passwords shall never be stored.

3.2.3.0.3   NFR-16: Session Security   User sessions shall be secured with randomly generated tokens, automatic timeout after 30 minutes of inactivity, and secure cookie attributes.

3.2.3.0.4   NFR-17: Access Control   The system shall enforce role-based access control, preventing unauthorized users from accessing restricted features or data.

3.2.3.0.5   NFR-18: Audit Trail   All security-relevant events (login attempts, permission changes, data modifications) shall be logged with timestamp, user identity, and action details.

3.2.3.0.6   NFR-19: Data Privacy   The system shall ensure that only authorized users can access cattle and farm data, maintaining confidentiality at all times.

3.2.4   Usability Requirements

3.2.4.0.1   NFR-20: Learning Curve   Users with basic smartphone skills shall be able to perform common tasks (view cattle locations, respond to alerts) within 15 minutes of first use.

3.2.4.0.2 NFR-21: Interface Simplicity The mobile application interface shall be intuitive and easy to navigate for users with minimal technical knowledge.

3.2.4.0.3 NFR-22: Help Documentation The system shall provide context-sensitive help and user documentation accessible within the application.

3.2.4.0.4 NFR-23: Error Messages Error messages shall be clear, specific, and provide guidance on how to resolve the issue.

3.2.4.0.5 NFR-24: Consistency User interface elements, terminology, and interaction patterns shall be consistent throughout the application.

3.2.5 Maintainability Requirements

3.2.5.0.1 NFR-25: Code Documentation Source code shall include inline comments for complex logic and comprehensive API documentation.

3.2.5.0.2 NFR-26: Modular Architecture The system shall be designed with modular architecture allowing individual components to be updated without affecting others.

3.2.5.0.3 NFR-27: Version Control All source code shall be maintained in Git version control system with meaningful commit messages.

3.2.5.0.4 NFR-28: Database Maintenance The system shall support routine maintenance operations (backup, optimization, archival) without requiring system shutdown.

3.2.6 Scalability Requirements

3.2.6.0.1 NFR-29: Cattle Population Support The system shall support monitoring of at least 5,000 individual cattle per installation without hardware upgrades.

3.2.6.0.2 NFR-30: Horizontal Scalability The system architecture shall support horizontal scaling of application servers and database instances to accommodate growth.

3.2.6.0.3   NFR-31: Data Storage Capacity   The system shall store complete location and activity data for all cattle for minimum 2 years with efficient retrieval.

3.2.7   Portability Requirements

3.2.7.0.1   NFR-32: Android Platform Support   The mobile application shall run on Android devices version 10.0 and above without modification.

3.2.7.0.2   NFR-33: Cloud Platform Independence   The system architecture shall minimize dependencies on specific cloud provider features to facilitate potential migration.

3.2.8   Availability Requirements

3.2.8.0.1   NFR-34: Planned Maintenance   Planned maintenance windows shall be scheduled during low-usage periods (midnight to 4 AM) with 48-hour advance notification.

3.2.8.0.2   NFR-35: Offline Capability   The mobile application shall cache recently viewed data and provide read-only access when network connectivity is unavailable.

3.3   External Interface Requirements

3.3.1   User Interface Requirements

3.3.1.0.1   IR-01: Mobile Platform Support   The system shall provide native mobile application for Android (version 10.0 and above).

3.3.1.0.2   IR-02: Mobile Navigation Structure   The mobile application shall implement bottom navigation with sections: Dashboard, Map, Alerts, Cattle List, and Settings.

3.3.1.0.3   IR-03: Touch-Friendly Interface   All interactive elements shall have minimum touch target size of 48x48 dp for accessibility.

3.3.1.0.4   IR-04: Responsive Map Interface   The mobile map interface shall support pinch-to-zoom, two-finger rotation, marker clustering, and smooth panning.

3.3.1.0.5   IR-05: Web Browser Compatibility   The web application shall function correctly on current versions of Chrome, Firefox, Safari, and Edge browsers.

3.3.1.0.6   IR-06: Responsive Web Design   The web interface shall adapt to different screen sizes maintaining usability from 1024x768 to 4K displays.

3.3.2   Hardware Interface Requirements

3.3.2.0.1   IR-07: Device Communication Protocol   The system shall communicate with GPS collar devices using MQTT protocol over secure TLS connection.

3.3.2.0.2   IR-08: Data Packet Format   GPS collar devices shall transmit data in JSON format containing device ID, timestamp, GPS coordinates, accuracy, battery percentage, and activity metrics.

3.3.2.0.3   IR-09: Device Command Interface   The system shall support sending configuration commands to devices including data transmission frequency adjustment and low-power mode activation.

3.3.2.0.4   IR-10: Mobile Device GPS Integration   The mobile application may access device GPS to show user location on maps relative to cattle positions.

3.3.3   Software Interface Requirements

3.3.3.0.1   IR-11: Cloud IoT Service   The system shall interface with Azure IoT Hub or AWS IoT Core using standard MQTT or AMQP protocols.

3.3.3.0.2   IR-12: Cloud Database Interface   The system shall interface with cloud database services using standard SQL queries and ORM frameworks.

3.3.3.0.3   IR-13: Cloud Storage Interface   The system shall interface with cloud blob storage for storing images, reports, and backup files.

3.3.3.0.4   IR-14: Mapping Service Integration   The system shall integrate with Google Maps API or equivalent for map display and geocoding functions.

3.3.3.0.5   IR-15: SMS Gateway Interface   The system shall interface with SMS gateway service via REST API for sending text notifications.

3.3.3.0.6   IR-16: Email Service Interface   The system shall interface with email delivery service via SMTP or REST API for notifications and reports.

3.3.3.0.7   IR-17: Power BI Integration   The system shall expose data through REST API endpoints compatible with Power BI data connectors.

3.3.4   Communication Interface Requirements

3.3.4.0.1   IR-18: HTTPS Communication   All communication between client applications and cloud services shall use HTTPS with TLS 1.2 or higher encryption.

3.3.4.0.2   IR-19: RESTful API   The system shall expose RESTful API following standard HTTP methods (GET, POST, PUT, DELETE).

3.3.4.0.3   IR-20: JSON Data Format   All API communications shall use JSON format for request and response bodies.

3.3.4.0.4   IR-21: API Authentication   API requests shall be authenticated using bearer tokens (JWT) transmitted in Authorization headers.

3.3.4.0.5   IR-22: API Rate Limiting   The API shall implement rate limiting (default 1000 requests per hour) with appropriate HTTP 429 status codes.

3.4   Design Constraints

3.4.0.0.1   DR-01: IEEE Standards Compliance   Software development shall adhere to IEEE Std 830-1998 for requirements specification.

3.4.0.0.2   DR-02: Android Development Standards   The mobile application shall follow Android development best practices and Material Design guidelines.

3.4.0.0.3   DR-03: Cloud Platform Selection   The system shall be deployed on either Microsoft Azure or Amazon Web Services cloud infrastructure.

3.4.0.0.4   DR-04: Programming Language   The Android mobile application shall be developed using JavaScript programming language.

3.4.0.0.5   DR-05: Database Technology   The system shall use SQL database (Azure SQL or Amazon RDS) for structured data storage.

Chapter 4

System Models

4.1 Use Case Model

4.1.1 Use Case Diagram

The use case diagram illustrates the functional interactions between system actors and the CattleCare Pro system. The primary actors are:

- **Farm Owner/Administrator:** Interacts with the system to monitor cattle, receive alerts, view reports, and configure system settings

- **System Administrator:** Manages user accounts, devices, and system configuration

- **GPS Collar Device:** Provides location and activity data (represented as external system)

4.1.2 Primary Use Cases

4.1.2.1 UC-01: User Login

Actor: Farm Owner/Administrator, System Administrator

Precondition: User has valid account credentials

Main Flow:

1. User enters username and password

2. System validates credentials

3. System creates secure session

4. System displays main dashboard

Postcondition: User is authenticated and can access authorized features

4.1.2.2 UC-02: Monitor Cattle Location

Actor: Farm Owner/Administrator

Precondition: User is logged in, GPS collars are active

Main Flow:

1. User navigates to Map view

2. System retrieves current GPS coordinates

3. System displays cattle locations on interactive map

4. User can zoom, pan, and select individual cattle

5. System shows detailed information for selected cattle

Postcondition: User views current cattle locations

4.1.2.3 UC-03: View Activity Data

Actor: Farm Owner/Administrator

Precondition: User is logged in, activity data is available

Main Flow:

1. User selects specific cattle or group

2. User specifies date range

3. System retrieves activity data

4. System displays activity graphs and metrics

5. User can compare with historical baselines

Postcondition: User views activity analysis

4.1.2.4   UC-04: Receive Alert Notification

Actor: Farm Owner/Administrator

Precondition: Alert condition is detected

Main Flow:

1. System detects anomaly (geofence violation, inactivity, etc.)

2. System generates alert record

3. System sends push notification to mobile device

4. User receives and views notification

5. User acknowledges or resolves alert

Postcondition: User is notified of critical event

4.1.2.5   UC-05: Generate Report

Actor: Farm Owner/Administrator

Precondition: User is logged in, data is available

Main Flow:

1. User navigates to Reports section

2. User selects report type and parameters

3. System generates report

4. System displays report with visualizations

5. User can export report in desired format

Postcondition: User obtains analytical report

4.1.2.6   UC-06: Configure Geofence

Actor: Farm Owner/Administrator

Precondition: User is logged in with admin privileges

Main Flow:

1. User navigates to Geofence Management

2. User creates new geofence by drawing on map

3. User names and describes geofence

4. System saves geofence configuration

5. System begins monitoring cattle against new boundary

Postcondition: New geofence is active

4.1.2.7   UC-07: Manage User Accounts

Actor: System Administrator

Precondition: Admin is logged in

Main Flow:

1. Admin navigates to User Management

2. Admin creates, modifies, or deactivates user accounts

3. Admin assigns roles and permissions

4. System validates and saves changes

5. System logs administrative action

Postcondition: User accounts are updated

4.1.3   Use Case Diagram
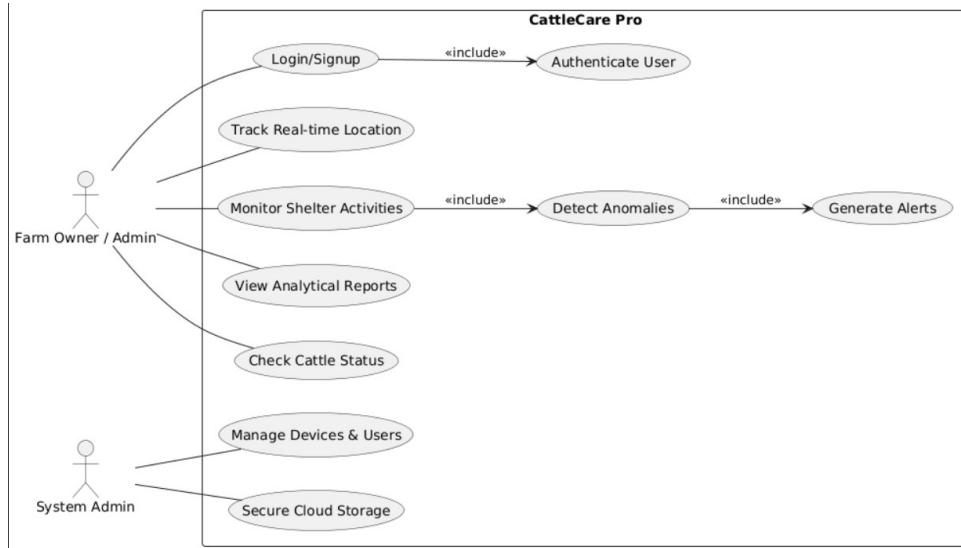
Figure 4.1: Use Case Diagram of CattleCare Pro

4.2   Context Diagram

The context diagram represents the CattleCare Pro system as a single process and shows its interactions with external entities. The system boundary encompasses all internal processing, while external entities include:

- **Farm Owner/Admin:** Submits monitoring requests, receives cattle data and alerts

- **System Administrator:** Manages users, devices, and system configuration

- **GPS Collar Devices:** Provide location and activity data to system

- **Cloud Server:** Stores and processes data

- **Power BI:** Receives data for analytics visualization

4.2.1 Context Diagram
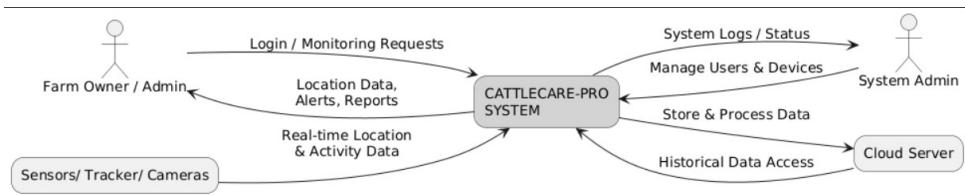
Figure 4.2: Context Diagram of CattleCare Pro

Chapter 5

Appendices

5.1 Glossary

5.1.1 Technical Terms

Accelerometer: A sensor that measures acceleration forces, used in collar devices to detect cattle movement and activity levels.

**API (Application Programming Interface):** A set of protocols and tools for building software applications that specify how components should interact.

Baseline Behavior: The normal or typical activity pattern established for an individual animal over time, used as reference for anomaly detection.

Bearer Token: An authentication token that grants access to protected resources, typically passed in the Authorization header of HTTP requests.

Cloud Computing: Delivery of computing services including servers, storage, databases, and software over the internet.

Collar Device: IoT hardware worn by cattle that includes GPS, accelerometer, battery, and cellular communication capabilities.

Dashboard: A visual display of important information organized for quick monitoring and decision-making.

Data Encryption: Process of converting information into code to prevent unauthorized access.

Geofencing: Use of GPS or RFID technology to create virtual geographic boundary, enabling software to trigger response when device enters or leaves area.

IoT Hub: Cloud service that provides bidirectional communication between IoT application and devices it manages.

JSON (JavaScript Object Notation): Lightweight data interchange format that is easy for humans to read and write.

JWT (JSON Web Token): Compact means of representing claims to be transferred between two parties, commonly used for authentication.

Power BI: Business analytics service by Microsoft providing interactive visualizations with self-service business intelligence capabilities.

Push Notification: Message sent from application to user's device that appears even when application is not actively being used.

5.2 Analysis Models

5.2.1 Cost-Benefit Analysis

5.2.1.1 Implementation Costs

- GPS collar devices: $50-100 per device

- Cloud hosting: $200-500 per month

- Mobile app development: One-time development cost

- System maintenance: Ongoing operational cost

5.2.1.2 Expected Benefits

- Reduced cattle loss from theft (estimated 5-10% reduction)

- Early disease detection reducing mortality

- Improved operational efficiency (20-30% time savings)

- Better grazing management

- Data-driven decision making

5.2.2 Risk Analysis

Table 5.1: Risk Assessment Matrix

Risk	Probability	Impact	Mitigation Strategy
Network coverage gaps	High	High	Store data locally, sync when connected
Device battery failure	Medium	Medium	Low battery alerts, regular maintenance
Cloud service outage	Low	High	Redundant systems, local caching
User adoption resistance	Medium	Medium	Training programs, gradual rollout
Data security breach	Low	High	Encryption, access control, auditing
GPS signal loss	Medium	Medium	Multiple position sources, interpolation

5.3 Future Enhancements

5.3.1 Planned Features for Version 2.0

- **Health Monitoring:** Integration with temperature and heart rate sensors for comprehensive health tracking

- **Breeding Management:** Automated estrus detection and breeding recommendations

- **Feed Optimization:** Integration with feeding systems for automated nutrition management

- **Weather Integration:** Correlation of weather data with cattle behavior

- **Multi-Farm Support:** Capability to manage multiple farm locations from single interface

- **Veterinary Integration:** Direct sharing of data with veterinary systems

- **Machine Learning:** Advanced predictive analytics for disease outbreak prediction

- **Voice Commands:** Hands-free operation using voice interface

- **AR Visualization:** Augmented reality features for field identification

5.3.2 Technology Roadmap

- **Q1 2025:** iOS application development

- **Q2 2025:** Advanced analytics and ML integration

- **Q3 2025:** Health sensor integration

- **Q4 2025:** Multi-farm and enterprise features

5.4 Requirements Traceability Matrix

Table 5.2: Requirements Traceability

Req ID	Requirement	Priority	Test Case
FR-01	User account creation	High	TC-AUTH-01
FR-02	Secure login	High	TC-AUTH-02
FR-03	Password security	High	TC-AUTH-03
FR-12	Receive GPS coordinates	Critical	TC-GPS-01
FR-15	Display current locations	Critical	TC-MAP-01
FR-27	Create geofence areas	High	TC-GEO-01
FR-32	Geofence violation alerts	Critical	TC-ALERT-01
FR-42	Real-time dashboard	High	TC-DASH-01
FR-45	Power BI integration	Medium	TC-BI-01
NFR-01	UI response time	High	TC-PERF-01
NFR-09	System uptime	High	TC-REL-01
NFR-14	Data encryption	Critical	TC-SEC-01

5.5 Supporting Documentation References

5.5.1 Technical Documentation

- Android Development Guide: https://developer.android.com/guide

- Kotlin Programming Language: https://kotlinlang.org/docs

- Google Maps Android API: https://developers.google.com/maps/documentation/android-sdk

- Firebase Cloud Messaging: https://firebase.google.com/docs/cloud-messaging

- Power BI Developer Documentation: https://docs.microsoft.com/power-bi/developer

5.5.2 Academic References

- Wathes, C. M., et al. (2008). "Precision livestock farming." Journal of Agricultural Science.

- Rutten, C. J., et al. (2013). "Invited review: Sensors to support health management on dairy farms." Journal of Dairy Science.

- Berckmans, D. (2014). "Precision livestock farming technologies for welfare management in intensive livestock systems."