LANKA METRO TRANSIT (PVT) LTD

MINISTRY OF TRANSPORT, HIGHWAYS AND URBAN DEVELOPMENT.

FUNCTIONAL REQUIREMENTS SCHEDULE (FRS)

PROCUREMENT FOR THE DESIGN, BUILD, MAINTAIN, AND TRANSFER OF THE METRO BUS DIGITAL PLATFORM (MBDP)

PROCUREMENT NO: LMT/DM/PRO/2026/001/R00

Version 2.0

March 2026

Prepared for: Lanka Metro Transit (PVT) Ltd

ALIGNED WITH: - SRI LANKA NATIONAL DIGITAL ECONOMY BLUEPRINT - SRI LANKA NATIONAL PROCUREMENT GUIDELINES (NPG) - TRANSPORT SECTOR DIGITALIZATION STRATEGY

1. DOCUMENT CONTROL

1.1. Document Information

Item	Details
Document Title	Functional Requirements Schedule Metro Bus Digital Platforr
Document Reference	LMT/DM/PRO/2026/001/R00
Version	2.0
Date	March 2026
Classification	OFFICIAL For Procurement Use

2. CONTENTS

1. PART A: INTRODUCTION AND FRAMEWORK

1.1. Introduction

1.1.1. PURPOSE AND AUTHORITY

This document, titled Functional Requirements Schedule (FRS) Metro Bus Digital Platform, defines the complete, authoritative, and consolidated functional requirements of the Metro Bus Digital Platform (MBDP).

This document has been prepared in alignment with the Sri Lanka National Digital Economy Blueprint and the Transport Sector Digitalization Strategy. It operates under the governance of the Transport Chief Digital Information Officer (CDIO) model, with oversight from the Digital Steering Committee.

Upon approval, this Functional Requirements Schedule shall be treated as the single source of truth for functional scope. All bidders shall base their technical and commercial proposals strictly on the functional requirements defined herein.

1.1.2. DOCUMENT STRUCTURE

- **Part A:** Introduction and Framework
- **Part B:** Functional Requirements by Module
- **Part C:** Interface Specifications
- **Part D:** Delivery Timeline
- **Part E:** Non-Functional Requirements Traceability
- **Part F:** Embedded Systems Specification
- **Part G:** Annexures
- **Annex -SLA** : Service Level Agreements (SLAs)
- **Annex-DPI :** National Digital Transport DPI Alignment

The following presents **all functions related to this project**. A set of abbreviations is used to indicate the **timeline** and the **relevant platforms**. Detailed explanations of these abbreviations are provided below.

1. **Ref** – Used as the **function code**. This reference is used throughout the project to identify the specific function.
2. **Functional Requirement** –Provides a clear and simple description of the required function. It provides a concise explanation of the function's complete operation, enabling an overall understanding of its scope.
3. **Del. = Delivery Phase (P1-P5)**.

   This specifies in which phase the relevant function should be implemented. Functions within the same module may be categorized into different phases based on project requirements.

Del.	Requirement Example	Meaning
P1	View real-time bus locations	This will be delivered in Phase 1 (Core Operations)
P2	Submit general enquiries	This will be delivered in Phase 2 (Operational Admin)
P3	Preventive maintenance scheduling	This will be delivered in Phase 3 (Maintenance)
P4	Automated reorder triggers	This will be delivered in Phase 4 (Stores)

P5	Predictive maintenance analytics	This will be delivered in Phase 5 (Analytics)

4. Int. = Interface (M/W/B/E/P)

The "Int." column indicates which user interface(s) will provide access to this functionality.

4.1. Interface Types:

Interface.	Requirement Example	Who Can Access	How They Access
M = Mobile	• Access via mobile app (iOS/Android) • Designed for a mobile-first user experience • Supports offline capabilities where applicable	Passengers & Staff	Mobile app only
W = Web	• Access via web browser (desktop/laptop) • Full-featured administrative interface • Typically for back-office staff and administrators	Passengers & Staff	Web interface only
B = Both (Mobile + Web)	• Available on both the mobile app and the web interface • Users can access from either platform • Data synchronized across platforms	Passengers & Staff	Both the mobile app and website with login
E = Embedded	• Built into on-bus hardware or bus stop displays • Runs on specialized embedded systems • Not accessible via general-purpose devices	Staff	On-bus HMI (embedded system)
P = Public	• Available to the general public without authentication • Accessible via web and mobile without login • No user account required	Anyone (public)	Mobile app or website, no login needed

***Note** – When implementing the functions mentioned here, additional supporting functions may be required at the practical/operational level across different platforms to properly fulfill these requirements. Please take those into consideration as well.*

1.2. Platform Overview and Scope

1.2.1. UNIFIED PLATFORM CONCEPT

The Metro Bus Digital Platform operates as a single, unified digital ecosystem. All users access the same platform through appropriate interfaces based on their roles and permissions. Users authenticate the first stage using Normal login with OTP verification, and the second stage using SL-UDI (Sri Lanka Universal Digital Identity) credentials.

1.2.2. PLATFORM INTERFACES

1. **Mobile Interface** - Native apps (Android/iOS) for passengers, operators, assistants, technicians, examiners
2. **Web Interface** - Browser-based administrative, management, and operational functions
3. **Embedded Interface** - On-bus systems and bus stop displays
4. **Public Interface** - Unauthenticated access to basic services

1.2.3. INITIAL DEPLOYMENT PARAMETERS

Parameter	Value
Routes	6 selected main routes within Colombo city
Fleet Size	120 buses
Infrastructure	1 dedicated service station
Scalability	Architecture supports 500+ buses, 20+ routes

1.3. Access Control and Governance Framework

1.3.1. USER ROLES

1. **Passenger (Without Account)** - Public information access
2. **Passenger (With Account)** - Full passenger services
3. **Operator (Driver)** - Vehicle operation functions
4. **Assistant** - Passenger service functions
5. **Technician** - Maintenance execution
6. **Examiner** - Quality assurance
7. **Supervisor** - Team oversight
8. **Operations Controller** - Control center functions
9. **HR Administrator** - HR management
10. **Finance Administrator** - Financial functions
11. **Stores Manager** - Inventory and procurement
12. **Fleet Manager** - Vehicle management
13. **System Administrator** - Platform configuration
14. **Super Administrator** - Complete platform control
15. **PPP Vendor -** bus deployment model alongside LMT-owned fleet

1.3.2. SUPER ADMINISTRATOR CAPABILITIES

- User Management (create, modify, deactivate accounts; assign roles)
- Role Management (create, modify, clone roles)

- Dashboard Management (create, assign dashboards)
- Function Access Control (enable/disable functions, set permissions)

1.3.3. MOBILE APPLICATION ARCHITECTURE

The platform SHALL deliver exactly TWO native mobile applications:

PASSENGER APP:	
Target users	**:** General public (authenticated and unauthenticated)
Functions	: All PAS-XX requirements with Int. = M or B
Languages	: Sinhala, Tamil, English (user-selectable)
Distribution	: Public app stores - Google Play and Apple App Store

STAFF APP (single unified application):	
Target users	: All LMT and PPP vendor staff
Architecture	: Single app with role-based feature modules - login detects role(s) and shows only relevant modules
Languages	: English only
Distribution	: Enterprise MDM or private app store

1.3.4. HARDWARE APPLICATION ARCHITECTURE

Bus Core APP (On-Bus MCU Software):	
Target users	:Operators (Drivers), system automated processes
Functions	:All OBS-XX, FAR-XX, PIS-XX, DRV-XX, GPS-XX, BDT-XX, BCS-XX, BSM-XX requirements with Int. = E
Architecture	:Embedded software running on the Main Control Unit (MCU), an industrial computer installed on each bus. The on-bus hardware supplier provides the MCU and all connected devices. The platform vendor develops and maintains the embedded application software that runs on the MCU, coordinating all on-bus subsystems (POS terminals, passenger displays, GPS, CCTV, audio, vehicle sensors) and communicating with the cloud backend via 4G. Offline operation is mandatory when connectivity is unavailable.
Languages	:English (driver interface); Sinhala, Tamil, English (passenger-facing displays and audio)
Distribution	: Pre-installed OS on MCU by hardware supplier; OTA updates managed by Digital platform provider

Bus POS Terminal	
Target users	:Passengers (tap-in/tap-out), Assistants (manual fare operations)
Architecture	:Embedded application on POS terminal hardware; receives route/stop data from MCU; sends transaction summaries back to MCU. Hardware and base terminal firmware supplied by the on-bus hardware supplier. The platform vendor provides only the backend payment engine and transaction processing APIs - the terminal application software is the responsibility of the hardware supplier, with integration via documented APIs to the platform backend.

Languages	: Sinhala, Tamil, English
Distribution	:Enterprise MDM provide platform vendor

Display Boad	
Target users	: General public (passengers at bus stops/stactions)
Architecture	:The display board hardware is supplied and installed by a separate display board hardware supplier. The platform vendor is responsible for providing the backend facility only - i.e., the cloud-side APIs that push real-time arrival data, service alerts, advertising content, and emergency announcements to the display board MCU. The on-board embedded display rendering software (content generation, HDMI output, fallback scheduling, local camera/meter integration) is the responsibility of the display board hardware supplier or digital-platform provider **(But this depends on display hardware type),** digital-platform provider must provide and document backend APIs.
Languages	:Sinhala, Tamil, English (rotating multilingual display content)
Distribution	:If a platform is provided, it can be used; accordingly, otherwise, the digital platform provider must develop an OTA . **This will depend on the display hardware type**

Supplier Responsibility Note:

On-bus hardware (MCU, POS terminals, displays, GPS, CCTV, sensors, audio) bus deports(CCTV System, access control terminal) and bus stop display board hardware (MCU, screen, IP camera, electricity meter, modem) are procured separately from the respective hardware suppliers. Each hardware supplier is responsible for the embedded OS and SDK for building each device communication that runs on their hardware. The platform software vendor's scope covers:

a) the cloud backend platform, APIs, MCU software, payment Terminal App, and Display Board system (It on depends).
b) integration APIs that the hardware embedded software connects to.
c) OTA configuration and content delivery to hardware endpoints. Refer to Part F: Embedded Systems Specification for detailed hardware–software boundary definitions.

1.3.5. STAFF APP ROLE-BASED MODULE STRUCTURE:

Module	Visible To	Key Functions	Phase
General Staff Services	ALL staff (always visible)	Attendance, leave, pay slips, shift view, training, grievance, wellness	P2
Operator Module	Operators (Drivers)	Duty management, vehicle inspection [DVR-01-XX], route navigation, emergency controls [DRV-06-XX]	P2
Assistant Module	Assistants	Passenger assistance, lost and found, and feedback collection	P2
Supervisor Module	Supervisors	Team oversight, approval workflows, performance dashboards	P3

Technician Module	Technicians	Work orders [MNT-03-01 to MNT-03-10], checklists, photo documentation, parts scanning	P4
Examiner Module	Examiners	Inspection queue [MNT-05-01], quality checklists, approval/rejection	P4

Multi-Role Access: A staff member with multiple roles sees ALL assigned modules simultaneously. The home screen shows a module switcher. Role assignments are managed via web admin interface [ADM-01-XX] and sync to the app on login.

Phased Delivery: The Staff App shell (login, general staff services, role detection) is delivered in Phase 2. New modules are added via app update - no separate installation required. Architecture SHALL supports dynamic module loading for future roles.

1.4. Cross-Cutting Functional Principles

1.4.1. NATIONAL DIGITAL INFRASTRUCTURE INTEGRATION

- **SL-UDI:** Universal digital identity for authentication
- **GovPay/Lanka Pay:** All fare transactions through the government payment infrastructure
- **NDX/MoT-DX:** Secure data sharing using GTFS-RT, AVL standard schemas
- **LGC:** Government cloud hosting
- **SOC/NOC:** Security and network monitoring

Note: -

The above-mentioned services form part of the government digital transformation initiative's Digital Blueprint prepared and provided by the Digital Economy Ministry. These components are planned to be rolled out in phases over time. Accordingly, this system must be designed to be integrated with them step by step as they become available. Until such integrations are enabled, the architecture should be designed by reserving appropriate integration placeholders. For services that are critical to the continuous operation of the system, it is appropriate to adopt suitable alternative services that meet the required standards.

The detailed alignment requirements between the MBDP and the National Digital Transport DPI architecture - including component mapping (C1–C9), role separation rules, licensing pathways, C4 integration obligations, data governance mandates, and phased compliance milestones — are defined in **Annex DPI: National Digital Transport DPI Alignment Framework** (Document Reference: MT/04/09/07/MBDP/01-ANNEX-DPI). All bidders must demonstrate compliance with Annex DPI requirements in their technical proposals.

1.4.2. CLOUD HOSTING CONTINGENCY AND LGC MIGRATION

The MBDP platform shall be designed for deployment on the Lanka Government Cloud (LGC) as the primary hosting environment, in accordance with the national Digital Blueprint infrastructure strategy. Where LGC is not available as a fully operational **public cloud environment at the time** a deployment phase is scheduled to commence, the Service Provider shall host the platform on an alternative public cloud environment that meets the following minimum conditions:

(a) The cloud provider shall have a data centre presence within the Asia-Pacific region.

(b) The hosting environment shall comply with the security, data sovereignty, and privacy requirements defined in this FRS, the PDPA, and any directives issued by SL-CERT.

(c) The alternative environment shall support the same availability tiers, RPO/RTO targets, and performance SLAs specified in the SLA Schedule.

(d) The architecture deployed on the interim platform shall be designed to be portable and shall not incorporate proprietary services that would impede migration to LGC.

The Service Provider shall prepare and submit, as part of the **Implementation Plan**, a detailed LGC Migration Plan covering the complete transition of all platform components, data, and integrations from the interim hosting environment to LGC. The migration plan shall include a risk assessment, a rollback strategy, an estimated migration timeline, and a validation and testing plan to confirm functional equivalence post-migration.

All costs associated with interim hosting (for the duration until LGC becomes operational) and the one-time migration to LGC shall be presented separately in the Financial Proposal, as specified in the Bidding Forms.

> ***Cross-Reference:*** *This requirement supplements the existing note under Section 1.4.1 (National Digital Infrastructure Integration) regarding designing integration placeholders for government services that are not yet available. The LGC contingency formalises the hosting aspect of that principle.*

1.4.3. SECURITY AND COMPLIANCE

- Zero-trust security architecture
- PDPA compliance for data protection
- SOC-level monitoring and audit trails
- Transport sector cyber baseline compliance

1.4.4. PPP VENDOR ACCESS MODEL

The platform supports a Public-Private Partnership (PPP) model where private vendors operate buses alongside the LMT-owned fleet. The following access and data governance rules apply:

Data Visibility Rules:

- PPP vendors see ONLY data for their own fleet (vehicles, operators, assistants, revenue, maintenance)
- PPP vendors do NOT see LMT internal financial data, HR data for LMT staff, or other PPP vendors' data
- Aggregate operational data (route performance, ridership) MAY be shared for routes operated by the vendor
- LMT administrators see ALL data across all vendor partitions

Portal Access:

- PPP vendors access the platform via the same web interface as LMT staff, filtered by data scope permissions
- PPP vendor administrators can manage their own staff (operators, assistants) within the platform
- PPP vendor staff (operators, assistants) use the same Staff App as LMT staff

Revenue and Financial Integration:

- Per-kilometer payment calculations [FIN-14-01] use GPS data from the PPP vendor's buses - visible to both LMT and the vendor
- PPP vendors can view their own payment summaries [FIN-14-03], but CANNOT modify calculation parameters

Operational Integration:

- PPP vendor buses appear on the unified fleet tracking dashboard [OFM-01-01] with ownership indicators [OFM-01-09]
- Scheduling of PPP vendor buses [OFM-03-02] is managed centrally by LMT operations
- PPP vendors manage their own maintenance workflows but report maintenance status through the platform

1.4.5. ACCESSIBILITY

- WCAG 2.1 Level AA compliance
- Language Requirements
  - Public-facing interfaces (passenger mobile app, public website, bus stop displays): SHALL support all three languages **(Sinhala, Tamil, English)** with user language selection
  - Internal/staff-facing systems (web administrative panels, management dashboards, operational tools): SHALL be in **English** only to maintain operational consistency
- Offline capability for mobile and embedded interfaces.

1.4.6. DEVELOPMENT AND DEPLOYMENT PRACTICES

The system SHALL be developed using automated continuous integration and continuous deployment (CI/CD) practices:

- Automated code building and testing on every update
- Automated deployment to test environments
- Version-controlled source code with change tracking
- Automated quality checks before production release

1.4.7. OPEN-SOURCE READINESS

The system SHALL be developed in a manner that allows the source code to be made publicly available as open source once the system becomes stable and operational. The vendor SHALL:

- Structure code for public release (clear documentation, standard licensing)
- Remove any proprietary or sensitive components into separate modules
- Maintain clean code practices suitable for public distribution
- Provide documentation for community contribution
- Note: Open-source release is not required initially, but the system architecture must not prevent future public release.

1.5. Integration Architecture and Standards

1.5.1. SYSTEM INTEGRATION PRINCIPLES

The Metro Bus Digital Platform SHALL implements service-oriented architecture (SOA) with the following principles:

1. **API-First Design:** All inter-module communication via REST APIs with OpenAPI 3.0 specifications
2. **Event-Driven Integration:** Real-time data flows via MQTT message broker for IoT devices
3. **Microservices Architecture:** Independent deployment and scaling of functional modules
4. **Data Integration:** Single source of truth for master data (vehicles, routes, stops, employees)

Pattern	Use Case	Protocol	Example
Synchronous API	User-initiated transactions	REST/HTTPS	Passenger queries about route information
Asynchronous Events	Real-time telemetry	MQTT/TLS	Bus reports GPS position
Batch Processing	Daily reconciliation	Scheduled jobs	Revenue settlement
Webhook Callbacks	External system notifications	HTTPS POST	Payment gateway confirmation

Note: - Even if a protocol is mentioned, it does not have to be the exact same one. It is sufficient to carry out the process using any suitable protocol while maintaining standards.

1.5.2. CRITICAL INTEGRATION POINTS

Ref.	Integration Requirement	Del.
INT-01-01	GPS position data flows to passenger information in <10 seconds	P1
INT-01-02	Fare transactions post to the general ledger within 1 hour	P1
INT-01-03	Work order parts consumption updates inventory in real-time	P3
INT-01-04	Driver schedule changes sync to payroll within 24 hours	P2
INT-01-05	Maintenance fault codes automatically create work orders	P3
INT-01-06	GTFS-RT feed updates within 30 seconds of a position change	P2
INT-01-07	Customer complaints route to operations within 15 minutes	P2
INT-01-08	All integrations SHALL implement retry logic (3 attempts)	P1
INT-01-09	Failed integration messages SHALL queue for manual review	P1
INT-01-10	Integration health monitoring dashboard for administrators	P1

1.5.3. DATA STANDARDS

Standard	Application	Compliance Level
GTFS/GTFS-RT	Passenger information	Mandatory
ISO 8601	Date/time formats	Mandatory
WGS84	Geographic coordinates	Mandatory
PCI DSS v4.0	Payment card data	Mandatory
OAuth 2.0	API authentication	Mandatory

OpenAPI 3.0	API documentation	Mandatory
IFRS	Financial Reporting	Mandatory

1.5.4. AUTHENTICATION AND LOGIN FRAMEWORK

Authentication Phasing Strategy:

Phase	Primary Method	Additional Controls	Notes
P1 – P4	Username + OTP verification [IAM-01-02]	MFA for admin roles [IAM-01-05]; SSO across all apps [IAM-01-01]	Platform-native identity service operates
P5	SL-UDI second factor [IAM-01-03]	Single Transport Account linkage [PAS-02-06]	SL-UDI replaces native identity behind same abstraction interface

Transitional Architecture Requirement: The authentication module SHALL use an abstraction layer that allows swapping the identity provider without modifying any consuming module.

Guest-to-Authenticated Transition:

- Passengers in unauthenticated mode (PAS-01) SHALL seamlessly transition to authenticated mode (PAS-02) within the same app session via a “Sign In” button
- The app SHALL preserves the current context (route being viewed, journey being planned) across the transition
- [PAS-01-10] Guest mode “advanced features” are defined as: saved route history (device-local), location-based notifications, trip planning history (device-local)

1.5.5. OFFLINE CAPABILITY FRAMEWORK

All mobile and embedded interfaces SHALL support offline operation under this three-tier model:

Tier	Components	Capability	Minimum Duration
Tier 1 - Full Offline	On-bus fare collection [FAR-01 to FAR-04], GPS logging [GPS-01-01 to GPS-01-06], passenger info displays [PIS-01 to PIS-03], transaction queuing [OBS-02-04]	Full functionality, no degradation	8 hours continuous; 24 h transaction cache
Tier 2 - Partial Offline	Passenger app route/schedule viewing [PAS-03-07], offline ticket display [PAS-04-07], technician work order viewing	Read-only, no transactions	App functions within 100 MB device storage; auto-refresh on reconnect
Tier 3 - Graceful Degradation	Bus stop displays [BSD-01-09], OCC fleet tracking, web-based modules	Static schedule / last-known data with "stale data" indicator after 60 s	Until connectivity restored

NOT required to work offline: Report generation, analytics dashboards, admin configuration changes, real-time fleet tracking on web dashboard, payment settlement, and reconciliation.

Sync and Conflict Resolution:

- Sync order when connectivity restores transactions first → telemetry → logs
- Conflict resolution: server timestamp wins for configuration data; on-bus device wins for transaction data (bus is the source of truth for fare events)
- Failed sync retries 3 times with exponential backoff, then queues for manual review [INT-ERR-01]

1.5.6. DATA CLASSIFICATION AND PRIVACY FRAMEWORK

Data Classification Levels:

Level	Definition	Examples	Retention Period	Access
PUBLIC	Open data, no restrictions	Route info, timetables, GTFS feeds	Indefinite	Anyone
INTERNAL	LMT operational data	Fleet telemetry, operational KPIs, aggregated ridership	5 years	Authenticated LMT / PPP staff per role
CONFIDENTIAL	Personally identifiable or commercially sensitive	Passenger profiles, employee records, PPP vendor financials	Per legal schedule below	Role-based; access logged
RESTRICTED	Highest sensitivity	Payment card data, CCTV footage, SL-UDI credentials	Minimum necessary	Named individuals only; audit trail mandatory

Retention Schedule:

Data Type	Retention Period	Legal Basis	Disposal Method
Financial records	5 years	Sri Lankan tax law, SLFRS	Secure deletion with audit log
Employee records	Employment duration + 3 years	Labour law	Secure deletion
Passenger PII	Until account deletion + 30 days	PDPA	Anonymisation then deletion
Fare transaction records	5 years	Financial reporting, audit	Archive then secure deletion
GPS telemetry	2 years	Operational	Aggregate then delete raw data
CCTV footage - standard	30 days	PDPA, security policy	Automatic overwrite
CCTV footage - incident-flagged	1 year	PDPA, security policy	Manual review before deletion
Audit logs	7 years	Compliance	Read-only archive
Analytics data (anonymised)	Indefinite	Business need	N/A - no PII retained

PDPA Compliance Requirements:

- Passenger consent [PAS-02-02] SHALL be granular: separate consent for location tracking, payment processing, and marketing communications
- Data subject access requests [ADM-05-06] SHALL be fulfilled within 30 days per PDPA
- Analytics module [ADS] SHALL only process anonymised or aggregated data - no individual-level tracking without explicit consent
- Open data publishing [ADS-04-04] SHALL undergo automated PII detection before publication

1.6. Shared Services and Cross-Module Functions

The following functions SHALL be implemented as centralized services consumed by all modules, eliminating duplication and ensuring consistency.

1.6.1. IDENTITY AND ACCESS MANAGEMENT (IAM)

Ref.	Functional Requirement	Del.	Int.
IAM-01-01	Single sign-on (SSO) across all web and mobile applications	P1	B
IAM-01-02	Username login with OTP Verification Process	P1	B
IAM-01-03	Integration with SL-UDI for passenger authentication	P5	B
IAM-01-04	Role-based access control (RBAC) engine for all modules	P1	W
IAM-01-05	Multi-factor authentication (MFA) for administrative functions	P1	W
IAM-01-06	Session management with configurable timeout (Mentions Users)	P1	B
IAM-01-07	Password policy enforcement (complexity, expiry, history)	P1	W
IAM-01-08	User activity audit trail across all modules	P1	W

1.6.2. MODULAR SERVICE ARCHITECTURE AND MODULE REPLACEABILITY

The platform SHALL be designed as independently deployable services. All communication between services MUST pass through documented APIs only.

Service Boundary Map:

Service	Owns Data For	Exposes APIs For	Consumes APIs From
IAM Service	Users, roles, sessions, permissions	Authentication, authorisation, user lookup	None (foundational)
Notification Service	Notification logs, templates	Send notification, delivery status	IAM
Passenger Service	Passenger profiles, tickets, complaints	Journey planning, ticket validation, complaint tracking	IAM, Notification, Asset Register, Payment
On-Bus Service	Trip data, fare transactions, GPS telemetry	Transaction upload, telemetry stream, device status	IAM, Asset Register, Fare Config
Bus Stop Display Service	Display config, content schedules	Display status, content update	Asset Register, Notification, On-Bus (arrival data)
Operations & Fleet Service	Schedules, dispatch, routes, assignments	Fleet status, schedule query, route info, KPI data	IAM, Asset Register, On-Bus, HR
Operations Control Service	Incidents, alerts, communication logs	Incident management, alert dispatch	Operations & Fleet, On-Bus, Notification

Maintenance Service	Work orders, inspections, history	Work order management, inspection data	IAM, Asset Register, Operations & Fleet, Stores
HR Service	Employee records, attendance, leave, payroll	Employee lookup, shift data, payroll calculation	IAM, Notification, Workflow
Finance Service	GL, AP, AR, revenue, expenses, budgets	Financial postings, revenue query, payment processing	IAM, Operations & Fleet, HR, Stores
Stores & Procurement Service	Parts catalogue, inventory, POs, vendors	Stock query, PO management, vendor lookup	IAM, Finance, Maintenance, Workflow
Analytics Service	Data warehouse, ML models, dashboards	Report query, prediction API, dashboard data	All modules (read-only via ETL/API)
Platform Admin Service	System config, audit logs, fare tables	Config management, audit query, CCTV access tokens	IAM, All modules
Advertising Service	Ad inventory, campaigns, content, revenue	Ad content delivery, revenue tracking	Finance, Bus Stop Display, On-Bus
CCTV access platform	Provide on-demand CCTV access, integrated with the Admin Service	To enable secure on-demand video streaming.	IAM and CCTV modules

Module Isolation Rules:

- Service A SHALL call Service B's API - it SHALL NOT query Service B's database directly
- Service B SHALL publish events to a shared message broker for event-driven flows - no point-to-point callbacks
- If Service B is unavailable, Service A SHALL degrade gracefully (queue requests, show cached data, or display "service unavailable") rather than fail entirely [INT-ERR-05]

Module Replacement Procedure:

When replacing Module X with an alternative implementation, the replacement module SHALL:

- Implement all APIs currently exposed by Module X (as documented in the API developer portal)
- Subscribe to all events that Module X currently subscribes to
- Publish all events that Module X currently publishes
- Support data migration from Module X through documented export APIs and data schemas
- Require NO code changes in any other module - only the service registry entry for Module X needs updating to point to the replacement

1.6.3. SERVICE BOUNDARY STANDARDS

API Contract Requirements:

- Every inter-module API SHALL be documented in OpenAPI 3.0 format
- API versioning SHALL follow semantic versioning (v1, v2, etc.)
- Breaking changes SHALL only be introduced in new major versions
- The previous major version SHALL remain operational for a minimum of 6 months after a new major version is released
- All APIs SHALL include a /health endpoint returning service status
- All APIs SHALL implement standard error response formats

Service Discovery:

- The platform SHALL implement a service registry where each module registers its API endpoints
- Modules SHALL discover other modules' endpoints through the registry - not through hardcoded URLs
- The registry SHALL support multiple instances of the same module for load balancing and failover

Circuit Breaker Pattern:

- All inter-module API calls SHALL implement circuit breaker logic
- When a dependent module fails:
    a. Open the circuit after 3 consecutive failures.
    b. return gracefully degraded responses using cached data.
    c. periodically attempt reconnection.
    d. close the circuit when the dependent module recovers
- Critical operations (fare collection, GPS tracking) SHALL continue with local/cached data when backend services are unavailable

Vendor Deliverables for Architecture Compliance:

- Complete OpenAPI documentation for every inter-module boundary Service dependency diagram showing all API and event relationships.
- Deployment guide demonstrating independent module deployment.
- Module replacement guide with step-by-step procedure, Architecture Decision Records (ADRs) for all service boundary decisions

Architecture Compliance Verification Test (Stabilization Period):

The vendor SHALL demonstrate module independence by:

I. Shutting down one non-critical module (e.g., Advertising or Analytics).
II. Demonstrating that all other modules continue operating normally with graceful degradation.
III. Restarting the module and demonstrating data recovery and sync.

1.6.4. UNIFIED NOTIFICATION SERVICE

Ref.	Functional Requirement	Del.	Int.
NOT-01-01	Send SMS notifications via LMT Given gateway	P1	W
NOT-01-02	Send email notifications with templates	P1	W
NOT-01-03	Send in-app notifications with read/unread status	P1	B
NOT-01-04	Notification template management with multilingual support	P1	W
NOT-01-05	Delivery status tracking and retry logic	P1	W
NOT-01-06	Notification audit log (who received what when)	P1	W

1.6.5. COMMON WORKFLOW ENGINE

Ref.	Functional Requirement	Del.	Int.
WFL-01-01	Configurable multi-step approval workflows	P2	W
WFL-01-02	Role-based approval routing with delegation	P2	W
WFL-01-03	Email/SMS notifications for pending approvals	P2	W
WFL-01-04	Approval of history and audit trail	P2	W
WFL-01-05	Escalation rules for overdue approvals	P2	W

Ref.	Functional Requirement	Del.	Int.
WFL-01-06	Bulk approval capability for similar requests	P2	W

1.6.6. ENTERPRISE REPORTING PLATFORM

Ref.	Functional Requirement	Del.	Int.
REP-01-01	Parameterized report builder with drag-and-drop interface	P2	W
REP-01-02	Scheduled report generation and distribution	P2	W
REP-01-03	Export to PDF, Excel, CSV formats	P2	W
REP-01-04	Report templates library with role-based access	P2	W
REP-01-05	Interactive data visualization (charts, graphs, maps)	P2	W
REP-01-06	Report on subscription and automatic delivery	P2	W

1.6.7. CENTRAL ASSET REGISTER

Ref.	Functional Requirement	Del.	Int.
AST-01-01	Master vehicle registry (single source of truth)	P1	W
AST-01-02	Vehicle configuration management (hardware, software versions)	P1	W
AST-01-03	Device assignment to vehicles (GPS, POS, cameras)	P1	W
AST-01-04	Vehicle lifecycle status (active, maintenance, retired)	P1	W
AST-01-05	Vehicle ownership tracking (LMT vs. PPP vendor)	P1	W
AST-01-06	API for all modules to query vehicle master data	P1	W

1.6.8. INTEGRATED DOCUMENT MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
DOC-01-01	Centralized document repository with folder structure	P2	W
DOC-01-02	Document upload with metadata tagging	P2	B
DOC-01-03	Document version control and history	P2	W
DOC-01-04	Document search by name, tags, content	P2	W
DOC-01-05	Role-based document access permissions	P2	W
DOC-01-06	Document retention policy enforcement	P2	W

1.6.9. SHARED SERVICES USAGE MATRIX

Module	IAM	Notifications	Workflow	Reporting	Asset Register	Documents
Passenger Services	✓	✓	-	-	-	-
On-Bus System	-	✓	-	-	✓	-
Operations	✓	✓	✓	✓	✓	-
Maintenance	✓	✓	✓	✓	✓	✓
HR	✓	✓	✓	✓	-	✓
Finance	✓	✓	✓	✓	✓	✓
Stores	✓	✓	✓	✓	-	✓
Administration	✓	✓	✓	✓	✓	✓

1.7. Cross-Module Integration Requirements

1.7.1. INTEGRATION PRINCIPLES

- **INT-01:** All modules SHALL integrate through well-defined API contracts with versioning
- **INT-02:** Cross-module data SHALL flow automatically without manual intervention
- **INT-03:** Integration failures SHALL not block critical operations (graceful degradation)
- **INT-04:** System SHALL provide integration monitoring dashboards for administrators

1.7.2. INTEGRATION TIMING REQUIREMENTS

All cross-module data flows SHALL specify timing using these codes:

- **RT**: Real-time synchronous (<1 second)
- **AS**: Asynchronous near-real-time (<1 minute)
- **B24**: Daily batch processing
- **M**: Manual trigger required

Note: - The data flow frequency has been indicated in brackets "[_]" at a few key points. However, when preparing documents in the future and when making relevant references in all sections, let us maintain this same practice consistently.

1.7.3. INTEGRATION ERROR HANDLING REQUIREMENTS

INT-ERR-01	System SHALL implements retry logic for failed integrations (3 attempts, exponential backoff)
INT-ERR-02	System SHALL queue failed integration messages for manual review
INT-ERR-03	System SHALL send alerts when integration failures exceed threshold (>5% failure rate)
INT-ERR-04	System SHALL provide administrator interface to replay failed integration messages
INT-ERR-05	Critical operations SHALL continue with graceful degradation when non-critical integrations fail
INT-ERR-06	System SHALL logs all integration errors with complete context for troubleshooting

1.8. System Architecture - Multi-Provider Service Model

The MBDP platform supports a multi-provider operational model where Lanka Metro Transit (LMT) operates its own fleet alongside Private Partner (PPP) vendors who deploy and operate buses under contract.

Data Isolation:

- Each PPP vendor operates within a data partition (tenant) - LMT has a super-tenant view across all partitions
- Data isolation is enforced at the application layer through RBAC [IAM-01-04] and data scope restrictions [ADM-01-05]

Revenue Attribution:

- Fare revenue from PPP vendor buses is attributed to the vendor based on vehicle registration [OFM-00-06]
- Per-kilometer payments to PPP vendors are calculated from GPS data [FIN-14-01]

- Fare revenue flows to LMT; per-kilometer contractual payments flow back to PPP vendors

Fleet Integration:

- All buses (LMT and PPP) appear on the unified fleet tracking system [OFM-01-01] with ownership indicators [OFM-01-09]
- Scheduling and dispatch are managed centrally by LMT [OFM-03-01]
- PPP vendors maintain their own buses but report maintenance status through the platform

Contractual SLA Monitoring:

- The platform automatically tracks PPP vendor performance metrics KPI dashboards [KPI-01-07] show per-vendor performance
- Performance incentive/penalty calculations [OFM-08-06] support per-vendor reporting
- Additionally, the system should include availability monitoring, a KPI dashboard, and a monthly report generator. I**t must be ensured through system audits that these functions operate automatically.**

2. PART B: FUNCTIONAL REQUIREMENTS BY MODULE

This section outlines the functions that should be included in the overall system, and the system will be designed based on these core functions. All functions have been organized into main modules and sub-modules to ensure ease of identification. The following presents the relevant main modules and sub-modules.

1. Passenger Services	
1.1 Unauthenticated Access (Without Account)	1.2 Authenticated Access (With Account)
1.3 Journey Planning	1.4 Fare Payment and Ticketing
1.5 Claims and Dispute Resolution	1.6 Lost and Found
1.7 Feedback and Support	1.8 Service Information and Discovery
1.9 Accessibility Compliance and Monitoring	
2. Public Information Services	
2.1 Data Exchange and Standards Compliance	2.2 GTFS-Realtime Feed Generation
3. On-Bus System	
3.1 Main Control Unit	3.2 Fare Collection & Payment
3.3 Passenger Information Systems	3.4 Bus Accessibility Features
3.5 Operator Interface & Operations (Driver)	3.6 Location Tracking & GPS
3.7 Data Collection, Logging & Analytics (Bus Data)	3.8 Bus Communication Systems
3.9 Bus Safety & Monitoring Systems	
4. Bus Stop Display System	
4.1 Real-Time Arrival Information	4.2 Announcements and Content
4.3 Display Management And CCTV	4.4 Display Installation and Maintenance
4.5 Display Board Viewing and Management Interface	
5. Operations And Fleet Management	
5.1 Vehicle Registration and Onboarding	5.2 Real-Time Vehicle Tracking
5.3 Operator Behavior Monitoring	5.4 Scheduling and Dispatch
5.5 Vehicle Health Monitoring	5.6 Fuel Management
5.7 Passenger Information Systems Integration	5.8 Fare Collection and Revenue Integration
5.9 Regulatory Compliance and Performance Reporting	5.10 Onboard Safety and Surveillance Systems
5.11 Depot Logistics Management	5.12 Advanced Analytics and Route Optimization
5.13 Reporting and Business Intelligence	5.14 Service Performance Metrics and KPIS
6. Operations Control Centre - 05	
6.1 Real-Time Dashboards	6.2 Alerts and Incident Management
6.3 Communication Hub	6.4 Breakdown and Bus Replacement Workflow
7. Maintenance Management - 06	
7.1 Preventive Maintenance	7.2 Maintenance History and Records
7.3 Repair Workflow	7.4 Technician Functions (Mobile-Enabled)
7.5 Examiner Functions (Quality Assurance)	7.6 Vehicle Inspection
8. Human Resources Management	
8.1 Employee Records	8.2 Attendance and Shift Management
8.3 Leave Management	8.4 Payroll Integration

8.5 Performance Management	8.6 Training Management
8.7 Employee Self-Service (Mobile-Enabled)	8.8 Grievance and Complaint Management
9. Finance And Accounting	
9.1 Revenue Management	9.2 Expense Management
9.3 General Ledger	9.4 Accounts Payable
9.5 Fixed Asset Management	9.6 Budgeting and Reporting
9.7 Bank Reconciliation	9.8 Tax Management
9.9 Financial Reporting	9.10 Audit and Compliance
9.11 Cash Management	9.12 Cost Allocation and Analysis
9.13 Procurement-Finance Integration (Critical)	9.14 PPP Vendor Revenue and Payments
9.15 Inventory Accounting	
10. Stores, Inventory, And Procurement Management	
10.1 Parts Catalogue	10.2 Stock Control
10.3 Reorder Management	10.4 Stock Transactions
10.5 Procurement	10.6 Vendor Management
10.7 Returns and Warranty Management	10.8 Inventory Reporting
10.9 Asset and Tools Management	
11. Analytics And Decision Support	
11.1 Operational Analytics	11.2 Predictive Analytics
11.3 Citizen-Centric Insights Dashboard	11.4 Data Management
11.5 Analytics Data Integration	11.6 Digital Vehicle Inspection Reports (Dvir)
11.7 Security and Compliance	11.8 CCTV Access Control
11.9 Fare Table Version Control	11.10 Bus Configuration Management
11.11 Connectivity and Sync Monitoring	11.12 Data Usage Tracking and Management
12. Platform Administration	
12.1 Role Configuration	12.2 Dashboard Management
12.3 System Configuration	12.4 Integration and Api Management
12.5 Integration and Api Management	12.6 Security and Compliance
13. Advertising Management	
13.1 Ad Space Inventory	13.2 Campaign Management
13.3 Content Distribution	13.4 Revenue Tracking

2.1. Passenger Services

2.1.1. UNAUTHENTICATED ACCESS (WITHOUT ACCOUNT)

Ref.	Functional Requirement	Del.	Int.
PAS-01-01	View all bus routes, stops, and service descriptions	P1	P
PAS-01-02	View published timetables and service frequencies	P1	P
PAS-01-03	View real-time bus locations and estimated arrival times	P1	P
PAS-01-04	View fare structures and concession information	P1	P
PAS-01-05	View service announcements and disruption notices	P1	P
PAS-01-06	Access fare calculation tools	P1	P
PAS-01-07	View proximity-based services (Near You – nearby bus stops, routes)	P1	M
PAS-01-08	Submit general enquiries through contact forms	P2	P
PAS-01-09	View public lost and found listings	P2	P
PAS-01-10	Access guest mode enabling device-local route history, location-based notifications, and trip planning history without requiring account creation	P2	M

2.1.2. AUTHENTICATED ACCESS (WITH ACCOUNT)

Ref.	Functional Requirement	Del.	Int.
PAS-02-01	Manage personal profile information	P1	B
PAS-02-02	Provide and manage PDPA consent	P1	B
PAS-02-03	Save frequent routes and stops	P2	M
PAS-02-04	Configure notification preferences via unified notification service	P2	M
PAS-02-05	Quick access dashboard for favorite services	P2	M
PAS-02-06	Maintain Single Transport Account (STA) linked to SL-UDI	P5	B
PAS-02-07	Automatic concession eligibility based on SL-UDI attributes	P5	B

2.1.3. JOURNEY PLANNING

Ref.	Functional Requirement	Del.	Int.
PAS-03-01	Search for routes based on origin, destination, and time	P1	B
PAS-03-02	search and set the origin location on the map	P1	M
PAS-03-03	search and set the destination location on the map	P1	M
PAS-03-04	Display route details, including stops, transfers, waiting time, journey time, and fare	P1	B
PAS-03-05	Display real-time bus locations on an interactive map	P1	B
PAS-03-06	Display estimated arrival times at selected stops	P1	M
PAS-03-07	Support offline navigation (no internet required)	P1	M
PAS-03-08	Display the nearest bus stop to the origin, along with the distance	P1	M
PAS-03-09	Display the nearest bus stop to the destination with the distance	P1	M
PAS-03-10	Display walking distance/time to the original bus stop	P1	M
PAS-03-11	Display walking distance/time from the destination bus stop	P1	M
PAS-03-12	Display occupancy levels for approaching buses	P1	M
PAS-03-13	Notify passengers of approaching buses	P1	M

Ref.	Functional Requirement	Del.	Int.
PAS-03-14	Notify passengers of service disruptions	P1	M
PAS-03-15	Auto-detect origin from mobile GPS location	P1	M

2.1.4. FARE PAYMENT AND TICKETING

Ref.	Functional Requirement	Del.	Int.
PAS-04-01	Display transaction history with detailed breakdowns	P1	B
PAS-04-02	Generate a dynamic QR code in the mobile app or printable to get the season or ticket	P2	B
PAS-04-03	Support refund requests with identity verification	P2	B
PAS-04-04	Download payment statements	P2	B
PAS-04-05	Purchase digital tickets for routes/trips	P3	B
PAS-04-06	Process all payments through GovPay	P1	B
PAS-04-07	Support offline display of valid tickets	P1	M
PAS-04-08	View active, past, and expired tickets	P3	B
PAS-04-09	Top up travel card via mobile application (tap mobile using NFC)	P2	M
PAS-04-10	Top up travel card via website (login required)	P2	W
PAS-04-11	Display travel card balance and transactions	P2	B
PAS-04-12	Integrate digital wallet for payments with NFC (Near Field Communication) support	P2	B
PAS-04-13	Configure auto top-up for travel card	P2	B
PAS-04-14	Automatic concession application	P4	B
PAS-04-15	Track travel expenditure and analytics	P4	B

2.1.5. CLAIMS AND DISPUTE RESOLUTION

Ref.	Functional Requirement	Del.	Int.
PAS-05-01	Submit travel claims for missing entry/exit	P4	B
PAS-05-02	Track claim status in real-time	P4	B
PAS-05-03	Payment for penalty fees through the app	P4	B
PAS-05-04	Submit overcharge dispute requests	P4	B

2.1.6. LOST AND FOUND

Ref.	Functional Requirement	Del.	Int.
PAS-06-01	Report lost items with description, location, and date	P3	B
PAS-06-02	Search found item listings by category, date, and route	P3	B
PAS-06-03	Submit claims for found items	P3	B
PAS-06-04	Track status of lost item reports and claims	P3	B
PAS-06-05	Notify when matching items are found	P3	B
PAS-06-06	Provide collection instructions for claimed items	P3	B
PAS-06-07	Assistant records found items with photos, description, bus, date	P3	B
PAS-06-08	Automatic matching with lost item reports	P3	B
PAS-06-09	Track physical custody (who has item, storage location)	P3	B
PAS-06-10	Escalate high-value items to supervisor approval	P3	B

Ref.	Functional Requirement	Del.	Int.
PAS-06-11	Generate unclaimed item disposal recommendations (>90 days)	P3	B

2.1.7. FEEDBACK AND SUPPORT

Ref.	Functional Requirement	Del.	Int.
PAS-07-01	Report on service issues including operator and assistant behavioral complaints that may trigger the demerit points system [HRM-05-06]	P2	B
PAS-07-02	Submit complaints with categorization	P2	B
PAS-07-03	Track complaint status	P2	B
PAS-07-04	Rate trips and provide service feedback	P2	M
PAS-07-05	Searchable FAQ in all languages	P2	B
PAS-07-06	In-app help and contextual guidance	P2	M
PAS-07-07	Integration with customer support systems	P2	B
PAS-07-08	Aggregate feedback for Citizen-Centric Insights Dashboard	P5	W

2.1.8. SERVICE INFORMATION AND DISCOVERY

Ref.	Functional Requirement	Del.	Int.
PAS-09-01	Location finder for customer service centers, etc.	P4	B
PAS-09-02	Propose new bus routes (community participation)	P4	B
PAS-09-03	View proximity-based service discovery (nearby stops, services)	P4	B

2.1.9. ACCESSIBILITY COMPLIANCE AND MONITORING

Ref.	Functional Requirement	Del.	Int.
ACC-01-01	Track wheelchair ramp deployments per trip with timestamp	P1	E
ACC-01-02	Book a wheelchair bay on a specific trip via the mobile app, with real-time bay availability display for incoming buses.	P1	M
ACC-01-03	Record wheelchair boarding/alighting events	P1	E
ACC-01-04	Monitor audio announcement system functionality	P1	E
ACC-01-05	Track driver assistance requests from passengers with disabilities	P1	M
ACC-01-06	Generate accessibility compliance reports for regulatory authority	P1	W
ACC-01-07	Alert when wheelchair bay occupied for next scheduled pickup	P2	E
ACC-01-08	Track priority seating usage and compliance	P2	E

2.2. Public Information Services

This outlines the features required for our **official website**, and in addition, the development of a **creative and visually engaging website** can be identified as a key requirement.

Ref.	Functional Requirement	Del.	Int.
PUB-01-01	Build an official website (Including the relevant web pages)	P2	W
PUB-01-02	Public access to route information	P2	W
PUB-01-03	Public access to bus stop information	P2	W
PUB-01-04	Display timetables and frequencies	P2	W
PUB-01-05	Display fare structures and concessions	P2	W
PUB-01-06	Real-time service status and disruptions	P2	W
PUB-02-01	Publish official service announcements	P2	W
PUB-02-02	Publish emergency/priority announcements	P2	W
PUB-02-03	Searchable FAQ and help content	P2	W
PUB-02-04	Submit general public enquiries	P2	W
PUB-02-05	Public notices on policies and passenger rights	P1	W
PUB-02-06	Publish vendor-related information	P4	W
PUB-02-07	Publish procurement opportunities	P4	W
PUB-02-08	Publish tender information and results	P4	W
PUB-03-01	Multilingual content (Sinhala, Tamil, English)	P1	W
PUB-03-02	WCAG 2.1 AA accessibility compliance	P1	W
PUB-03-03	Responsive design (desktop, tablet, mobile)	P1	W
PUB-03-04	Content management with approval workflows	P2	W
PUB-03-05	Version history and audit logs	P2	W

2.2.1. DATA EXCHANGE AND STANDARDS COMPLIANCE

This is a very important component of the system. According to the data exchange policies, the process of granting access to data must be automated, and the relevant security mechanisms must be discussed and designed accordingly. Therefore, the system should be designed in a way that allows the implementation of these provisions in the future.

Ref.	Functional Requirement	Del.	Int.
GTF-01-01	Generate GTFS static feed (routes, stops, schedules, calendar)	P2	W
GTF-01-02	Publish GTFS feed via public URL for journey planning apps	P2	W
GTF-01-03	Validate GTFS feed against Google specification	P2	W
GTF-01-04	Update GTFS feed automatically when schedules change	P2	W
GTF-01-05	Support GTFS translations (Sinhala, Tamil, English)	P2	W

2.2.2. GTFS-REALTIME FEED GENERATION

Ref.	Functional Requirement	Del.	Int.
GTF-02-01	Generate GTFS-RT vehicle positions feed from live GPS data	P2	W
GTF-02-02	Generate GTFS-RT trip updates feed (delays, cancellations)	P2	W
GTF-02-03	Generate GTFS-RT service alerts feed (disruptions, detours)	P2	W

Ref.	Functional Requirement	Del.	Int.
GTF-02-04	Publish GTFS-RT feeds via public URL with <30 second latency	P2	W
GTF-02-05	Enable third-party app integration (Google Maps, Transit App)	P2	W

2.3. On-Bus System

In **Part F: Embedded Systems Specification**, under **1. On-Bus System**, all hardware and all related details are included.

2.3.1. MAIN CONTROL UNIT

Ref.	Functional Requirement	Del.	Int.
Central Processing & Hub			
OBS-01-01	Central hub connecting all on-bus devices (validators, displays, GPS, CCTV, HMI)	P1	E
OBS-01-02	Manage communication with tapping machines (POS) devices	P1	E
OBS-01-03	Manage communication with passenger information displays	P1	E
OBS-01-04	Manage GPS data	P1	E
OBS-01-05	Manage CCTV recording, streaming, and storage	P2	E
OBS-01-06	Control and manage the Operator Human-Machine Interface	P2	E
OBS-01-07	Transmit fuel level, engine diagnostics, and all bus system status data to the backend when requested via API polling or scheduled push interval	P2	E
Offline/Online Mode Management			
OBS-02-01	Manage the fare table in both online and offline modes	P1	E
OBS-02-02	Support graceful degradation during connectivity loss	P1	E
OBS-02-03	Synchronize cached data when connectivity is restored	P1	E
OBS-02-04	Queue transactions during offline mode for later upload	P2	E
OBS-02-05	Securely store offline transactions with encryption	P1	E
System Health & Monitoring			
OBS-03-01	Report system health status to central monitoring	P2	E
OBS-03-02	Monitor operational status of all on-bus components	P2	E
OBS-03-03	Detect and log system errors for troubleshooting	P2	E

2.3.2. FARE COLLECTION & PAYMENT

Ref.	Functional Requirement	Del.	Int.
Payment Media Processing			
FAR-01-01	Accept Visa and Mastercard bank cards	P1	E
FAR-01-02	EMV-compliant card payment processing with security standards	P1	E
FAR-01-03	Deferred authorization for offline payment scenarios	P1	E
FAR-01-04	Record each cash fare deposit into the farebox via operator button press. Generate and print a thermal receipt for the passenger confirming the cash fare amount.	P1	E
FAR-01-05	Accept and process QR code scanning capability	P1	E

Ref.	Functional Requirement	Del.	Int.
FAR-01-06	Accept and process stored-value Travel Card payments	P5	E
FAR-01-07	Accept Apple Pay, Google Pay, Samsung Pay, Fitbit Pay, Garmin Pay	P5	E
Fare Calculation & Validation			
FAR-02-01	Calculate fare based on boarding and alighting locations	P1	E
FAR-02-02	Deduct the maximum fare on boarding (tap-in)	P1	E
FAR-02-03	Refund the difference between the actual and maximum fare on alighting (tap-out)	P1	E
FAR-02-04	Charge the maximum fare when the passenger fails to tap out	P1	E
FAR-02-05	Concessionary Fare Processing: Process child, senior, student, and disabled concessionary fares	P3	E
Transaction Processing & Security			
FAR-03-01	Record the boarding location, time, and deduct fare	P1	E
FAR-03-02	Record alighting location, time, and process refund	P1	E
FAR-03-03	Record transactions with timestamp, vehicle ID, route, GPS location	P1	E
FAR-03-04	Prevent duplicate fare validations within time threshold	P1	E
FAR-03-05	Encrypt sensitive transaction data for security	P1	E
FAR-03-06	Support configuration updates from central fare systems	P1	E
User Feedback & Status			
FAR-04-01	Insufficient Balance Detection: Alert passengers with "Please Pay Cash" message and audible beeps	P1	E
FAR-04-02	Real-Time Validation Feedback: Provide immediate visual and audible feedback on validation	P1	E
FAR-04-03	Display fare validation status to the operator	P1	E
FAR-04-04	Send a fare transaction notification to the passenger’s registered mobile app when a tap-in or tap-out event is processed against their account	P1	M

2.3.3. PASSENGER INFORMATION SYSTEMS

Ref.	Functional Requirement	Del.	Int.
Visual Displays - Exterior			
PIS-01-01	External Route Display: Show bus service number and destination on exterior	P1	E
PIS-01-02	External Door Display: Show the next 3 Bus Stops	P1	E
Visual Displays - Interior			
PIS-02-01	Next Stop / Multi-Stop / Route Information Display	P1	E
PIS-02-02	Intermediate Stops Display	P1	E
PIS-02-03	Display current time on interior screens	P1	E
PIS-02-04	Display number of stops remaining to key destinations Indicate when bus has arrived at a stop and Time	P1	E
PIS-02-05	Display detailed transfer point connection information	P1	E
Audio Announcements			
PIS-03-01	Automated audio announcements for next stop (3 languages: English, Sinhala, Tamil)	P1	E

Ref.	Functional Requirement	Del.	Int.
PIS-03-02	Pre-recorded Announcement Trigger	P1	E
PIS-03-03	Contextual announcements triggered by GPS	P2	E
PIS-03-04	Service / Emergency Announcements	P2	E
PIS-03-05	Manual Microphone Announcement	P3	E
PIS-03-06	Manual Announcement Triggers (operator)	P3	E
Real-Time Information & Advertising			
PIS-04-01	Provide real-time bus crowding status (seats/standing/limited/unknown)	P3	M
PIS-04-02	Bus Arrival Time Prediction	P3	M
PIS-04-03	Allocating a dedicated section for advertisements in the passenger app.	P5	M
PIS-04-04	Implementing a mechanism to play advertisements on the internal displays inside the bus.	P5	M

2.3.4. BUS ACCESSIBILITY FEATURES

Ref.	Functional Requirement	Del.	Int.
BAF-01-01	Wheelchair Bell System	P2	E
BAF-01-02	Wheelchair Bay Management (Notify Other all Bay full or not)	P2	E
BAF-01-03	Notify Operator to Manual Wheelchair Ramp	P2	E

2.3.5. OPERATOR INTERFACE & OPERATIONS(DRIVER)

Ref.	Functional Requirement	Del.	Int.
Bus Fare Console			
DRV-01-01	Touchscreen button for cash fare count (put full payment into cash box)	P1	E
Operator HMI (Human-Machine Interface)			
DRV-02-01	Touch-enabled interface for operator interaction and control	P1	E
DRV-02-02	Display current route information and upcoming stops	P1	E
DRV-02-03	Display trip status and schedule adherence metrics	P1	E
DRV-02-04	Automatic Stop Update current bus stop via GPS	P1	E
DRV-02-05	Manual Stop Override: Manually update bus stop when GPS	P2	E
DRV-02-06	Operational Alerts Display	P2	E
DRV-02-07	Driver must log the wheelchair passenger's drop-off and on status	P1	E
Authentication & Session Management			
DRV-03-01	Login with personal credentials to access system	P1	E
DRV-03-02	Automatically load correct schedule based on the driver ID	P1	E
DRV-03-03	Show service block in operator-specific format	P2	E
DRV-03-04	Start trip, end trip, record breaks, manage shift	P2	E
DRV-03-05	Allow manual override by authorized roles only	P3	E
Status & Performance Displays			
DRV-04-01	Show 24-hour time, system health indicator, alert icons	P2	E
DRV-04-02	Show distance to rear bus in minutes and its passenger load	P2	E

Ref.	Functional Requirement	Del.	Int.
DRV-04-03	Display current stop, next 2 stops, scheduled times	P2	E
DRV-04-04	Automatically scroll route information based on GPS location	P2	E
Navigation & Route Guidance			
DRV-05-01	Display full route map with real-time GPS position overlay, activated via F4 function button on operator HMI (F4 - Button)	P2	E
DRV-05-02	Junction guidance with countdown distance to next turn	P2	E
DRV-05-03	Navigate alternative routes during road closures	P2	E
Emergency & Safety Controls			
DRV-06-01	Panic button for emergency situations	P2	E
DRV-06-02	Direct emergency voice communication with the Operations Control Centre (OCC) via dedicated emergency channel	P2	E

2.3.6. LOCATION TRACKING & GPS

Ref.	Functional Requirement	Del.	Int.
GPS-01-01	Continuously track bus position via GPS	P1	E
GPS-01-02	Capture GPS location at 10-second intervals	P1	E
GPS-01-03	Transmit GPS location continuously for real-time tracking	P1	E
GPS-01-04	Automatically identify current bus stop via geofencing	P1	E
GPS-01-05	Trigger announcements and messages based on GPS coordinates	P1	E
GPS-01-06	Track whether bus follows assigned route	P1	E

2.3.7. DATA COLLECTION, LOGGING & ANALYTICS (BUS DATA)

Ref.	Functional Requirement	Del.	Int.
Transaction & Fare Logging			
BDT-01-01	Log all fare transactions	P1	E
BDT-01-02	Tap-In/Tap-Out Data Collection (locations with timestamps)	P1	E
BDT-01-03	Upload transaction records to central servers	P1	E
Operational Data Logging			
BDT-02-01	Bus Arrival Time Logging	P1	E
BDT-02-02	Gather data for Bus Service Reliability Framework	P3	E
BDT-02-03	Record complete trip data including route, times, stops	P1	E
Passenger Counting			
BDT-03-01	Automatic Passenger Counting (APCS)	P2	E
BDT-03-02	Real-Time Passenger Flow	P2	E
Vehicle Health & Telematics			
BDT-04-01	Collect vehicle diagnostics from OBD-II interface	P4	E
BDT-04-02	Track acceleration, braking, speed, turning patterns	P4	E
BDT-04-03	Monitor tire pressure, engine temperature, fluid levels	P4	E
BDT-04-04	Record engine idling duration for efficiency analysis	P4	E

2.3.8. BUS COMMUNICATION SYSTEMS

Ref.	Functional Requirement	Del.	Int.
Voice Communication			
BCS-01-01	Normal Priority Voice Call (F1 - Button)	P2	E
BCS-01-02	Priority Voice Call (F2)	P3	E
BCS-01-03	Breakdown Voice Call (F3)	P3	E
Text Messaging			
BCS-02-01	Broadcast Message Reception	P3	E
BCS-02-02	Message Status Indicator	P3	E
BCS-02-03	Acknowledge messages with thumbs up/down icons	P3	E
Data Transmission			
BCS-03-01	Transmit data via 4G/5G networks	P3	E
BCS-03-02	Upload data when parked at depot via WiFi	P3	E
BCS-03-03	Calculate data usage (Wi-Fi, system)	P3	E
System Updates & Configuration			
BCS-04-01	Remote Schedule Modification	P3	E
BCS-04-02	Firmware Over-the-Air Updates	P3	E

2.3.9. BUS SAFETY & MONITORING SYSTEMS

Ref.	Functional Requirement	Del.	Int.
Driver Safety Systems			
BSM-01-01	Driver Alcohol Test Before Trip-On	P3	E
CCTV & Video Systems			
BSM-02-01	CCTV Camera Integration	P3	E
BSM-02-02	Video Recording	P3	E
BSM-02-03	live feed access, clip retrieval by date/time/camera ID, and local storage management on the bus unit	P3	E
BSM-02-04	Incident Investigation Storage	P3	E
Schedule & Service Regulation			
BSM-03-01	Track deviation from scheduled headway in real-time	P2	E
BSM-03-02	Alert driver when running early or late beyond threshold	P2	E
BSM-03-03	Display following bus info to help driver regulate service spacing	P2	E
Vehicle & System Security			
BSM-04-01	Secure system boot and authentication on vehicle startup	P2	E
BSM-04-02	Detect and report unauthorized access to system components	P2	E

2.4. Bus Stop Display System

2.4.1. REAL-TIME ARRIVAL INFORMATION

Ref.	Functional Requirement	Del.	Int.
BSD-01-01	Display real-time estimated arrivals for buses	P1	E
BSD-01-02	Display route identifiers, destinations, directions	P1	E

Ref.	Functional Requirement	Del.	Int.
BSD-01-03	Display the passenger load (crowding level) of arriving buses	P1	E
BSD-01-04	show wheelchair bay availability status for incoming buses.	P1	E
BSD-01-05	Display next 3-5 buses with countdown	P1	E
BSD-01-06	Refresh at configurable intervals	P1	E
BSD-01-07	Display service status indicators (color-coded)	P2	E
BSD-01-08	Display occupancy indicators	P2	E
BSD-01-09	Fallback display when real-time data is unavailable	P1	E

2.4.2. ANNOUNCEMENTS AND CONTENT

Ref.	Functional Requirement	Del.	Int.
BSD-02-01	Display delay, diversion, cancellation notices	P1	E
BSD-02-02	Emergency/government priority messages	P1	E
BSD-02-03	Multilingual display with rotation	P1	E
BSD-02-04	Scheduled informational content rotation	P2	E
BSD-02-05	Public service announcements and weather conditions	P2	E
BSD-02-06	Advertising content (PPP framework)	P2	E
BSD-02-07	Content prioritization (service info priority)	P1	E

2.4.3. DISPLAY MANAGEMENT AND CCTV

Ref.	Functional Requirement	Del.	Int.
BSD-03-01	Configurable display layouts	P2	E
BSD-03-02	Remote content updates	P2	E
BSD-03-03	Display grouping for centralized management	P2	E
BSD-03-04	Time/event-based display behavior	P2	E
BSD-03-05	Report displays operational status	P1	E
BSD-03-06	Report communication failures	P1	E
BSD-03-07	Audit logs for content changes	P2	E
BSD-03-08	Station area CCTV integration	P2	E
BSD-03-09	CCTV event recording for security	P2	E
BSD-03-10	Uptime and usage metrics	P5	E
BSD-03-11	Support future display formats	P3	E

2.4.4. DISPLAY INSTALLATION AND MAINTENANCE

Ref.	Functional Requirement	Del.	Int.
BSD-03-01	Register new display with location, model, serial number, install date	P2	W
BSD-03-02	Installation verification checklist with photo documentation	P2	M
BSD-03-03	Automatic failure detection with diagnostic codes	P2	E
BSD-03-04	Create repair work orders from display failures	P2	W
BSD-03-05	Assign repair tasks to field technicians	P2	W
BSD-03-06	Track repair status and completion verification	P2	B
BSD-03-07	Display maintenance history and uptime statistics	P2	W

2.4.5. DISPLAY BOARD VIEWING AND MANAGEMENT INTERFACE

Ref.	Functional Requirement	Del.	Int.
BSD-04-01	Display board list view with sorting, search and filtering	P2	W
BSD-04-02	displays by status (online/offline/error/maintenance)	P2	W
BSD-04-03	Display board map view showing geographic locations	P2	W
BSD-04-04	Click display on map or list to view details and configure settings	P2	W
BSD-04-05	Bulk select displays from list for group operations	P2	W
BSD-04-06	Apply setting and freeware update, view sync status	P2	W
BSD-04-07	Display detailed info popup (model, firmware, IP, last update)	P2	W

2.5. Operations and Fleet Management

2.5.1. VEHICLE REGISTRATION AND ONBOARDING

Ref.	Functional Requirement	Del.	Int.
OFM-00-01	Register new vehicle with complete details (reg number, chassis, model, capacity[seats / standing])	P1	W
OFM-00-02	Capture wheelchair bay count as a mandatory vehicle registration field (alongside standing capacity and seat count)	P1	W
OFM-00-03	Upload vehicle documents (registration, insurance, fitness certificate)	P1	W
OFM-00-04	Assign and verify on-bus devices to vehicle (GPS, POS, control unit, CCTV)	P2	W
OFM-00-05	Configure vehicle-specific parameters (route restrictions, seating capacity)	P1	W
OFM-00-06	Track vehicle ownership (LMT-owned vs PPP vendor)	P1	W
OFM-00-07	Vehicle activation and deactivation with reason codes	P1	W

2.5.2. REAL-TIME VEHICLE TRACKING

Ref.	Functional Requirement	Del.	Int.
OFM-01-01	Display real-time locations of all buses on map fleet view dashboard	P1	W
OFM-01-02	Display vehicle status indicators (color-coded)	P1	W
OFM-01-03	Track route adherence (actual vs planned)	P1	W
OFM-01-04	Alert on route deviations	P1	W
OFM-01-05	Calculate estimated arrival times	P1	W
OFM-01-06	Geofencing with entry/exit alerts	P2	W
OFM-01-07	Historical route playback	P2	W
OFM-01-08	Track vehicle speed and movement patterns	P3	W
OFM-01-09	Track PPP vendor buses separately	P3	W

2.5.3. OPERATOR BEHAVIOR MONITORING

Ref.	Functional Requirement	Del.	Int.
OFM-02-01	Track speed compliance	P1	W

Ref.	Functional Requirement	Del.	Int.
OFM-02-02	Track idle time	P2	W
OFM-02-03	Detect harsh braking events	P3	W
OFM-02-04	Detect rapid acceleration events	P3	W
OFM-02-05	Calculate driving scores	P3	W
OFM-02-06	Track continuous driving hours	P3	W
OFM-02-07	Enforce rest period requirements	P3	W
OFM-02-08	Monitor cornering behavior	P3	W
OFM-02-09	Track door operation patterns	P3	W

2.5.4. SCHEDULING AND DISPATCH

Ref.	Functional Requirement	Del.	Int.
OFM-03-01	Route and schedule definition	P2	W
OFM-03-02	Vehicle assignment to routes	P2	W
OFM-03-03	Operator assignment to vehicles/routes **[RT]**	P2	W
OFM-03-04	Assistant assignment (operator-assistant pairing)	P2	W
OFM-03-05	Schedule adjustments for service variations	P2	W
OFM-03-06	Scheduling conflict detection	P2	W
OFM-03-07	Emergency vehicle deployment	P2	W
OFM-03-08	Shift rotation planning and management	P2	W
OFM-03-09	Peak/off-peak service frequency adjustment	P2	W
OFM-03-10	First/last bus schedule enforcement	P2	W
OFM-03-11	Service variation tracking (express, limited, etc.)	P3	W

2.5.5. VEHICLE HEALTH MONITORING

Ref.	Functional Requirement	Del.	Int.
OFM-04-01	Receive OBD-II diagnostic data	P3	W
OFM-04-02	Display vehicle health dashboard	P3	W
OFM-04-03	Alerts for critical health issues	P3	W
OFM-04-04	Track maintenance due dates	P3	W
OFM-04-05	Maintain maintenance history	P3	W
OFM-04-06	Breakdown incident logging	P3	w

2.5.6. FUEL MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
OFM-05-01	Track real-time fuel levels	P2	W
OFM-05-02	Record refueling events	P2	W
OFM-05-03	Calculate fuel consumption per km	P2	W
OFM-05-04	Detect fuel consumption anomalies	P3	W
OFM-05-05	Fuel efficiency analytics	P5	W
OFM-05-06	Fuel vendor transaction management	P3	W
OFM-05-07	Fuel budget tracking and forecasting	P3	W

2.5.7. PASSENGER INFORMATION SYSTEMS INTEGRATION

Ref.	Functional Requirement	Del.	Int.
OFM-06-01	Passenger load broadcasting (crowding levels)	P3	W
OFM-06-02	Bus stop PIDS data feed	P3	W
OFM-06-03	Onboard PIDS management (interior/exterior displays)	P3	W
OFM-06-04	Automated announcement triggering (GPS-based)	P3	W
OFM-06-05	Mobile app API publishing (real-time data)	P3	W
OFM-06-06	Monitored vs. scheduled flag for arrival predictions	P3	W
OFM-06-07	Next stop: indicator management	P3	W
OFM-06-08	Transfer point information display	P3	W
OFM-06-09	Service disruption announcement broadcasting	P3	W

2.5.8. FARE COLLECTION AND REVENUE INTEGRATION

Ref.	Functional Requirement	Del.	Int.
OFM-07-01	Payment system integration (contactless, mobile wallets)	P1	W
OFM-07-02	Fare(cash) box status monitoring	P1	W
OFM-07-03	Transaction data aggregation	P1	W
OFM-07-04	Revenue reconciliation reporting	P1	W
OFM-07-05	Concession card recognition tracking	P1	W
OFM-07-06	Fare evasion detection and reporting	P1	W
OFM-07-07	Distance-based fare calculation support	P1	W
OFM-07-08	Transfer fare application logic	P1	W
OFM-07-09	Daily revenue collection reporting	P1	W

2.5.9. REGULATORY COMPLIANCE AND PERFORMANCE REPORTING

Ref.	Functional Requirement	Del.	Int.
OFM-08-01	Excess wait time (EWT) calculator	P3	W
OFM-08-02	On-time adherence (OTA) tracking	P3	W
OFM-08-03	Scheduled mileage compliance monitoring	P3	W
OFM-08-04	Safety performance index tracking	P3	W
OFM-08-05	First/last bus punctuality reporting	P3	W
OFM-08-06	Performance incentive/penalty calculator	P3	W
OFM-08-07	Quality of Service (QoS) dashboard	P3	W
OFM-08-08	Regulatory submission report generator	P3	W
OFM-08-09	Service reliability metrics tracking	P3	W
OFM-08-10	Accident/incident reporting system	P3	W
OFM-08-11	Environmental compliance tracking	P3	W

2.5.10. ONBOARD SAFETY AND SURVEILLANCE SYSTEMS

Ref.	Functional Requirement	Del.	Int.
OFM-09-01	Multi-camera CCTV management	P4	W
OFM-09-02	Emergency button monitoring	P4	W

Ref.	Functional Requirement	Del.	Int.
OFM-09-03	Video footage retrieval and archiving	P4	W
OFM-09-04	Privacy compliance management	P4	W

2.5.11. DEPOT LOGISTICS MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
OFM-11-01	Depot parking optimization	P3	W
OFM-11-02	Bus washing schedule management	P3	W
OFM-11-03	Depot resource allocation management	P3	W
OFM-11-04	Bus deployment readiness status	P3	W
OFM-11-05	Cleaning and sanitization scheduling	P3	W

2.5.12. ADVANCED ANALYTICS AND ROUTE OPTIMIZATION

Ref.	Functional Requirement	Del.	Int.
OFM-12-01	Passenger volume analytics	P5	W
OFM-12-02	Demand forecasting engine	P5	W
OFM-12-03	Bus bunching/gapping detection	P5	W
OFM-12-04	Planned route change publisher	P5	W
OFM-12-05	Headway adherence monitoring	P5	W
OFM-12-06	Origin-destination pattern analysis	P5	W
OFM-12-07	Service frequency optimization recommendations	P5	W
OFM-12-08	Peak demand corridor identification	P5	W
OFM-12-09	Historical performance trend analysis	P5	W

2.5.13. REPORTING AND BUSINESS INTELLIGENCE

Ref.	Functional Requirement	Del.	Int.
OFM-13-01	Customizable report builder	P3	W
OFM-13-02	Automated scheduled report generation	P3	W
OFM-13-03	Operational performance reports	P3	W
OFM-13-04	Data visualization and charting	P3	W
OFM-13-06	Ad-hoc query builder	P3	W

2.5.14. SERVICE PERFORMANCE METRICS AND KPIS

Ref.	Functional Requirement	Del.	Int.
KPI-01-01	Calculate on-time performance (OTP) by route and time period	P3	W
KPI-01-02	Calculate schedule adherence (early/late departures)	P3	W
KPI-01-03	Calculate service delivery rate (scheduled vs. operated trips)	P3	W
KPI-01-04	Calculate passenger complaints per 100,000 passenger trips	P3	W
KPI-01-05	Calculate mean distance between failures (MDBF)	P3	W
KPI-01-06	Calculate fleet availability rate	P3	W
KPI-01-07	Dashboard showing KPIs with trend analysis	P3	W
KPI-01-08	Automated KPI reporting (daily, weekly, monthly)	P3	W

Ref.	Functional Requirement	Del.	Int.
KPI-01-09	KPI benchmarking against industry standards	P3	W

2.6. Operations Control Centre

2.6.1. REAL-TIME DASHBOARDS

Ref.	Functional Requirement	Del.	Int.
OCC-01-01	Real-time fleet status dashboard	P3	W
OCC-01-02	KPI display (utilization, on-time performance)	P3	W
OCC-01-03	Service disruption dashboard	P3	W
OCC-01-04	Passenger analytics dashboard	P3	W
OCC-01-05	Revenue tracking dashboard	P3	W
OCC-01-06	Configurable dashboard layouts	P3	W
OCC-01-07	Drill-down to detailed data	P3	W
OCC-01-08	Multi-screen dashboard distribution	P3	W

2.6.2. ALERTS AND INCIDENT MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
OCC-02-01	Alert acknowledgment workflows	P3	W
OCC-02-02	Real-time incident logging	P3	W
OCC-02-03	Incident severity classification	P3	W
OCC-02-04	Escalate unacknowledged alerts	P3	W
OCC-02-05	Maintain incident history	P3	W
OCC-02-06	Integrate with SOC for security incidents	P3	W
OCC-02-07	Emergency response coordination	P3	W
OCC-02-08	Vehicle breakdown assistance dispatch	P3	W
OCC-02-09	Medical emergency protocol activation	P3	W
OCC-02-10	Emergency contact notification system	P3	W
OCC-02-11	Incident resolution tracking	P3	W
OCC-02-12	Post-incident report generation	P3	W
OCC-02-13	Crisis communication management	P3	W

2.6.3. COMMUNICATION HUB

Ref.	Functional Requirement	Del.	Int.
OCC-03-01	Driver-dispatcher two-way messaging	P3	W
OCC-03-02	Broadcast messaging to all/selected vehicles	P3	W
OCC-03-03	Emergency SOS communication channel	P3	W
OCC-03-04	Emergency broadcast to passenger displays	P3	W
OCC-03-05	Route-specific instruction delivery	P3	W
OCC-03-06	Message read receipt tracking	P3	W
OCC-03-07	Pre-defined message template library	P3	W

Ref.	Functional Requirement	Del.	Int.
OCC-03-08	Voice communication integration	P3	W
OCC-03-09	Communication logs and audit trail	P3	W
OCC-03-10	Coordination with emergency services	P3	W
OCC-03-11	Multi-channel communication management	P3	W
OCC-03-12	staff communication management Via app and normal mobile number (get number HR section)	P3	W

2.6.4. BREAKDOWN AND BUS REPLACEMENT WORKFLOW

Ref.	Functional Requirement	Del.	Int.
OCC-04-01	Transfer passenger tap data from broken bus to replacement bus	P3	W
OCC-04-02	Notify replacement bus Operator and assistant of expected passenger count	P3	E/M
OCC-04-03	Notify replacement bus driver of expected passenger count	P3	W
OCC-04-04	Dispatch tow truck and assign depot for broken bus repair	P3	W
OCC-04-05	Send push notifications to affected passengers with updated arrival	P3	M
OCC-04-06	Log complete breakdown incident (timeline, response time, resolution)	P3	W

2.6.5. CCTV CONTROL

Ref.	Functional Requirement	Del.	Int.
OCC-05-01	Depot CCTV integration via VMS API	P3	W
OCC-05-02	Separate monitoring interface for bus hold stations and in-bus cameras, distinct from the depot VMS integration.	P3	W
OCC-05-03	limited access token mechanism to grant controlled, auditable CCTV footage access to authorised external parties (e.g., police, insurance).	P3	W
OCC-05-04	Access log and audit trail for all CCTV access events, including external party access via tokens.	P3	W

2.7. Maintenance Management

2.7.1. PREVENTIVE MAINTENANCE

Ref.	Functional Requirement	Del.	Int.
MNT-01-01	Maintenance schedules based on mileage, time, and engine hours	P3	B
MNT-01-02	Create work orders from scheduled items	P3	B
MNT-01-03	Track maintenance completion	P3	B
MNT-01-04	Preventive maintenance compliance reporting	P3	W
MNT-01-05	Predictive maintenance using OBD-II data	P3	W
MNT-01-06	Periodic inspection scheduler	P3	W
MNT-01-07	Roadworthiness certification tracking	P3	B

2.7.2. MAINTENANCE HISTORY AND RECORDS

Ref.	Functional Requirement	Del.	Int.
MNT-02-01	Maintain complete maintenance history	P3	W
MNT-02-02	Component lifecycle tracking	P3	W
MNT-02-03	Warranty period monitoring	P3	W
MNT-02-04	Service record documentation	P3	W
MNT-02-05	Maintenance cost tracking by vehicle	P3	W
MNT-02-06	Parts replacement history	P3	W
MNT-02-07	Vendor service history tracking	P3	W

2.7.3. REPAIR WORKFLOW

Ref.	Functional Requirement	Del.	Int.
MNT-03-01	Create repair work orders from defect reports	P3	B
MNT-03-02	Create work orders from inspection findings	P3	B
MNT-03-03	Work order assignment to technicians	P3	B
MNT-03-04	Work order prioritization	P3	B
MNT-03-05	Track work order status	P3	B
MNT-03-06	Parts requisition from work orders	P3	B
MNT-03-07	Record labor hours and costs	P3	B
MNT-03-08	Work order rework workflow	P3	B
MNT-03-09	Work order closure and documentation	P3	B
MNT-03-10	Automatically post parts costs to General Ledger upon work order closure	P3	W
MNT-03-11	Allocate parts costs to vehicle and route cost centers	P3	W

2.7.4. TECHNICIAN FUNCTIONS (MOBILE-ENABLED)

Ref.	Functional Requirement	Del.	Int.
MNT-03-01	Display assigned work orders on mobile	P3	M
MNT-03-02	Accept or reject work orders	P3	M
MNT-03-03	Job-specific task checklists	P3	M
MNT-03-04	Photo documentation (before, during, after)	P3	M
MNT-03-05	Parts usage logging with barcode scanning	P3	M
MNT-03-06	Progress notes with text, voice and voice-to-text	P3	M
MNT-03-07	Work time tracking	P3	M
MNT-03-08	Digital signature for completion	P3	M
MNT-03-09	Offline capability	P3	M
MNT-03-10	Request additional parts or support	P3	M

2.7.5. EXAMINER FUNCTIONS (QUALITY ASSURANCE)

Ref.	Functional Requirement	Del.	Int.
MNT-05-01	Display completed work pending inspection	P3	B
MNT-05-02	Job-specific inspection checklists	P3	B
MNT-05-03	Photo documentation of findings	P3	B
MNT-05-04	Quality rating of completed work	P3	B
MNT-05-05	Work approval with a digital signature	P3	B
MNT-05-06	Work rejection with feedback	P3	B
MNT-05-07	Track rework and re-inspection	P3	B
MNT-05-08	Quality metrics reports	P3	W
MNT-05-09	Technician performance scoring	P3	B

2.7.6. VEHICLE INSPECTION

Ref.	Functional Requirement	Del.	Int.
MNT-06-01	Pre-trip inspection checklists	P3	M
MNT-06-02	Post-trip inspection checklists	P3	M
MNT-06-03	Periodic safety inspection checklists	P3	M
MNT-06-04	Photo documentation for defects	P3	M
MNT-06-05	Record odometer and fuel readings	P3	M
MNT-06-06	Digital signature for certification	P3	M
MNT-06-07	Flag critical defects and notify supervisors	P3	M
MNT-06-08	Create work orders from defects	P3	M
MNT-06-09	Vehicle defect reporting workflow	P3	M
MNT-06-10	Inspection compliance tracking	P3	M

2.8. Human Resources Management

2.8.1. EMPLOYEE RECORDS

Ref.	Functional Requirement	Del.	Int.
HRM-01-01	Maintain employee records	P2	W
HRM-01-02	Maintain employment details	P2	W
HRM-01-03	Maintain operator license records	P2	W
HRM-01-04	Maintain permits and medical fitness records	P2	W
HRM-01-05	Maintain training certificates	P2	W
HRM-01-06	Maintain emergency contact information	P2	W
HRM-01-07	Block shift assignment for expired certifications **[RT]**	P2	W
HRM-01-08	Track employee document repository	P2	W

2.8.2. ATTENDANCE AND SHIFT MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
HRM-02-01	Record daily attendance	P2	B
HRM-02-02	Biometric attendance integration	P2	W
HRM-02-03	Shift pattern and roster creation	P2	W
HRM-02-04	Operator-assistant pairing	P2	W

Ref.	Functional Requirement	Del.	Int.
HRM-02-05	Enforce rest period constraints	P2	W
HRM-02-06	Calculate regular and overtime hours	P2	W
HRM-02-07	Shift swap requests	P2	B
HRM-02-08	Track shift preferences and availability	P2	B
HRM-02-09	Generate optimal shift schedules based on constraints	P2	W

2.8.3. LEAVE MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
HRM-03-01	Maintain leave balances by type	P2	B
HRM-03-02	Leave application with approval workflow	P2	B
HRM-03-03	Document attachment for leave	P2	B
HRM-03-04	Automatic leave balance adjustment	P2	B
HRM-03-05	Leave calendar with conflict detection	P2	W
HRM-03-07	Track leave history	P2	B
HRM-03-08	Generate leave accrual reports	P2	W
HRM-03-09	Support multiple leave policies by employee category	P2	W

2.8.4. PAYROLL INTEGRATION

Ref.	Functional Requirement	Del.	Int.
HRM-04-01	Calculate salary components	P2	W
HRM-04-02	Calculate overtime payments	P2	W
HRM-04-03	Process statutory deductions	P2	W
HRM-04-04	Payroll batch processing	P2	W
HRM-04-05	Track bonus and incentive payments	P2	W
HRM-04-06	Generate payroll reports and summaries	P2	W
HRM-04-07	Support arrears and retroactive payments	P2	W

2.8.5. PERFORMANCE MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
HRM-05-01	Track operator performance metrics integrating driving scores (OFM-02-05), passenger complaints (PAS-07-01), and safety incidents (OFM-08-10)	P2	W
HRM-05-02	Track assistant performance metrics	P2	W
HRM-05-03	Track technician performance metrics	P3	W
HRM-05-04	Periodic performance evaluations	P2	W
HRM-05-05	Disciplinary record management	P2	W
HRM-05-06	Automatically create disciplinary case when passenger complaint severity threshold exceeded	P2	W

2.8.6. TRAINING MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
HRM-06-01	Training program catalog	P3	W
HRM-06-02	Training enrollment with approval	P3	W
HRM-06-03	Track training completion	P3	W
HRM-06-04	Identify training needs	P3	W
HRM-06-05	Training materials on mobile	P3	M
HRM-06-06	Generate training certificates	P3	W
HRM-06-07	Medical certification monitoring	P3	W
HRM-06-08	Training record management	P3	W
HRM-06-09	Age compliance monitoring	P3	W
HRM-06-10	Safety operator certification tracking	P3	W
HRM-06-11	License renewal reminder system	P3	W
HRM-06-12	Mandatory training completion tracking	P3	W

2.8.7. EMPLOYEE SELF-SERVICE (MOBILE-ENABLED)

Ref.	Functional Requirement	Del.	Int.
HRM-07-01	View attendance records on mobile	P2	M
HRM-07-02	Apply for leave on mobile	P2	M
HRM-07-03	View leave balances on mobile	P2	M
HRM-07-04	View/download pay slips on mobile	P2	M
HRM-07-05	Update personal information on mobile	P2	M
HRM-07-06	View assigned shifts on mobile	P2	M
HRM-07-07	Access training materials on mobile	P3	M
HRM-07-08	Submit grievances or feedback on mobile	P3	M
HRM-07-09	Access wellness resources on mobile	P3	M

2.8.8. GRIEVANCE AND COMPLAINT MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
HRM-08-01	Anonymous grievance submission	P3	B
HRM-08-02	Grievance categorization and routing	P3	W
HRM-08-03	Track grievance investigation progress	P3	W
HRM-08-04	Maintain confidential complaint records	P3	W
HRM-08-06	Escalation workflow for unresolved grievances	P3	W

2.9. Finance and Accounting

2.9.1. REVENUE MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
FIN-01-01	Record and track all fare revenue transactions **[AS]**	P1	W
FIN-01-02	Reconcile with GovPay settlements	P1	W
FIN-01-03	Generate revenue reports by route, period, payment method, operator	P2	W
FIN-01-04	Identify and flag revenue discrepancies for investigation	P2	W
FIN-01-05	Process refunds with proper authorization and audit trail	P2	W
FIN-01-06	Generate revenue reports	P2	W
FIN-01-07	Track revenue by bus, operator, and time of day	P2	W
FIN-01-08	Track non-fare revenue (advertising, concessions, leases)	P2	W
FIN-01-09	Generate daily revenue summary reports	P2	W
FIN-01-10	Record farebox ID, bus number, route, shift details for each cash box	P2	W
FIN-01-11	Allow cash counting entry by denomination with timestamp	P2	W
FIN-01-12	Link cash counting session to CCTV footage with retrieval capability	P2	W
FIN-01-13	Reconcile counted cash against farebox transaction logs	P2	W
FIN-01-14	Flag discrepancies between expected and actual cash amounts	P2	W
FIN-01-15	Generate daily cash collection reconciliation reports	P2	W

2.9.2. EXPENSE MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
FIN-02-01	Track and categorize operational expenses by type and cost center	P2	W
FIN-02-02	Integrate fuel costs **[B24]**	P2	W
FIN-02-03	Integrate maintenance costs **[AS]**	P3	W
FIN-02-04	Integrate payroll costs **[B24]**	P2	W
FIN-02-05	Track cost per kilometer	P3	W
FIN-02-06	Track cost per passenger	P3	W
FIN-02-07	Record utility bills by type (electricity, water, internet) and depot	P3	W
FIN-02-08	Import or manually enter monthly utility bills	P3	W
FIN-02-09	Track utility consumption trends by depot and month	P3	W
FIN-02-10	Compare utility costs across depots	P3	W
FIN-02-11	Generate utility expense reports by depot and period	P3	W
FIN-02-12	Set utility budget limits and alert on overruns	P3	W

2.9.3. GENERAL LEDGER

Ref.	Functional Requirement	Del.	Int.
FIN-03-01	Maintain chart of accounts aligned with Sri Lankan accounting standards	P3	W
FIN-03-02	Support automated posting from sub-ledgers (AP, AR, Payroll, Inventory)	P3	W

Ref.	Functional Requirement	Del.	Int.
FIN-03-03	Execute period-end closing procedures with validation checks	P3	W

2.9.4. ACCOUNTS PAYABLE

Ref.	Functional Requirement	Del.	Int.
FIN-04-01	Maintain vendor master data with banking and tax information	P3	W
FIN-04-02	Process vendor invoices with validation and matching controls	P3	W
FIN-04-03	Perform three-way matching (PO, GRN, Invoice) before payment	P3	W
FIN-04-04	Schedule and execute vendor payments via GovPay integration	P3	W
FIN-04-05	Calculate and apply withholding taxes per Sri Lankan regulations	P3	W
FIN-04-06	Generate vendor aging and payment history reports	P3	W

2.9.5. FIXED ASSET MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
FIN-05-01	Maintain fixed asset register for fleet and infrastructure	P5	W
FIN-05-02	Asset categorization (buses, buildings, equipment)	P5	W
FIN-05-03	Record asset acquisition details	P5	W
FIN-05-04	Calculate and post depreciation using appropriate methods	P5	W
FIN-05-05	Track asset acquisitions, transfers, and disposals	P5	W
FIN-05-06	Support asset revaluation and impairment testing	P5	W
FIN-05-07	Generate fixed asset reports for financial statements	P5	W

2.9.6. BUDGETING AND REPORTING

Ref.	Functional Requirement	Del.	Int.
FIN-06-01	Define and manage budgets by cost center and account	P3	W
FIN-06-02	Track budget vs actual with variance analysis	P3	W
FIN-06-03	Generate budget overrun alerts and reports	P3	W

2.9.7. BANK RECONCILIATION

Ref.	Functional Requirement	Del.	Int.
FIN-07-01	Import bank statements electronically	P5	W
FIN-07-02	Automated matching of transactions	P5	W
FIN-07-03	Manual reconciliation for unmatched items	P5	W
FIN-07-04	Track deposits in transit	P5	W
FIN-07-05	Track outstanding checks	P5	W
FIN-07-06	Bank reconciliation statement generation	P5	W
FIN-07-07	Multiple bank account support	P5	W
FIN-07-08	Bank fee and charge recording	P5	W

2.9.8. TAX MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
FIN-08-01	Calculate applicable taxes (VAT, WHT, ESC, NBT) per Sri Lankan law	P5	W
FIN-08-02	Generate tax returns and compliance reports	P5	W
FIN-08-03	Track tax payments and maintain payment records	P5	W
FIN-08-04	Support tax audits with transaction history and documentation	P5	W

2.9.9. FINANCIAL REPORTING

Ref.	Functional Requirement	Del.	Int.
FIN-09-01	Generate profit and loss statements	P5	W
FIN-09-02	Generate a balance sheet	P5	W
FIN-09-03	Generate cash flow statements	P5	W
FIN-09-06	Support drill-down from summary to transaction detail	P5	W

2.9.10. AUDIT AND COMPLIANCE

Ref.	Functional Requirement	Del.	Int.
FIN-10-01	Maintain a complete audit trail for all financial transactions	P3	W
FIN-10-02	Export data for external auditors	P3	W
FIN-10-03	User activity logging	P3	W
FIN-10-04	Comply with Sri Lanka Financial Reporting Standards (SLFRS/LKAS)	P3	W
FIN-10-05	Lock financial periods to prevent backdated transactions	P3	W
FIN-10-06	Archive financial data per legal retention requirements (5 years)	P3	W

2.9.11. CASH MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
FIN-11-01	Track cash receipts and disbursements	P3	W
FIN-11-02	Manage petty cash with approval controls	P3	W

2.9.12. COST ALLOCATION AND ANALYSIS

Ref.	Functional Requirement	Del.	Int.
FIN-12-01	Define and maintain cost center hierarchy	P5	W
FIN-12-02	Allocate costs to routes, depots, and buses	P5	W
FIN-12-03	Calculate route profitability	P5	W
FIN-12-04	Generate cost analysis reports by service and location	P5	W

2.9.13. PROCUREMENT-FINANCE INTEGRATION (CRITICAL)

Ref.	Functional Requirement	Del.	Int.
FIN-13-01	Check budget availability before purchase order approval	P4	W
FIN-13-02	Record purchase order commitments against budget	P4	W
FIN-13-03	Create expense accrual when goods received (GRN posted)	P4	W
FIN-13-04	Reverse accrual and create payable when invoice matched	P4	W
FIN-13-05	Post inventory transactions to general ledger	P4	W
FIN-13-06	Post parts issuance to maintenance expense accounts	P4	W
FIN-13-07	Maintain inventory subsidiary ledger integrated with GL	P4	W

Ref.	Functional Requirement	Del.	Int.
FIN-13-08	Support FIFO and weighted average inventory valuation	P4	W
FIN-13-09	Execute month-end inventory and AP closing procedures	P4	W
FIN-13-10	Enforce segregation of duties between procurement and payment	P4	W
FIN-13-11	Require Finance approval for vendor payments	P4	W
FIN-13-12	Share vendor master data between Procurement and Finance	P4	W

2.9.14. PPP VENDOR REVENUE AND PAYMENTS

Ref.	Functional Requirement	Del.	Int.
FIN-14-01	Calculate per-kilometer payments using GPS-tracked distance	P4	W
FIN-14-02	Apply contracted rate tables by route and time period	P4	W
FIN-14-03	Generate monthly PPP vendor payment summaries	P4	W
FIN-14-04	Integrate with GovPay for automated PPP vendor disbursements	P4	W

2.9.15. INVENTORY ACCOUNTING

Ref.	Functional Requirement	Del.	Int.
FIN-15-01	Maintain inventory as asset in general ledger	P4	W
FIN-15-02	Post all inventory transactions to GL in real-time	P4	W
FIN-15-03	Calculate cost of goods issued (parts consumed)	P4	W
FIN-15-04	Identify obsolete inventory for write-down	P4	W
FIN-15-05	Generate inventory valuation and movement reports	P4	W

2.10. Stores, Inventory, and Procurement Management

2.10.1. PARTS CATALOGUE

Ref.	Functional Requirement	Del.	Int.
SIP-01-01	Master catalogue of spare parts with unique part numbers	P4	W
SIP-01-02	Categorize parts by type (engine, electrical, body, tires, filters, fluids, etc.)	P4	W
SIP-01-03	Record vehicle compatibility (which bus models use this part)	P4	W
SIP-01-04	Maintain primary supplier information per part	P4	W
SIP-01-05	Track current pricing and standard lead time	P4	W

2.10.2. STOCK CONTROL

Ref.	Functional Requirement	Del.	Int.
SIP-02-01	Track real-time stock levels with automatic updates on transactions	P4	B
SIP-02-02	Multi-location inventory (central warehouse + depot stores)	P4	B
SIP-02-03	Track bin/rack locations for efficient picking	P4	W
SIP-02-04	Stock valuation using FIFO or weighted average methods	P4	W
SIP-02-05	Barcode/QR scanning for all stock operations	P4	B
SIP-02-06	Print barcode stickers for part labeling	P4	W
SIP-02-07	Reserved stock tracking (allocated to work orders but not yet issued)	P4	W

2.10.3. REORDER MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
SIP-03-01	Configure minimum and maximum stock levels per part	P4	W
SIP-03-02	Auto-generate reorder alerts when stock falls below minimum	P4	W
SIP-03-03	Calculate recommended reorder quantities	P4	W
SIP-03-04	Critical parts flagging with higher service level targets	P4	W

2.10.4. STOCK TRANSACTIONS

Ref.	Functional Requirement	Del.	Int.
SIP-04-01	Goods receipt with quality inspection and discrepancy recording	P4	B
SIP-04-02	Three-way matching (PO, goods receipt note, supplier invoice)	P4	W
SIP-04-03	Parts issuance to work orders with technician acknowledgment	P4	B
SIP-04-04	Parts returns from work orders with reason codes and stock adjustment	P4	B
SIP-04-05	Stock transfers between warehouse and depot locations	P4	B
SIP-04-06	Physical stock count (cycle counting) with variance adjustment	P4	B
SIP-04-09	Mobile receiving capability with offline mode and sync	P4	M

2.10.5. PROCUREMENT

Ref.	Functional Requirement	Del.	Int.
SIP-05-01	Purchase requisition creation with approval workflow	P4	W
SIP-05-02	Purchase order generation from approved requisitions	P4	W
SIP-05-04	Track PO status (pending approval, issued, partially received, completed, cancelled)	P4	W
SIP-05-05	PO amendments with re-approval for significant changes	P4	W
SIP-05-06	Invoice processing and three-way matching	P4	W
SIP-05-07	Emergency procurement flag with expedited approval	P4	W

2.10.6. VENDOR MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
SIP-06-01	Maintain vendor master data (name, contact, tax ID, bank details)	P4	W
SIP-06-02	Approved vendor lists by part category	P4	W
SIP-06-03	Publish approved vendor list on public website (transparency)	P4	W
SIP-06-04	Publish procurement opportunities for vendor participation	P4	W
SIP-06-05	Vendor certification tracking (business registration, tax clearance)	P4	W

2.10.7. RETURNS AND WARRANTY MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
SIP-07-01	Return processing with reason codes (defective, wrong item, excess)	P5	B
SIP-07-02	Warranty period tracking per part with automated expiry alerts	P5	W
SIP-07-03	Warranty claim documentation (failure description, photos, dates)	P5	W
SIP-07-04	Link warranty claims to supplier for credit/replacement tracking	P5	W
SIP-07-05	Failed parts quarantine area with pending disposition status	P5	W

2.10.8. INVENTORY REPORTING

Ref.	Functional Requirement	Del.	Int.
SIP-08-01	Current stock level reports with alerts for below-minimum items	P4	W
SIP-08-02	Stock consumption reports by part and time period	P4	W
SIP-08-03	Stock valuation reports for financial accounting	P4	W
SIP-08-04	Slow-moving and non-moving stock reports (>6 months no usage)	P4	W
SIP-08-05	Procurement status reports (pending POs, overdue deliveries)	P4	W
SIP-08-06	Vendor performance reports (delivery timeliness, quality)	P4	W

2.10.9. ASSET AND TOOLS MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
SIP-09-01	Asset registry for major equipment (lifts, diagnostic machines, specialized tools)	P4	W
SIP-09-02	Tool checkout system with user accountability	P4	B
SIP-09-03	Tool check-in with condition verification	P4	W
SIP-09-04	Overdue tool alerts and return tracking	P4	W
SIP-09-05	Basic depreciation tracking for capitalized assets	P4	W

2.11. Analytics and Decision Support

2.11.1. OPERATIONAL ANALYTICS

Ref.	Functional Requirement	Del.	Int.
ADS-01-01	Fleet utilization analytics	P5	W
ADS-01-02	On-time performance analytics	P5	W
ADS-01-03	Ridership analytics	P5	W
ADS-01-04	Revenue per kilometer analytics	P5	W
ADS-01-05	Fuel efficiency analytics	P5	W
ADS-01-06	Maintenance cost analytics	P5	W

2.11.2. PREDICTIVE ANALYTICS

Ref.	Functional Requirement	Del.	Int.
ADS-02-01	Demand forecasting	P5	W
ADS-02-02	Predictive maintenance recommendations	P5	W
ADS-02-03	Schedule optimization recommendations	P5	W
ADS-02-04	Route optimization recommendations	P5	W

2.11.3. CITIZEN-CENTRIC INSIGHTS DASHBOARD

Ref.	Functional Requirement	Del.	Int.
ADS-03-01	Aggregate passenger feedback for policy makers	P5	W
ADS-03-02	Service quality trends	P5	W
ADS-03-03	Accessibility and inclusion metrics	P5	W
ADS-03-04	Complaint pattern analysis	P5	W

2.11.4. DATA MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
ADS-04-01	Data Lakehouse architecture integration	P5	W
ADS-04-02	Custom report builder	P5	W
ADS-04-03	Scheduled report generation	P5	W
ADS-04-04	Open data publishing through MoT-DX	P5	W
ADS-04-05	Data retention policies	P2	W

2.11.5. ANALYTICS DATA INTEGRATION

Ref.	Functional Requirement	Del.	Int.
ADS-05-01	Extract operational data from OFM module daily for analytics	P5	W
ADS-05-02	Extract financial data from FIN module daily for analytics	P5	W
ADS-05-03	Extract maintenance data from MNT module daily for analytics	P5	W
ADS-05-04	Extract HR data from HRM module daily for analytics	P5	W
ADS-05-05	Validate data quality before analytics processing	P5	W
ADS-05-06	Provide data refresh status indicators on all analytics dashboards	P5	W

2.11.6. DIGITAL VEHICLE INSPECTION REPORTS (DVIR)

Ref.	Functional Requirement	Del.	Int.
DVR-01-01	Pre-trip inspection checklist (brakes, lights, tires, fluids)	P1	W
DVR-01-02	Post-trip inspection checklist with defect reporting	P1	W
DVR-01-03	Driver digital signature certifying inspection completion	P1	W
DVR-01-04	Photo documentation for defects found during inspection	P1	W
DVR-01-05	Block vehicle from service if critical defects unresolved	P1	W
DVR-01-06	Automatic work order creation from inspection defects	P1	W
DVR-01-07	Supervisor review and approval of inspection reports	P1	W
DVR-01-08	Regulatory compliance reporting (inspection completion rates)	P1	W
DVR-01-09	Historical DVIR records by vehicle for compliance audits	P1	W

2.12. Platform Administration

2.12.1. ROLE CONFIGURATION

Ref.	Functional Requirement	Del.	Int.
ADM-01-01	Custom role creation	P2	W
ADM-01-02	Permission modification	P2	W
ADM-01-03	Role cloning	P2	W
ADM-01-04	Role hierarchy definition	P2	W
ADM-01-05	Data scope restrictions	P2	W
ADM-01-06	Access control matrix reports	P2	W

2.12.2. DASHBOARD MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
ADM-02-01	Custom dashboard creation	P2	W
ADM-02-02	Dashboard assignment to roles/users	P2	W
ADM-02-03	Default dashboard per role	P2	W
ADM-02-04	Read-only dashboard sharing	P2	W
ADM-02-05	Widget data source configuration	P2	W

2.12.3. SYSTEM CONFIGURATION

Ref.	Functional Requirement	Del.	Int.
ADM-03-01	Fare rule configuration	P1	W
ADM-03-02	Route and schedule configuration	P1	W
ADM-03-04	Workflow configuration	P2	W
ADM-03-05	Alert threshold configuration	P2	W
ADM-03-06	Configuration change history	P1	W
ADM-03-07	Configuration rollback	P2	W

2.12.4. INTEGRATION AND API MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
ADM-04-01	API developer portal	P2	W
ADM-04-02	API key management	P2	W
ADM-04-03	API rate limiting	P2	W
ADM-04-04	API usage monitoring	P2	W
ADM-04-05	API registration on MoT-DX	P2	W
ADM-04-06	API documentation and sandbox	P2	W

2.12.5. SECURITY AND COMPLIANCE

Ref.	Functional Requirement	Del.	Int.
ADM-05-01	SOC integration for security monitoring	P1	W
ADM-05-02	NOC integration for network monitoring	P2	W
ADM-05-03	Comprehensive audit logs	P1	W
ADM-05-04	Audit log retrieval and analysis	P1	W

Ref.	Functional Requirement	Del.	Int.
ADM-05-05	PDPA compliance tools	P1	W
ADM-05-06	Data subject access request handling	P2	W
ADM-05-07	Zero-trust security principles	P1	W

2.12.6. CCTV ACCESS CONTROL

Ref.	Functional Requirement	Del.	Int.
ADM-06-01	Grant role-based access to CCTV feeds (live and recorded)	P3	W
ADM-06-02	Issue time-limited access to security authorities	P3	W
ADM-06-03	Log all CCTV access (who, what camera, when, duration)	P3	W
ADM-06-04	Allow authorities to request footage by bus/location/time range	P3	W
ADM-06-05	Export footage with digital signature for legal evidence	P3	W

2.12.7. FARE TABLE VERSION CONTROL

Ref.	Functional Requirement	Del.	Int.
ADM-07-01	Track fare table version number for each bus	P1	W
ADM-07-02	Dashboard showing fare update status by bus (current/outdated)	P1	W
ADM-07-03	Alert when bus fails to load updated fare table within 24 hours	P1	W
ADM-07-04	Force immediate fare table update to specific buses	P1	W
ADM-07-05	Audit log of fare table updates (who, when, which buses)	P1	W

2.12.8. BUS CONFIGURATION MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
ADM-08-01	Configure bus hardware settings (ex - external display, pos, HMI)	P1	W
ADM-08-02	Control passenger display content per bus	P1	W
ADM-08-03	Create and manage bus groups (by route, depot, type, vendor)	P1	W
ADM-08-04	Apply configuration templates to bus groups (bulk configuration)	P1	W
ADM-08-05	Clone configuration from one bus to another	P1	W
ADM-08-06	Schedule configuration changes (apply at specific date/time)	P1	W
ADM-08-07	Bulk firmware update by bus with staged rollout	P1	W
ADM-08-08	Export/import bus configurations	P1	W
ADM-08-09	List all buses and Sort, multi select and search option	P1	W

2.12.9. CONNECTIVITY AND SYNC MONITORING

Ref.	Functional Requirement	Del.	Int.
ADM-09-01	Dashboard showing real-time connectivity status for all buses	P1	W
ADM-09-02	Dashboard showing real-time connectivity status for all displays	P1	W
ADM-09-03	Display time since last communication for each device	P1	W
ADM-09-04	Show connection quality metrics (signal strength, latency, packet loss)	P1	W
ADM-09-05	Display data sync queue size per bus (pending uploads)	P1	W
ADM-09-06	Track and display failed sync attempts with error codes	P1	W
ADM-09-07	Alert when device offline exceeds configured threshold	P1	W

Ref.	Functional Requirement	Del.	Int.
ADM-09-08	Historical connectivity reports (uptime, downtime patterns)	P1	W
ADM-09-09	Export connectivity data for analysis (CSV, Excel)	P1	W
ADM-09-10	Filter devices by connectivity status (online/offline/intermittent)	P1	W

2.12.10. DATA USAGE TRACKING AND MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
ADM-10-01	Maintain SIM card registry per device	P3	W
ADM-10-02	Record monthly data costs per device	P3	W
ADM-10-03	Dashboard showing top data consumers	P3	W
ADM-10-04	Historical data usage trends and analysis	P3	W
ADM-10-05	Export sheet (data usage, connection details and etc.)	P3	W

2.13. Advertising Management

2.13.1. AD SPACE INVENTORY

Ref.	Functional Requirement	Del.	Int.
ADV-01-01	Maintain ad space inventory	P5	W
ADV-01-02	Categorize ad spaces	P5	W
ADV-01-03	Pricing tiers for ad spaces	P5	W
ADV-01-04	Track availability and bookings	P5	W

2.13.2. CAMPAIGN MANAGEMENT

Ref.	Functional Requirement	Del.	Int.
ADV-02-01	Campaign creation	P5	W
ADV-02-02	Ad space selection and booking	P5	W
ADV-02-03	Campaign scheduling	P5	W
ADV-02-04	Content upload with validation	P5	W
ADV-02-05	Content approval workflow	P5	W
ADV-02-06	Service info priority over advertising	P5	W

2.13.3. CONTENT DISTRIBUTION

Ref.	Functional Requirement	Del.	Int.
ADV-03-01	Distribute content to on-bus displays	P5	E
ADV-03-02	Distribute content to bus stop displays	P5	E
ADV-03-03	Content rotation scheduling	P5	W
ADV-03-04	Service info priority (60/40 ratio)	P5	E
ADV-03-05	Emergency override of advertising	P5	E

2.13.4. REVENUE TRACKING

Ref.	Functional Requirement	Del.	Int.
ADV-04-01	Track advertising revenue	P5	W
ADV-04-02	Generate invoices	P5	W
ADV-04-03	Track payment status	P5	W
ADV-04-04	Estimate impression metrics	P5	W
ADV-04-05	Generate revenue reports	P5	W

2.14. SUMMARY REQUIREMENTS

All requirement counts below are verified against Part B content. Total functional requirements: 810

2.14.1. TOTAL REQUIREMENTS BY MODULE AND PHASE

The table below shows the count of functional requirements per module, broken down by delivery phase. Counts reflect verified parsing of Part B requirement tables. "Shared Services" covers IAM, Notification, Workflow, Reporting, Asset Register, and Document Management requirements.

Module	Total	P1	P2	P3	P4	P5
1. Passenger Services	80	32	23	13	9	3
2. Public Information Services	27	4	20	0	3	0
3. On-Bus System	106	52	27	22	3	2
4. Bus Stop Display System	35	11	22	1	0	1
5. Operations & Fleet Management	115	20	17	64	4	10
6. Operations Control Centre	42	0	0	42	0	0
7. Maintenance Management	54	0	0	54	0	0
8. Human Resources Management	58	0	43	15	0	0
9. Finance & Accounting	88	2	14	26	20	26
10. Stores, Inventory & Procurement	47	0	0	0	43	4
11. Analytics & Decision Support	33	9	1	0	0	23
12. Platform Administration	61	29	22	10	0	0
13. Advertising Management	20	0	0	0	0	20
Shared Services (IAM, NOT, WFL, REP, AST, DOC)	38	19	18	0	0	1
Integration Requirements (INT)	6	6	0	0	0	0
TOTAL	**~810**	**~184**	**~207**	**~247**	**~82**	**~90**

2.14.2. REQUIREMENTS BY PHASE

Phase durations are from the Master Delivery Timeline (Part D, Section D.1.1). All figures are verified against the Master Timeline table.

Phase	Name	Duration	Requirements	Key Deliverables
Phase 1	Passenger Services & Fare Collection	10 weeks	178	Passenger app, on-bus systems (fare collection, GPS), GovPay integration, foundation infrastructure

Phase 2	Staff Operations & Operational Launch	15 weeks	207	Staff App (Operator + Assistant modules), on-bus HMI/CCTV, OCC, HR management, fleet duty management
Phase 3	Administrative Operations & Back-Office	20 weeks	247	Finance & Accounting, full OCC, Operations & Fleet (advanced), Maintenance Management, lost & found
Phase 4	Maintenance & Stores	10 weeks	82	Maintenance Management (complete), Stores & Inventory, Procurement, Technician + Examiner modules
Phase 5	Analytics & Optimization	10 weeks (5A) + 4–6 weeks (5B optional)	90	Reporting, custom report builder, GTFS-RT / MoT-DX integration, data warehouse; AI analytics (optional)
Stabilization	Full System Integration & Acceptance	4 weeks	N/A	Load testing (500 buses simulated), security hardening, final documentation, acceptance sign-off
TOTAL		**~63 weeks (P1–P5A + Stabilization)**	**810**	**Complete Metro Bus Digital Platform**

2.14.3. INTERFACE DISTRIBUTION

Distribution of requirements across interface types. "Both (B)" means accessible via mobile app and web portal. "Public (P)" means accessible without authentication.

Interface Type	Count	%	Primary Users and Use Cases
Mobile (M)	59	7%	Passengers (journey planning, ticketing), Operators, Assistants, Technicians - field staff with mobile-only functions
Web (W)	512	64%	Administrators, Managers, Finance, HR, Stores - back-office staff using desktop/laptop browsers
Both - Mobile + Web (B)	88	11%	Staff and passengers who access the same function from either device (e.g., dashboards, notifications, profiles)
Embedded (E)	137	17%	On-bus hardware (HMI, tapping machines, displays, GPS, CCTV) and bus stop display boards
Public (P)	8	1%	Unauthenticated passengers - no login required (public route info, fare info, service status)
TOTAL	**804**	**100%**	

3. PART C: INTERFACE SPECIFICATIONS

3.1. Mobile Interface Requirements

3.1.1. MOBILE-ENABLED FUNCTIONS BY ROLE

Role	Functions
Passenger	All passenger services (PAS-01 to PAS-08)
Operator	Shift management, vehicle inspection, route navigation, performance, emergency
Assistant	Passenger assistance, lost and found, and feedback collection
Technician	Work orders, checklists, photo documentation, parts scanning
Examiner	Inspection queue, quality checklists, approval/rejection
All Staff	Employee self-service (attendance, leave, payslips)

3.1.2. MOBILE TECHNICAL REQUIREMENT

Ref.	Requirement	Priority
MOB-01	Native apps for Android (API 26+) and iOS (13+)	P1
MOB-02	Offline data caching	P1
MOB-03	Offline transaction queuing with sync	P1
MOB-04	Push notification support	P1
MOB-05	Biometric authentication	P2
MOB-06	GPS location services	P1
MOB-07	Camera integration	P2
MOB-08	Barcode/QR code scanning	P2
MOB-09	Voice-to-text input	P2

3.2. Web Interface Requirements

3.2.1. WEB TECHNICAL REQUIREMENTS

Ref.	Requirement	Priority
WEB-01	Responsive design	P1
WEB-02	Support Chrome, Firefox, Safari, Edge	P1
WEB-03	WCAG 2.1 Level AA compliance	P1
WEB-04	Session management	P1
WEB-05	Keyboard navigation	P1
WEB-06	Print-friendly reports	P2
WEB-07	Data export (PDF, Excel, CSV)	P2

3.3. Embedded Interface Requirements

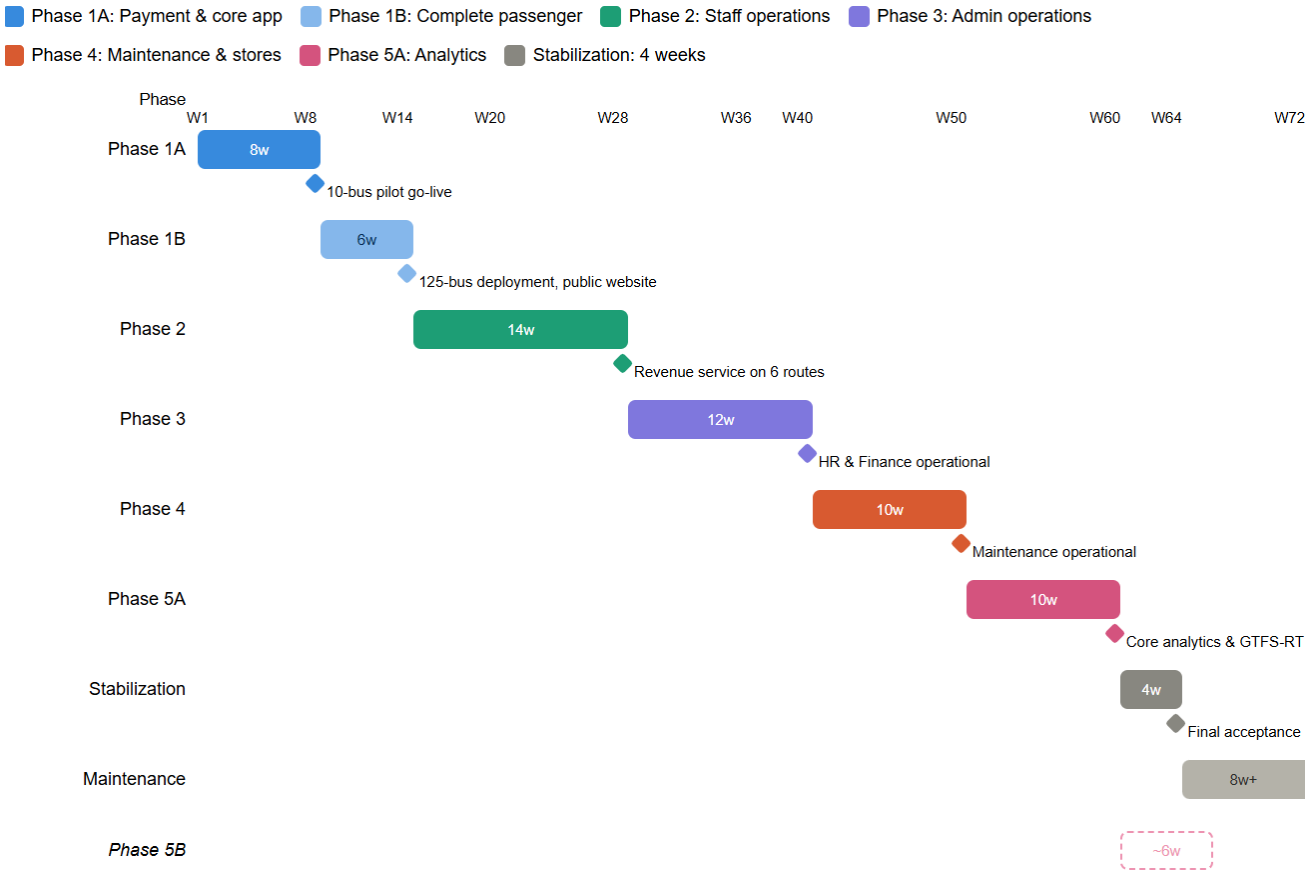
3.3.1. EMBEDDED TECHNICAL REQUIREMENTS

Ref.	Requirement	Priority
EMB-01	High reliability (99.9% uptime)	P1
EMB-02	Graceful degradation during connectivity loss	P1
EMB-03	Automatic recovery after power interruption	P1
EMB-04	Secure boot and tamper detection	P1
EMB-05	Remote software updates	P2
EMB-06	Health monitoring and status reporting	P1
EMB-07	EMV compliance for payment terminals	P1
EMB-08	Deferred authorization for offline payments	P1

4. PART D: DELIVERY TIMELINE

4.1.1. DELIVERY TIMELINE VISUALIZED AS A GANTT CHART

Here's the MBDP delivery timeline visualized as a Gantt chart. Each phase shows its duration in weeks with milestone diamonds marking the key deliverables. The dashed bar at the bottom shows the optional Phase 5B (AI Analytics) which runs in parallel with stabilization if contracted. The summary cards at the bottom give the key numbers at a glance.



4.1.2. MASTER DELIVERY TIMELINE

This table is the single authoritative timeline. All phase section headings below reference this table. Where any discrepancy exists between this table and a phase's narrative section, this table prevails.

Phase	Start Week	End Week	Duration	Requirements	Key Milestone	Acceptance
Phase 1A	Week 1	Week 7	8 weeks	~90	Week 13 – go live payment platform and passenger mobile app basic features	See Part E, E.4 Phase 1A
Phase 1B	Week 7	Week 13	6 weeks	~100	Complete all the rest of Phase 1 all functions.	See Part E, E.4 Phase 1B

					Public web side, mobile App 1P complete version,	
Phase 2	Week 14	Week 27	15 weeks	~180	Week 27 - 120-bus revenue service on 6 routes	See Part E, E.4 Phase 2
Phase 3	Week 28	Week 39	20 weeks	~150	Week 39 - Back-office operational (HR, Finance)	See Part E, E.4 Phase 3
Phase 4	Week 40	Week 49	10 weeks	~100	Week 49 - Maintenance and stores operational	See Part E, E.4 Phase 4
Phase 5A	Week 50	Week 59	10 weeks	~60	Week 59 - Core analytics and GTFS-RT live	See Part E, E.4 Phase 5A
Phase 5B (Optional)	Week 60+	TBD	4–6 weeks	~30	TBD - AI Analytics (subject to contract)	Forecast accuracy > 85%
Stabilization	After Phase 5A	+ 4 weeks	4 weeks	N/A	Final acceptance sign-off	99.0% uptime; zero critical defects
Maintenance Period	After Stabilization	-	18 months mandatory + 12 months optional	-	Quarterly business reviews	Per Part E, E.3 SLAs

Total development duration (P1 through P5A + Stabilization): approximately 63 weeks from contract signature.

Phase	Key Deliverables	Mobile Deliverables	Staff Training Required
Phase 1	Phase 1A: Core passenger app, fare collection, payment integration, foundation infrastructure. Phase 1B: Complete passenger app, public website, on-bus displays/audio, driver HMI, bus stop displays,	Passenger App (iOS + Android) public launch	Passenger app orientation
Phase 2	Staff App (Operator + Assistant modules), on-bus systems (HMI, CCTV, GPS), Operations Control Centre, fleet allocation, duty management, real-time GPS processing	Staff App shell + Operator module + Assistant module	Operator training (6 h), Assistant training (4 h), OCC controller training
Phase 3	HR Management (complete), Finance and Accounting (complete), enhanced OCC functions	Staff App update: Supervisor module	HR admin training, Finance admin training, Supervisor training

Phase 4	Maintenance Management (complete), Stores & Inventory, Procurement Management, barcode/QR scanning	Staff App update: Technician module + Examiner module	Technician training (8 h), Examiner training (6 h), Stores manager training
Phase 5A	Reports, custom report builder, dashboard builder, MoT-DX / GTFS-RT integration, open data API, data warehouse with ETL	No new app release	Analytics user training
Phase 5B	Demand forecasting, predictive maintenance, and AI schedule optimisation (all require ≥6 months of operational data)	No new app release	Data science team training

- Custom report builder (self-service analytics)
- Dashboard builder with role-based templates
- MoT-DX integration (GTFS-RT publishing)
- Open data API for third-party developers
- Data warehouse with ETL pipelines

Acceptance: All reports are functional, MoT-DX publishing real-time data, API accessible
Bidding Requirement: ALL vendors MUST provide a technical approach and pricing for Option A

- **Total Contract Duration:** - Development + Stabilization + 18 months mandatory maintenance
- **Training Before Access: -** Staff must complete training and demonstrate competency before getting system access phase by phase.
- **Phase 1 Pilot Must Succeed: -** The 3-week pilot with 10 buses is mandatory validation. If it fails, we fix issues before expanding. No shortcuts.
- **Security Clearance Required (Phase 2+): -** SL-CERT (Sri Lanka Computer Emergency Readiness Team) must issue a security clearance certificate before any Phase 2+ deployment. Non-negotiable.

4.2. Phase 1: Passenger Services & Fare Collection

Phase 1 delivers the foundational passenger-facing platform and fare collection infrastructure. To enable early validation and risk mitigation, Phase 1 is internally structured as two sub-phases (1A and 1B). All P1-designated functional requirements are delivered across these two sub-phases. The sub-phase split does not change any requirement reference codes.

4.2.1. PHASE 1A: PAYMENT PLATFORM & CORE PASSENGER APP

Duration: 8 weeks (Week 1 - Week 8)
Start: Contract signature
Key Milestone: Week 8 - Go-live of payment platform and core passenger mobile app.
Deliverables:

- Foundation infrastructure: Lanka Government Cloud (LGC) environment, CI/CD pipelines, security baseline, API gateway, database layer
- Identity and access management: SSO, OTP login, RBAC engine, MFA for admin functions [IAM-01-01 through IAM-01-08]

- Passenger mobile app (Android + iOS) - core features: real-time bus locations, route/stop information, fare calculator, service announcements [PAS-01-01 through PAS-01-07]
- Fare collection: EMV card acceptance, QR code scanning, tap-in/tap-out processing, distance-based fare calculation, cash farebox recording [FAR-01-01 through FAR-03-02]
- payment gateway integration and fare revenue recording [FIN-01-01, FIN-01-02, OFM-07-01 through OFM-07-09]
- GPS tracking: continuous position capture at 10-second intervals, geofencing, route adherence [GPS-01-01 through GPS-01-06]
- Notification service: SMS, email, in-app notifications with templates and audit [NOT-01-01 through NOT-01-06]

Acceptance: payments settlement reconciliation for 1 full day with zero discrepancies, GPS tracking visible on passenger app. See Phase 1A Acceptance Criteria.

4.2.2. PHASE 1B: COMPLETE PASSENGER SERVICES & PUBLIC WEB

Duration: 6 weeks (Week 9 – Week 14)
Start: Immediately following Phase 1A acceptance
Key Milestone: Week 14 - Complete passenger platform with public website, full mobile app.
Deliverables:

- Passenger mobile app - complete version: user account management, journey planning, transaction history, accessibility features [PAS-02-01 through PAS-04-07, ACC-01-01 through ACC-01-06]
- On-bus embedded software for MCU: central hub, POS terminal communication, fare table management, offline mode [OBS-01-01 through OBS-02-05]
- Public website: route information, timetables, fare structures, multilingual content, WCAG 2.1 AA compliance [PUB-02-05, PUB-03-01 through PUB-03-03]
- On-bus passenger information systems: external route displays, interior next-stop displays, audio announcements in three languages [PIS-01-01 through PIS-03-02]
- Driver interface: HMI touchscreen, route display, trip status, GPS-based stop updates, login and schedule loading [DRV-01-01 through DRV-03-02]
- Bus stop display system: real-time arrivals, service alerts, emergency messages, multilingual rotation [BSD-01-01 through BSD-03-06]
- Operations and fleet management foundations: vehicle registration, fleet tracking dashboard, route adherence [OFM-00-01 through OFM-02-01]
- Bus hardware configuration: device settings, display content, bus groups, bulk config, firmware updates [ADM-08-01 through ADM-08-09]
- Integration error handling: retry logic, message queuing, failure alerts [INT-01-08 through INT-01-10]
- Expansion from 10-bus pilot to full 120-bus fleet deployment across all 6 routes

Acceptance: public website operational; complete passenger app on app stores; all P1 requirements verified. See Phase 1B Acceptance Criteria.

4.3. Phase 2: Staff Operations & Operational Launch

Duration: 14-16 weeks

Start: Week 7

Key Milestone: Week 22 - Revenue service launch

Deliverables:

- Operator and Assistant mobile applications
- On-bus systems integration (HMI, CCTV, GPS)
- Operations Control Center (complete)
- Fleet allocation and duty management
- Staff administration (operator authorization, attendance)
- Real-time GPS data processing

Acceptance: complete all bus fleet operation and introduces staff app

4.4. Phase 3: Administrative Operations

Duration: 10-12 weeks

Start: Week 23

Key Milestone: Week 34 - Back-office operational

Deliverables:

- Human Resources Management (complete)
- Finance and Accounting (complete)
- Advanced OCC functions - Enhanced passenger services (multi-route planning, complaints)

Acceptance: HR managing 200+ staff, Finance reconciling daily revenue

4.5. Phase 4: Maintenance & Stores

Duration: 8-10 weeks

Start: Week 35

Key Milestone: Week 44 - Maintenance operational

Deliverables:

- Maintenance Management (complete)
- Technician and Examiner mobile applications
- Stores and Inventory Management
- Procurement Management
- Barcode/QR scanning

Acceptance: Maintenance system managing all 120 buses, stores operational

4.6. Phase 5: Analytics & Optimization

4.6.1. PHASE 5 OPTION A: CORE ANALYTICS (MANDATORY)

Duration: 10 weeks

Start: Week 45

Key Milestone: Week 54 - Core analytics operational

Deliverables: Operational, financial, maintenance, and HR reports

4.6.2. PHASE 5 OPTION B: AI-BASED ANALYTICS & PREDICTION **(OPTIONAL)**

Duration: Additional 4-6 weeks (Weeks 55-60)

Start: After Option A completion OR after 6-12 months of data accumulation

Deliverables (in addition to Option A):

- **Ridership Pattern Analysis:** Peak hour identification, seasonal trends, demand patterns
- **Demand Forecasting Models:** ML-based ridership prediction, route-level forecasts, special event prediction, demand-based route identification
- **Predictive Maintenance:** Component failure prediction, maintenance scheduling optimization, parts inventory optimization
- **AI-Assisted Schedule Optimization:** Route frequency optimization, service level recommendations, resource allocation optimization

Technical Requirements:

- Minimum 6 months' operational data required for model training
- Model accuracy targets: Demand forecasting >85%, Predictive maintenance >80% accuracy

Acceptance:

- Models operational and generating predictions
- Demand forecasting achieving >85% accuracy
- Predictive maintenance reduces unplanned downtime by >20%
- Schedule optimization recommendations validated by the operations team

5. PART F: EMBEDDED SYSTEMS SPEC

Purpose of This Section

This section provides a **simple overview** of the hardware environment where the software will operate. It is not a detailed technical specification but rather a basic understanding of:

- What hardware systems exist on buses and at bus stops
- What components are connected to each system
- How your software will interact with these systems

Note: Detailed hardware specifications and installation guides have been provided separately to the bus hardware vendor.

5.1. ON-BUS SYSTEM

5.1.1. SYSTEM OVERVIEW

The On-Bus System is an **integrated digital platform installed on each bus**. Think of it as a specialized computer system with various connected devices.

Central Computer (Main Control Unit - MCU):

- Industrial computer running embedded Linux or Android
- Coordinates all devices on the bus
- Runs your embedded software
- Communicates with cloud backend via 4G

Your software will run on this central computer and manages all connected devices.

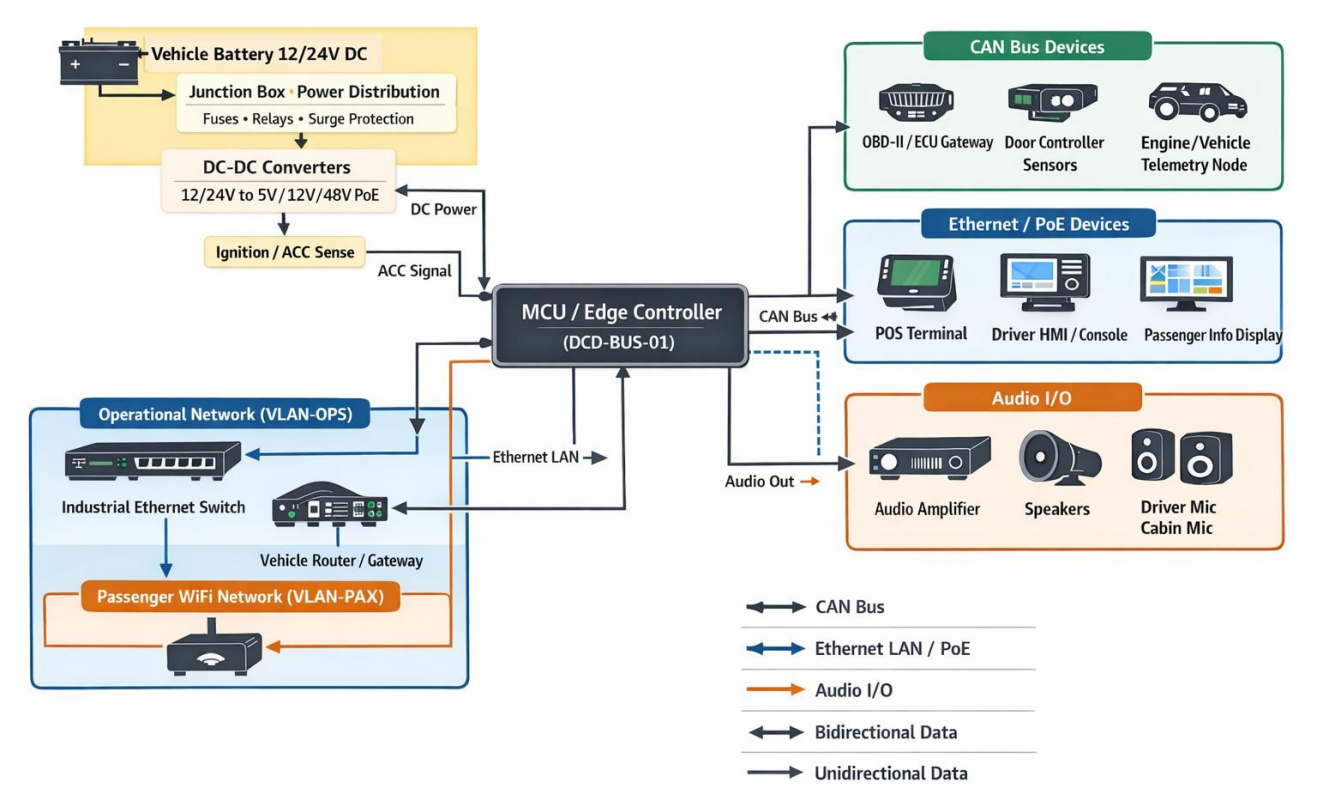
5.1.2. CONNECTED DEVICES

The following devices connect to the Main Control Unit:

Device	Quantity	Purpose	Software Responsibility
POS Terminals	4 units	Fare collection (tap cards)	Receive route/stop data from MCU; Send transaction summaries back
Passenger Displays	3 screens	Show next stop, route info	Receive display content from the MCU
GPS Module	1 unit	Track bus location	Provide the location to MCU every 10 seconds
CCTV Cameras	4 cameras	Video recording	Controlled by MCU; footage stored locally or uploaded
Driver Display	1 touchscreen	Driver interface (route info, alerts)	Managed by MCU software
Vehicle Sensors	Via CAN bus	Engine data, doors, fuel level	Read by MCU for monitoring
Audio System	Speakers + mic	Announcements, driver communication	Controlled by MCU
4G Modem	1 unit	Internet connectivity	Used by MCU to communicate with backend

5.1.3. SYSTEM ARCHITECTURE DIAGRAM

The digital bus system operates on a centralized architecture where the Main Control Unit (MCU) serves as the primary integration point for all subsystems. The MCU manages data flow, coordinates device operations, and maintains communication with external control centers.



5.1.4. WHAT YOUR SOFTWARE DOES

Your embedded software on the Main Control Unit will:

1. **Collect Data:**
   - GPS position every 10 seconds
   - Vehicle status (speed, fuel, doors)
   - Passenger tap-in/tap-out transactions from POS terminals
   - CCTV footage for incidents
2. **Send Data to Devices:**
   - Display content to passenger screens (next stop, route)
   - Route and stop information to POS terminals for fare calculation
   - Audio announcements (automatic based on GPS location)
3. **Communicate with Backend:**
   - Upload GPS, transactions, and system status via 4G
   - Download schedules, fare tables, and software updates
   - Enable two-way voice between driver and dispatch
4. **Manage Operations:**
   - Trigger announcements at correct stops
   - Record CCTV when needed
   - Handle offline mode when no internet connection

5.1.5. IMPORTANT HARDWARE CHARACTERISTICS

Power: System runs on vehicle 24V battery with ~6-hour backup battery

Offline Capability: System must work without internet (store data and upload later)

Operating Conditions: Operates in -20°C to +70°C with vehicle vibration

Network: Two separate networks:

- Operational network (MCU, POS, displays, CCTV)
- Passenger Wi-Fi (isolated for passenger internet access)

5.2. BUS STOP DISPLAY BOARD

5.2.1. SYSTEM OVERVIEW

The Bus Stop Display Board is a **digital sign at bus stops** showing real-time bus arrival information. It uses similar hardware to the on-bus system but with a simpler configuration.

Central Computer (Main Control Unit - MCU):

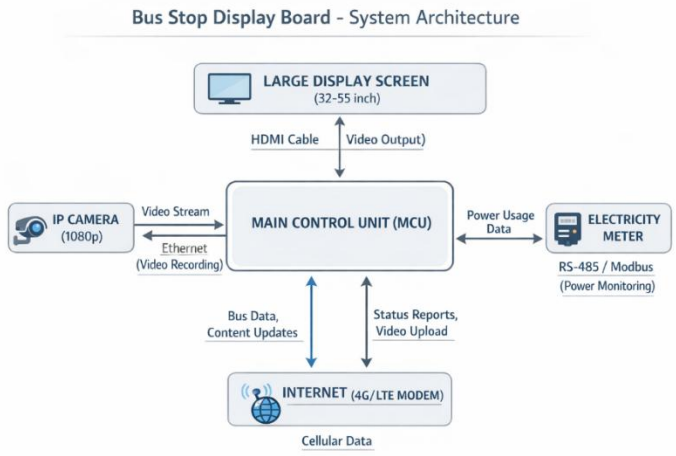
- Industrial computer running embedded Linux or Android (same as on-bus)
- Runs your display management software
- Communicates with cloud backend via Modem
- **Key Difference:** Outputs video directly to display via HDMI cable

Your software will run on this computer and generate the display content.

5.2.2. CONNECTED DEVICES

Device	Quantity	Purpose	Software Responsibility
Large Display	1 screen (32"-55")	Show bus arrivals and announcements	MCU generates video output via HDMI
IP Camera	1 camera	Security monitoring at bus stop	Controlled by MCU; similar to bus CCTV
Electricity Meter	1 interface	Monitor power consumption	Read by MCU and report to backend
4G Modem	1 unit	Internet connectivity	Used by MCU to receive arrival data and upload video

5.2.3. SYSTEM ARCHITECTURE DIAGRAM



5.2.4. WHAT YOUR SOFTWARE DOES

Your software on the Display Board will:

1. **Receive Real-Time Data:**
   - Bus arrival information from backend (next 3-5 buses with countdown)
   - Service alerts (delays, diversions, cancellations)
   - Emergency announcements
   - Advertising content
2. **Generate Display Content:**
   - Create video output showing arrival times, alerts, and ads
   - Output via HDMI to the display screen
   - Rotate between multiple languages (English, Sinhala, Tamil)
3. **Monitor Systems:**
   - Read electricity meter (track power usage)
   - Manage IP camera (similar to bus CCTV)
   - Report displays board health to backend
4. **Handle Connectivity:**
   - Receive updates via 4G connection
   - Show fallback content if internet unavailable (static schedule)

5.2.5. KEY DIFFERENCES FROM ON-BUS SYSTEM

Feature	On-Bus System	Display Board
Display Control	Network API to multiple displays	Direct HDMI video output to single display
Complexity	Many devices (POS, GPS, CCTV, etc.)	Simple setup (display + camera + meter)
Movement	Mobile (on vehicle)	Stationary (mounted at bus stop)
Power	Vehicle 24V battery	AC mains + UPS backup
Camera System	6-10 cameras with local storage	1 camera with cloud upload

5.3. COMMON ELEMENTS

5.3.1. SIMILARITIES BETWEEN BOTH SYSTEMS

Both systems share common characteristics:

Hardware:

- Similar Main Control Unit (industrial Linux or Android computer)
- 4G/LTE connectivity for cloud communication
- Camera systems (CCTV control logic is identical)

Software Architecture:

- Embedded Linux or Android operating system
- Real-time data processing requirements
- Offline operation capability
- Remote software updates (over-the-air)
- Health monitoring and diagnostics

Code Reusability: You can reuse significant portions of code between systems:

- CCTV recording and streaming modules
- Network communication protocols
- Health monitoring
- Data logging and upload
- Software update mechanisms

5.3.2. DEVELOPMENT APPROACH

What You Will Develop:

For On-Bus System:

- Embedded software for Main Control Unit
- Integration with all connected devices
- Data collection and upload logic
- Driver interface application

For Display Board:

- Embedded software for Main Control Unit
- Display content rendering (HDMI video output)
- Real-time arrival data processing
- CCTV integration (reuse from on-bus code)

What You Will Receive:

Hardware samples for development:

- 1-2 complete on-bus hardware sets
- 1-2 complete display board units

Access to test buses for field testing

5.4. TECHNICAL SUMMARY FOR PROCUREMENT

5.4.1. ON-BUS SYSTEM

Hardware Environment:

- Industrial embedded Linux or Android computer (Main Control Unit)
- 10+ connected devices via various interfaces
- 4G connectivity with offline capability
- Operates in a harsh vehicle environment

Software Requirements:

- Real-time data collection and processing
- Multi-device coordination
- Offline operation with data queuing
- Remote monitoring and updates

5.4.2. BUS STOP DISPLAY BOARD

Hardware Environment:

- Industrial embedded Linux or Android computer (Main Control Unit)
- HDMI video output to a large display
- Single IP camera and electricity meter
- 4G connectivity with fallback content

Software Requirements:

- Display content generation and rendering
- Real-time arrival data processing
- Simple device management
- Remote content updates

6. PART G: ANNEXURES

6.1. Annex A: Key Definitions

The following terms are used throughout this document. Informal synonyms are noted where terminology may vary in practice. All formal references in this document use the term shown in the "Term" column.

Term	Definition
Operator	Staff member responsible for driving the bus. Also referred to informally as "Driver," - that term is not used in this document.
Assistant	Staff member responsible for passenger services on the bus: managing fare collection, assistance, and handling passenger queries. Also known informally as "Conductor," that term is not used in this document.
POS Terminal	A point-of-sale device is installed on the bus for processing contactless fare payments via tap-in/tap-out and also known as a tapping machine, a validator, or card reader.
Farebox	A physically sealed cash collection box on the bus where cash fares are deposited. Includes a counting mechanism and thermal receipt printer. Also referred to as cash box.
MCU	Main Control Unit - the central industrial computer installed on each bus that coordinates all on-bus devices (POS terminals, displays, GPS, CCTV, audio). Also referred to as an on-bus computer or central unit.
Backend	The central cloud-hosted server infrastructure running on Lanka Government Cloud (LGC) that processes, stores, and serves all platform data. Also referred to as central servers, cloud backend, or server-side.
MCS	Monitoring and Control Station - the Operations Control Centre's central monitoring system. Also referred to as a control centre or dispatch centre.
OCC	Operations Control Centre - the physical room and software system used for centralized fleet monitoring and dispatch. Also referred to as the control room.
HMI	Human-Machine Interface - the touchscreen display unit used by the Operator to interact with the on-bus system. Also referred to as a driver display or operator terminal.
STA	Single Transport Account - a unified passenger account linked to SL-UDI for managing payments, tickets, and concessions across all transport services.
EMV	Europay, MasterCard, Visa - the global standard for chip-based and contactless card payments. Also referred to as contactless payment or tap-to-pay.
Deferred Authorization	Processing a payment transaction offline and settling it later when connectivity is available. Also referred to as offline authorization or store-and-forward.
APCS	Automatic Passenger Counting System - sensors (typically infrared or camera-based) installed at bus doors that automatically count passengers boarding and alighting. Also referred to as a passenger counter.
VMS	Video Management System - third-party software managing CCTV cameras at depots. MBDP provides a unified viewing interface; VMS handles the recording infrastructure.
PPP Vendor	A private company operating buses under contract alongside the LMT-owned fleet in a Public-Private Partnership model. PPP vendor staff (operators, assistants) use the same platform as LMT staff, filtered by data scope.

GovPay	The Sri Lankan government's centralised payment gateway is used for processing all digital fare transactions and settlements. Not in the real-time transaction path - used for batch settlement and reconciliation.
GTFS	General Transit Feed Specification - an open standard for publishing public transit schedules and route information. Used by journey planning apps (e.g., Google Maps, Transit App).
GTFS-RT	GTFS Realtime - an extension of GTFS that provides real-time updates, including vehicle positions, trip delays, and service alerts.
LGC	Lanka Government Cloud - the Sri Lankan government's centralised cloud hosting infrastructure. All MBDP backend services are hosted on LGC.
SL-UDI	Sri Lanka Universal Digital Identity - the national digital identity system used for second-factor passenger authentication from Phase 5 onward.

6.2. Annex B: Abbreviations

All abbreviations used in this document are listed below in alphabetical order.

Abbreviation	Full Form
AP	Accounts Payable
APCS	Automatic Passenger Counting System
API	Application Programming Interface
AR	Accounts Receivable
AVL	Automatic Vehicle Location
BPM	Business Process Management
CAN	Controller Area Network (vehicle diagnostics bus protocol)
CDIO	Chief Digital Information Officer
CI/CD	Continuous Integration / Continuous Deployment
DPI	Digital Public Infrastructure
DVIR	Driver Vehicle Inspection Report
EMV	Europay, MasterCard, Visa (contactless payment standard)
ETL	Extract, Transform, Load (data pipeline process)
EWT	Excess Waiting Time (service reliability metric)
FIFO	First In, First Out (inventory management method)
GL	General Ledger
Gov NOC	Government Network Operations Centre
GovPay	Government Payment Gateway (Sri Lanka)
GRN	Goods Received Note
GTFS	General Transit Feed Specification
GTFS-RT	General Transit Feed Specification - Realtime
HMI	Human-Machine Interface
IAM	Identity and Access Management
IFRS	International Financial Reporting Standards
IoT	Internet of Things
KPI	Key Performance Indicator
LGC	Lanka Government Cloud

LKAS	Lanka Accounting Standard
MCS	Monitoring and Control Station
MCU	Main Control Unit (on-bus central computer)
MDBF	Mean Distance Between Failures
MDM	Mobile Device Management
MFA	Multi-Factor Authentication
MoT-DX	Ministry of Transport Data Exchange
MQTT	Message Queuing Telemetry Transport (IoT messaging protocol)
MSA	Master Services Agreement
NDX	National Data Exchange
NFC	Near Field Communication
NPG	National Procurement Guidelines
OBD-II	On-Board Diagnostics II (vehicle diagnostics standard)
OCC	Operations Control Centre
OTA	Over-the-Air (software/firmware update method)
OTP	One-Time Password
PDPA	Personal Data Protection Act (Sri Lanka)
PII	Personally Identifiable Information
PO	Purchase Order
POS	Point-of-Sale terminal
PPP	Public-Private Partnership
QoS	Quality of Service
RBAC	Role-Based Access Control
RFP	Request for Proposals
SL-UDI	Sri Lanka Universal Digital Identity
SLA	Service Level Agreement
SLFRS	Sri Lanka Financial Reporting Standard
SOC	Security Operations Centre
SSO	Single Sign-On
STA	Single Transport Account
UAT	User Acceptance Testing
VM	Virtual Machine
VMS	Video Management System
WCAG	Web Content Accessibility Guidelines
WGS84	World Geodetic System 1984 (GPS coordinate standard)

6.3. Annex C: Reference Code Registry

This annex is the single master index of all requirement reference codes. After all duplicate resolution and gap closure work is complete, this registry SHALL be fully populated with every reference code, its description, module, delivery phase, and interface type.

Reference Code Format:

[MODULE]-[SUBMODULE]-[SEQUENCE] where MODULE = 3-letter module abbreviation, SUBMODULE = 2-digit sub-module number (01, 02, 03…), SEQUENCE = 2-digit sequential number within that sub-module (01, 02, 03…). Example: PAS-03-07 = Passenger Services, sub-module 3 (Journey Planning), requirement 7.

Module Abbreviation Registry:

Code	Module / Sub-Module
PAS	Passenger Services
PUB	Public Information Services
OBS	On-Bus System - Central Control / Offline Mode Management
FAR	On-Bus System - Fare Collection & Payment
PIS	On-Bus System - Passenger Information Systems
BAF	On-Bus System - Bus Accessibility Features
DRV	On-Bus System - Operator Interface & Operations (Driver)
GPS	On-Bus System - Location Tracking & GPS
BDT	On-Bus System - Data Collection, Logging & Analytics
BCS	On-Bus System - Bus Communication Systems
BSM	On-Bus System - Bus Safety & Monitoring Systems
BSD	Bus Stop Display System
OFM	Operations and Fleet Management
KPI	Operations - Service Performance Metrics and KPIs (sub-module)
OCC	Operations Control Centre
MNT	Maintenance Management
HRM	Human Resources Management
FIN	Finance and Accounting
SIP	Stores, Inventory, and Procurement Management
ADS	Analytics and Decision Support
ADM	Platform Administration
ADV	Advertising Management
GTF	Data Exchange / GTFS Standards
IAM	Shared Service - Identity and Access Management
NOT	Shared Service - Unified Notification Service
WFL	Shared Service - Common Workflow Engine
REP	Shared Service - Enterprise Reporting Platform

AST	Shared Service - Central Asset Register
DOC	Shared Service - Integrated Document Management
ACC	Accessibility Compliance and Monitoring
INT	Integration Requirements (cross-module)

END OF DOCUMENT

This document is prepared in alignment with the Sri Lanka National Digital Economy Blueprint and Transport Sector Digitalization Strategy. All functional requirements operate under the governance of the Transport CDIO model with Digital Steering Committee oversight.