



NGORONGORO CONSERVATION AREA AUTHORITY

Software Requirements Specification

NCAA Digital Transformation - Infrastructure & Hardware Module

Version: 1.0

Date: 2025-11-06

Status: Draft

<https://www.ncaa.go.tz>

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1 Document Information

| Field | Value |
|-----------------|--|
| Project Name | NCAA Digital Transformation - Infrastructure & Hardware Module |
| Version | 1.0 |
| Date | 2025-11-06 |
| Project Manager | TBD |
| Tech Lead | TBD |
| Qa Lead | TBD |
| Platforms | ['Hardware', 'Network', 'Infrastructure'] |
| Document Status | Draft |
| Module Code | INFRASTRUCTURE |
| Parent Project | NCAA Digital Transformation - Ngorongoro Gateway System |

2 Project Overview

2.1 What Are We Building

2.1.1 System Function

Complete hardware and network infrastructure for 9 gates, each equipped with Intel NUC application server, NAS backup system, WiFi access point, staff workstations (desktop PC and tablet), network infrastructure, and UPS power backup. System designed for reliable offline-first operation in remote locations with challenging conditions.

2.1.2 Users

- Gate Staff: Use desktop PC and tablets for daily operations
- IT Staff: Maintain and troubleshoot hardware
- System Administrators: Monitor infrastructure health
- Management: Review infrastructure costs and performance

2.1.3 Problem Solved

Aging infrastructure from 1959 at Lemala, no computer at Lemala 2, unreliable power at Ndutu (no electricity), no WiFi for mobile operations, no backup systems causing data loss risk, no standardized hardware across gates causing maintenance challenges, insufficient infrastructure at Main Gate causing staff overwork

2.1.4 Key Success Metric

All 9 gates equipped with standardized hardware, 99.5% hardware uptime, 2-4 hour UPS runtime, WiFi coverage for mobile operations, complete backup redundancy (NUC → NAS → USB), total project cost ~\$22,600 for 9 gates (~\$2,215 per gate)

2.2 Scope

2.2.1 In Scope

- Intel NUC application servers (9 units + 2 spares)
- NAS backup systems with RAID 1 (9 units)

- WiFi access points (9 units)
- Desktop PC workstations (9 units)
- Tablets for mobile operations (9 units)
- Network switches (9 units)
- UPS power backup (9 units, 1000VA each)
- Barcode/QR scanners (9 units)
- Receipt printers (9 units)
- IP cameras for vehicle inspection (9+ units)
- Network cabling and accessories
- Spare parts buffer (10%)
- Installation and setup
- Staff training on hardware
- Maintenance procedures and documentation

2.2.2 Out Of Scope

- Internet connectivity (existing infrastructure)
- Building modifications or construction
- Solar power systems (except where existing needs repair)
- Satellite communication systems
- Building HVAC or climate control
- Physical security systems (locks, barriers)
- Furniture or office equipment beyond computers

3 User Requirements

3.1 Compute Storage

| Feature Code | I Want To | So That I Can | Priority | Notes |
|-------------------------|---|---|----------|--|
| FT-INFRA-NUC-SETUP | Deploy Intel NUC as primary application server at each gate | Run PostgreSQL, Python backend, and React PWA locally with fast performance | Must | Intel NUC 11/12, 16GB RAM, 512GB NVMe SSD. Ubuntu Server 22.04 LTS. Cost ~\$300 per unit. |
| FT-INFRA-NUC-SPECS | Ensure NUC has sufficient processing power for real-time operations | Handle vehicle detection, database queries, and sync without performance issues | Must | Minimum Intel i5, prefer i7. Support for 24/7 operation. Passive cooling preferred for dusty environment. |
| FT-INFRA-NUC-REDUNDANCY | Maintain 2 spare NUC units at Old HQ | Quickly replace failed units at remote gates | Must | Spare units pre-configured and ready to deploy. Documented replacement procedure. Cost: 2 units @ \$300 = \$600. |
| FT-INFRA-NAS-SETUP | Deploy NAS with RAID 1 at each gate for backup storage | Protect against data loss with hourly backups and disk redundancy | Must | 4-bay Synology / QNAP, 2x 2TB HDD RAID 1. Supports snapshots. Cost: ~\$700 NAS + \$150 drives = \$850 per gate. |

| Feature Code | I Want To | So That I Can | Priority | Notes |
|-----------------------|--|---|----------|---|
| FT-INFRA-NAS-CAPACITY | Ensure NAS has sufficient capacity for 30+ days backup retention | Maintain complete backup history for recovery and audit | Must | 2TB per drive sufficient for estimated 50GB/month growth. RAID 1 provides 2TB usable. |

3.2 Network Infrastructure

| Feature Code | I Want To | So That I Can | Priority | Notes |
|-------------------|--|--|----------|--|
| FT-INFRA-WIFI-AP | Deploy WiFi access points at all gates | Enable tablet usage for mobile registration and inspection | Must | Outdoor AP (TP-Link EAP or Ubiquiti). Weather-resistant. Coverage 50-100m. Cost ~\$150-200 per unit. |
| FT-INFRA-SWITCH | Deploy network switch at each gate | Connect NUC, NAS, AP, desktop PC, and cameras | Must | 5-8 port gigabit switch. PoE support preferred for cameras and AP. Cost ~\$30-50 per unit. |
| FT-INFRA-CABLING | Properly cable network infrastructure | Ensure reliable connectivity between devices | Must | Cat6 ethernet cables. Cable management. Outdoor-rated where needed. Cost ~\$20 per gate. |
| FT-INFRA-TOPOLOGY | Implement standardized network | Simplify troubleshooting and maintenance | Must | Standard topology: NUC → Switch → (NAS, AP, PC, Camera). |

| Feature Code | I Want To | So That I Can | Priority | Notes |
|--------------|---------------------------|---------------|----------|---|
| | topology across all gates | | | Internet via existing connection to Switch. |

3.3 Staff Devices

| Feature Code | I Want To | So That I Can | Priority | Notes |
|-------------------------|---|---|----------|---|
| FT-INFRA-PC-WORKSTATION | Deploy desktop PC as primary workstation at each gate | Provide staff with reliable computing for registration and operations | Must | Budget desktop PC (~\$300-400). Connects via ethernet/WiFi to NUC. Monitor, keyboard, mouse included. |
| FT-INFRA-TABLET | Deploy tablet for mobile operations at each gate | Enable mobile vehicle inspection and visitor registration | Must | Android/iPad tablet (~\$200). WiFi only. Ruggedized case. PWA access to system. |
| FT-INFRA-PERIPHERALS | Provide barcode scanners and receipt printers | Support permit scanning and receipt printing | Must | Barcode/QR scanner ~\$50-100. Receipt printer ~\$100-150. USB connection to PC. |

3.4 Power Backup

| Feature Code | I Want To | So That I Can | Priority | Notes |
|-------------------------|--|--|----------|---|
| FT-INFRA-UPS-DEPLOYMENT | Deploy UPS at each gate for power backup | Maintain operations during power outages | Must | UPS 1000VA (~\$150-200). Powers NUC + NAS + Switch. |

| Feature Code | I Want To | So That I Can | Priority | Notes |
|------------------------|--|--|----------|--|
| | | common at remote locations | | Runtime 2-4 hours. USB/network management. |
| FT-INFRA-UPS-CAPACITY | Ensure UPS capacity sufficient for 2-4 hour runtime | Cover typical power outage duration | Must | Load: NUC (65W) + NAS (50W) + Switch (10W) = ~125W. 1000VA UPS provides 3-4hr at this load. |
| FT-INFRA-SOLAR-UPGRADE | Repair/upgrade solar systems where needed (Lemala 1) | Provide reliable power at locations without grid power | Should | Solar systems failed at Lemala 1 (infrastructure from 1959). Assessment required. Not included in \$22,600 budget. |

3.5 Camera Systems

| Feature Code | I Want To | So That I Can | Priority | Notes |
|--------------------|--|--|----------|--|
| FT-INFRA-CAM-IP | Deploy IP cameras for vehicle inspection | Enable automated vehicle detection and documentation | Must | IP camera 1080p+, H.264/H.265. PoE powered. Adjustable mount. Weather-resistant. Cost ~\$200-300 per camera. |
| FT-INFRA-CAM-MOUNT | Install adjustable camera mounts | Capture vehicles of varied heights (1.5m to 4m) | Must | Adjustable mounting hardware. Manual or motorized adjustment. Per |

| Feature Code | I Want To | So That I Can | Priority | Notes |
|--------------------|--|---|----------|---|
| | | | | Nov 3 revision feedback. |
| FT-INFRA-CAM-MULTI | Deploy multiple cameras at high-volume gates | Capture multiple angles (front, side) at busy locations like Seneto | Should | 2-3 cameras at Karatu, Seneto, Main Gate. Single camera at remote gates. Budget for 15 total cameras. |

3.6 Installation

| Feature Code | I Want To | So That I Can | Priority | Notes |
|-------------------------|---|---|----------|---|
| FT-INFRA-INSTALL-PILOT | Install and configure hardware at 3 pilot gates first | Validate setup and identify issues before full deployment | Must | Pilot gates: Karatu, Seneto, Main Gate. Test all components. Refine installation procedures. |
| FT-INFRA-INSTALL-REMOTE | Plan installation at remote locations with logistics challenges | Successfully deploy hardware at Ndotu, Lemala 1&2 despite access difficulties | Must | Remote locations require 4WD access. Coordinate with NCAA staff. Plan for multi-day installation. |
| FT-INFRA-INSTALL-CONFIG | Pre-configure NUC and NAS units before deployment | Minimize on-site configuration time at remote gates | Must | Configure at Old HQ: OS, PostgreSQL, PWA, network settings. Test before transport. |
| FT-INFRA-INSTALL-DOCS | Document installation procedures with photos | Enable future maintenance and troubleshooting | Must | Installation manual with photos. Network diagram per |

| Feature Code | I Want To | So That I Can | Priority | Notes |
|--------------|-----------|---------------|----------|--------------------------------------|
| | | | | gate. Configuration checklist. |

3.7 Maintenance

| Feature Code | I Want To | So That I Can | Priority | Notes |
|-------------------------|---|--|----------|---|
| FT-INFRA-MAINT-SCHEDULE | Establish maintenance schedule for all hardware | Prevent failures and extend hardware lifespan | Must | Monthly: clean dust filters, check connections. Quarterly: UPS battery test. Annually: hardware inspection. |
| FT-INFRA-MAINT-REMOTE | Enable remote troubleshooting capabilities | Resolve issues without traveling to remote gates | Must | SSH access from Old HQ. Remote desktop. System monitoring. Reduces need for site visits. |
| FT-INFRA-MAINT-SPARES | Maintain 10% spare parts buffer | Quickly replace failed components | Must | Spares at Old HQ: 2x NUC, hard drives, power supplies, cables, switches. Cost ~\$2,000. |
| FT-INFRA-MAINT-TRAINING | Train local staff on basic hardware maintenance | Enable first-level troubleshooting at gates | Must | Training: restart procedures, basic network troubleshooting, when to escalate. Laminated quick reference guides. |

3.8 Environmental

| Feature Code | I Want To | So That I Can | Priority | Notes |
|----------------------|---|--------------------------------------|----------|--|
| FT-INFRA-ENV-DUST | Protect hardware from dust in conservation area | Prevent premature hardware failure | Must | Enclosed racks or cabinets. Dust filters. Regular cleaning schedule. Passive cooling preferred. |
| FT-INFRA-ENV-HEAT | Ensure hardware operates in high temperatures | Maintain reliability in hot climate | Must | Hardware rated for 0-40°C operation. Adequate ventilation. Monitor temps. Passive cooling for NUC. |
| FT-INFRA-ENV-WEATHER | Protect outdoor equipment from weather | Maintain WiFi and camera reliability | Must | Weather-resistant enclosures. IP65+ rating for outdoor devices. Lightning protection for antennas. |

3.9 Cost Management

| Feature Code | I Want To | So That I Can | Priority | Notes |
|----------------------|---|--|----------|--|
| FT-INFRA-COST-BUDGET | Deliver project within ~\$22,600 budget for 9 gates | Meet financial constraints while achieving goals | Must | Budget: \$20,000 hardware (9 gates @ \$2,215) + \$600 spare NUCs + \$2,000 spare parts = \$22,600. |
| | | | Must | |

| Feature Code | I Want To | So That I Can | Priority | Notes |
|------------------------|---|--|----------|---|
| FT-INFRA-COST-TRACKING | Track costs per gate during procurement | Ensure budget compliance and identify cost savings | | Detailed cost tracking spreadsheet. Bulk purchase discounts. Local vs international procurement comparison. |
| FT-INFRA-COST-TCO | Calculate total cost of ownership including maintenance | Plan for ongoing operational costs | Should | TCO: hardware (\$22,600), maintenance (est \$2,000/year), power (UPS batteries \$150/year per gate), replacement cycle (5 years). |



4 Technical Requirements

4.1 Performance Standards

| Requirement | Target | How To Test |
|--------------------|----------------------------|--|
| Hardware uptime | ≥ 99.5% | Monitor uptime over 90 days, including UPS failover events |
| UPS runtime | 2-4 hours at typical load | Full load test with mains disconnected |
| WiFi coverage | 50-100m radius per gate | Site survey with tablets at various distances |
| Network throughput | ≥ 100 Mbps local network | iperf between devices |
| NUC query response | < 100ms for 95% of queries | Database performance testing |

4.2 Platform Requirements

| Platform | Minimum Version | Target Version | Notes |
|-----------|---|--|--|
| Intel NUC | NUC 11 with i5, 16GB RAM, 512GB NVMe | NUC 12 with i7, 16GB RAM, 512GB NVMe | Ubuntu Server 22.04 LTS pre-installed |
| NAS | 4-bay Synology DS420j or QNAP TS-453D | Synology DS423+ or QNAP TS-464 | 2x 2TB HDD (WD Red or Seagate IronWolf) in RAID 1 |
| WiFi AP | TP-Link EAP225-Outdoor or Ubiquiti UAP-AC-M | TP-Link EAP245 or Ubiquiti UAP-AC-PRO | Weather-resistant, 802.11ac minimum, PoE powered |
| UPS | APC Back-UPS 1000VA or CyberPower CP1000 | APC Smart-UPS 1000VA with network card | USB/network management, 2-4hr runtime at 125W load |

4.3 Security Privacy

| Requirement | Must Have | Implementation |
|---------------------------------|-----------|--|
| Physical security for equipment | True | Locked racks/cabinets at each gate. Access limited to authorized staff. |
| Network security | True | Firewalls on NUCs. WiFi WPA3 encryption. Network segmentation. |
| Hardware asset tracking | True | Asset register with serial numbers, locations, purchase dates. Annual inventory. |



5 External Dependencies

5.1 Third Party Services

| Service | What It Does | Criticality | Backup Plan |
|---------------------------|--------------------------------|--------------|---|
| Internet Service Provider | Existing internet connectivity | Nice to have | Offline operation, cellular data for sync |

5.2 Device Requirements

| Feature | Required | Optional | Notes |
|------------------------------------|----------|----------|---|
| 4WD vehicle access to remote gates | True | False | Required for installation at Ndutu, Lemala 1&2 |
| Existing electrical infrastructure | True | False | Grid power or solar. Ndutu has no electricity (requires solar upgrade). |

6 Release Planning

6.1 Development Phases

| Phase | Features Included | Timeline | Success Criteria |
|----------------------------------|--|----------|---|
| Phase 1 (Pilot - 3 Gates) | ['Hardware procurement', 'Installation at Karatu, Seneto, Main Gate', 'Configuration and testing', 'Staff training'] | 8 weeks | 3 gates fully operational, hardware performing to spec, staff trained and confident |
| Phase 2 (Intermediate - 3 Gates) | ['Installation at Old HQ, Nabi, Olduvai', 'Lessons learned from pilot applied', 'Remote support procedures established'] | 6 weeks | 6 gates operational, standardized installation procedures, remote troubleshooting working |
| Phase 3 (Remote - 3 Gates) | ['Installation at Ndutu, Lemala 1, Lemala 2', 'Solar system assessment/upgrade where needed', 'Complete documentation'] | 8 weeks | All 9 gates operational, solar power stable, complete maintenance documentation |

6.2 Release Checklist

- All hardware procured and inventory verified
- NUC and NAS units pre-configured at Old HQ
- Network topology documented per gate
- Installation completed at all 9 gates
- UPS runtime tested and verified (2-4 hours)
- WiFi coverage verified at all gates

- Camera systems operational where deployed
- Spare parts buffer established at Old HQ (2x NUC, drives, etc)
- Maintenance schedule established
- Staff trained on hardware operation and basic troubleshooting
- Remote access configured for all gates
- Hardware warranty and support contracts in place
- Asset register complete with all serial numbers



7 Risks Assumptions

7.1 Risks

| Risk | Probability | Impact | Mitigation |
|---|-------------|--------|---|
| Hardware delays due to import/shipping challenges in Tanzania | Medium | Medium | Early procurement, local suppliers for some items, buffer in timeline |
| Harsh environment causing premature hardware failure | Medium | High | Ruggedized equipment, dust protection, spare parts buffer, extended warranties |
| Power infrastructure inadequate at remote locations | High | High | UPS backup, solar system upgrades where needed, low-power hardware choices |
| Remote gate access difficulties delaying installation | Medium | Medium | Coordinate with NCAA logistics, 4WD vehicle arranged, multi-day installation windows |
| Hardware theft or vandalism at remote locations | Low | High | Locked cabinets, physical security, insurance, asset tracking, local security awareness |

7.2 Assumptions

- Bulk purchase discounts achievable for ~30% savings
- Local power infrastructure adequate with UPS backup

- Remote gates accessible by vehicle during installation
- Staff capable of basic hardware operation with training
- Existing network infrastructure can be leveraged where available
- Hardware lifespan 5+ years with proper maintenance
- Spare parts available locally or via 2-week shipping



8 Market Specific Considerations

8.1 Primary Market

- Ngorongoro Conservation Area, Tanzania - 9 remote gates

8.2 Target Demographics

- Gate staff using hardware daily
- IT staff maintaining systems

8.3 Local Considerations

- Dusty environment requiring frequent cleaning
- High temperatures (up to 40°C) requiring adequate cooling
- Remote locations with limited vehicle access
- Limited local technical expertise requiring simple, reliable hardware
- Import duties and shipping costs for hardware
- Tanzania power standards (230V, 50Hz, Type D/G plugs)
- Aging infrastructure at some gates (Lemala 1 from 1959)

8.4 Hardware Availability

8.4.1 Local Dar Es Salaam

Desktop PCs, tablets, cables, some networking gear

8.4.2 Regional Nairobi

Intel NUCs, WiFi APs, switches, UPS

8.4.3 International

NAS units, specialized cameras, high-end equipment

9 Sign Off

9.1 Approval

| Role | Name | Signature | Date |
|------|------|-----------|------|
| | | | |

9.2 Document History

| Version | Date | Changes Made | Changed By |
|---------|------------|---|------------------|
| 1.0 | 2025-11-06 | Initial draft based on gate nodes architecture document | Development Team |

10 Detailed Feature Requirements

10.1 Ft Infra Nuc Setup

10.1.1 Priority

Must Have

10.1.2 User Story

As an IT administrator, I want to deploy Intel NUC as primary application server at each gate so that I can run PostgreSQL, Python backend, and React PWA locally with fast performance

10.1.3 Preconditions

Intel NUC 11/12 procured; Ubuntu Server 22.04 LTS image prepared; network configured

10.1.4 Postconditions

NUC operational at gate; PostgreSQL running; PWA accessible; verified performance benchmarks met

10.1.5 Test Cases

| Id | Description | Weight |
|------------------|---|--------|
| INFRA-NUC-TC-001 | Install Ubuntu Server 22.04 LTS on NUC | High |
| INFRA-NUC-TC-002 | Install and configure PostgreSQL 15+ on NUC | High |
| INFRA-NUC-TC-003 | Deploy Python backend and React PWA | High |
| INFRA-NUC-TC-004 | Verify query response time <100ms | High |
| INFRA-NUC-TC-005 | Test 24/7 continuous operation for 7 days | High |

10.2 Ft Infra Nuc Specs

10.2.1 Priority

Must Have

10.2.2 User Story

As an IT administrator, I want NUC to have sufficient processing power for real-time operations so that vehicle detection, database queries, and sync run without performance issues

10.2.3 Preconditions

NUC specifications validated; processing requirements documented

10.2.4 Postconditions

NUC meets all performance benchmarks; vehicle detection runs in <5 seconds; database queries <100ms

10.2.5 Test Cases

| Id | Description | Weight |
|------------------|---|--------|
| INFRA-NUC-TC-006 | Verify Intel i5/i7 processor installed | High |
| INFRA-NUC-TC-007 | Verify 16GB RAM installed and available | High |
| INFRA-NUC-TC-008 | Verify 512GB NVMe SSD performance (read/write speeds) | High |
| INFRA-NUC-TC-009 | Test real-time vehicle detection performance | High |
| INFRA-NUC-TC-010 | Load test with concurrent database operations | High |

10.3 Ft Infra Nuc Redundancy

10.3.1 Priority

Must Have

10.3.2 User Story

As an IT manager, I want to maintain 2 spare NUC units at Old HQ so that I can quickly replace failed units at remote gates

10.3.3 Preconditions

2 additional NUC units procured; pre-configuration completed; documentation prepared

10.3.4 Postconditions

Spare NUCs ready for deployment; replacement procedure tested; staff trained

10.3.5 Test Cases

| Id | Description | Weight |
|------------------|---|--------|
| INFRA-NUC-TC-011 | Pre-configure 2 spare NUC units with standard image | High |
| INFRA-NUC-TC-012 | Document and test replacement procedure | High |
| INFRA-NUC-TC-013 | Verify spare NUC can replace operational unit in <2 hours | High |

10.4 Ft Infra Nas Setup

10.4.1 Priority

Must Have

10.4.2 User Story

As an IT administrator, I want to deploy NAS with RAID 1 at each gate so that I can protect against data loss with hourly backups and disk redundancy

10.4.3 Preconditions

NAS unit and 2x 2TB drives procured; network configured; backup scripts prepared

10.4.4 Postconditions

NAS operational with RAID 1; hourly backups configured; verification successful

10.4.5 Test Cases

| Id | Description | Weight |
|------------------|---|--------|
| INFRA-NAS-TC-001 | Configure NAS with 2x 2TB drives in RAID 1 | High |
| INFRA-NAS-TC-002 | Configure hourly backup from NUC to NAS | High |
| INFRA-NAS-TC-003 | Verify backup completes in <10 minutes | High |
| INFRA-NAS-TC-004 | Test single drive failure recovery | High |
| INFRA-NAS-TC-005 | Configure daily snapshots with 30-day retention | High |

10.5 Ft Infra Nas Capacity

10.5.1 Priority

Must Have

10.5.2 User Story

As an IT administrator, I want NAS to have sufficient capacity for 30+ days backup retention so that I can maintain complete backup history for recovery and audit

10.5.3 Preconditions

Storage requirements calculated; 2TB RAID 1 configuration validated

10.5.4 Postconditions

NAS has adequate capacity; storage monitoring configured; alerts set at 80%

10.5.5 Test Cases

| Id | Description | Weight |
|------------------|---|--------|
| INFRA-NAS-TC-006 | Verify 2TB usable capacity available | High |
| INFRA-NAS-TC-007 | Monitor storage growth over 30 days | Medium |
| INFRA-NAS-TC-008 | Test storage alert at 80% capacity | Medium |
| INFRA-NAS-TC-009 | Verify 30-day backup retention maintained | High |

10.6 Ft Infra Wifi Ap

10.6.1 Priority

Must Have

10.6.2 User Story

As a gate staff member, I want WiFi access points at all gates so that I can use tablets for mobile registration and inspection

10.6.3 Preconditions

Outdoor WiFi AP procured; mounting location identified; network configured

10.6.4 Postconditions

WiFi operational with 50-100m coverage; tablets connected; performance verified

10.6.5 Test Cases

| Id | Description | Weight |
|-------------------|---|--------|
| INFRA-WIFI-TC-001 | Install and configure outdoor WiFi AP | High |
| INFRA-WIFI-TC-002 | Verify WiFi coverage 50-100m radius | High |
| INFRA-WIFI-TC-003 | Test tablet connectivity and performance | High |
| INFRA-WIFI-TC-004 | Verify weather-resistant housing protection | Medium |
| INFRA-WIFI-TC-005 | Test WPA3 encryption and security | High |

10.7 Ft Infra Switch

10.7.1 Priority

Must Have

10.7.2 User Story

As an IT administrator, I want a network switch at each gate so that I can connect NUC, NAS, AP, desktop PC, and cameras

10.7.3 Preconditions

5-8 port gigabit switch procured; PoE capability verified; cabling prepared

10.7.4 Postconditions

Switch operational; all devices connected; gigabit throughput verified

10.7.5 Test Cases

| Id | Description | Weight |
|------------------|---|--------|
| INFRA-NET-TC-001 | Install and configure network switch | High |
| INFRA-NET-TC-002 | Connect all devices (NUC, NAS, AP, PC, cameras) | High |
| INFRA-NET-TC-003 | Verify gigabit throughput (≥ 100 Mbps) | High |
| INFRA-NET-TC-004 | Test PoE power delivery to cameras and AP | High |

10.8 Ft Infra Cabling

10.8.1 Priority

Must Have

10.8.2 User Story

As an IT administrator, I want properly cabled network infrastructure so that I can ensure reliable connectivity between devices

10.8.3 Preconditions

Cat6 ethernet cables procured; cable management hardware ready; outdoor-rated cables where needed

10.8.4 Postconditions

All devices properly cabled; cable management neat; outdoor cabling weatherproof

10.8.5 Test Cases

| Id | Description | Weight |
|------------------|---|--------|
| INFRA-NET-TC-005 | Cable all devices with Cat6 ethernet | High |
| INFRA-NET-TC-006 | Install cable management for organization | Medium |

| Id | Description | Weight |
|------------------|-------------------------------------|--------|
| INFRA-NET-TC-007 | Test cable integrity and throughput | High |
| INFRA-NET-TC-008 | Verify outdoor cables weatherproof | Medium |

10.9 Ft Infra Topology

10.9.1 Priority

Must Have

10.9.2 User Story

As an IT administrator, I want standardized network topology across all gates so that I can simplify troubleshooting and maintenance

10.9.3 Preconditions

Standard topology documented; network diagram prepared; IP addressing scheme defined

10.9.4 Postconditions

All gates follow standard topology; documentation complete; troubleshooting simplified

10.9.5 Test Cases

| Id | Description | Weight |
|------------------|--|--------|
| INFRA-NET-TC-009 | Implement standard topology at each gate | High |
| INFRA-NET-TC-010 | Document network topology with diagrams | High |
| INFRA-NET-TC-011 | Verify consistent IP addressing across gates | High |

10.10 Ft Infra Pc Workstation

10.10.1 Priority

Must Have

10.10.2 User Story

As a gate staff member, I want a desktop PC as primary workstation so that I can perform registration and operations reliably

10.10.3 Preconditions

Desktop PC procured; monitor, keyboard, mouse included; network connection ready

10.10.4 Postconditions

PC operational; PWA accessible; performance adequate for daily operations

10.10.5 Test Cases

| Id | Description | Weight |
|-----------------|--|--------|
| INFRA-PC-TC-001 | Install and configure desktop PC | High |
| INFRA-PC-TC-002 | Connect PC to network (ethernet or WiFi) | High |
| INFRA-PC-TC-003 | Access PWA and verify functionality | High |
| INFRA-PC-TC-004 | Test daily operations performance | High |

10.11 Ft Infra Tablet

10.11.1 Priority

Must Have

10.11.2 User Story

As a gate staff member, I want a tablet for mobile operations so that I can perform mobile vehicle inspection and visitor registration

10.11.3 Preconditions

Android/iPad tablet procured; ruggedized case included; WiFi configured

10.11.4 Postconditions

Tablet operational; PWA accessible; mobile operations tested successfully

10.11.5 Test Cases

| Id | Description | Weight |
|---------------------|---|--------|
| INFRA-TABLET-TC-001 | Configure tablet with PWA | High |
| INFRA-TABLET-TC-002 | Test WiFi connectivity to gate network | High |
| INFRA-TABLET-TC-003 | Verify mobile registration and inspection workflows | High |
| INFRA-TABLET-TC-004 | Test ruggedized case protection | Medium |

10.12 Ft Infra Peripherals

10.12.1 Priority

Must Have

10.12.2 User Story

As a gate staff member, I want barcode scanners and receipt printers so that I can scan permits and print receipts

10.12.3 Preconditions

Barcode/QR scanner and receipt printer procured; USB connections available

10.12.4 Postconditions

Peripherals operational; permit scanning working; receipt printing functional

10.12.5 Test Cases

| Id | Description | Weight |
|---------------------|--|--------|
| INFRA-PERIPH-TC-001 | Install and configure barcode/QR scanner | High |
| INFRA-PERIPH-TC-002 | Install and configure receipt printer | High |
| INFRA-PERIPH-TC-003 | Test permit scanning workflow | High |
| INFRA-PERIPH-TC-004 | Test receipt printing workflow | High |

10.13 Ft Infra Ups Deployment

10.13.1 Priority

Must Have

10.13.2 User Story

As a gate staff member, I want UPS at each gate for power backup so that operations continue during power outages

10.13.3 Preconditions

UPS 1000VA procured; load calculated (NUC+NAS+Switch ~125W); installation location identified

10.13.4 Postconditions

UPS operational; 2-4 hour runtime verified; monitoring configured

10.13.5 Test Cases

| Id | Description | Weight |
|------------------|-------------------------------------|--------|
| INFRA-UPS-TC-001 | Install and configure UPS 1000VA | High |
| INFRA-UPS-TC-002 | Connect NUC, NAS, and Switch to UPS | High |
| INFRA-UPS-TC-003 | | High |

| Id | Description | Weight |
|------------------|---|--------|
| | Test runtime under full load (verify 2-4 hours) | |
| INFRA-UPS-TC-004 | Configure USB/network management interface | High |
| INFRA-UPS-TC-005 | Test automatic system notifications on power events | Medium |

10.14 Ft Infra Ups Capacity

10.14.1 Priority

Must Have

10.14.2 User Story

As an IT administrator, I want UPS capacity sufficient for 2-4 hour runtime so that typical power outage duration is covered

10.14.3 Preconditions

Load calculation complete (NUC 65W + NAS 50W + Switch 10W = 125W); UPS specifications verified

10.14.4 Postconditions

Runtime requirement met; battery health monitoring configured; replacement schedule established

10.14.5 Test Cases

| Id | Description | Weight |
|------------------|--|--------|
| INFRA-UPS-TC-006 | Verify load calculation accurate (measure actual draw) | High |
| INFRA-UPS-TC-007 | Full discharge test to verify 2-4 hour runtime | High |
| INFRA-UPS-TC-008 | | Medium |

| Id | Description | Weight |
|------------------|---|--------|
| | Configure battery health monitoring | |
| INFRA-UPS-TC-009 | Test low battery alerts and graceful shutdown | High |

10.15 Ft Infra Solar Upgrade

10.15.1 Priority

Should Have

10.15.2 User Story

As an IT manager, I want to repair/upgrade solar systems where needed so that reliable power is available at locations without grid power

10.15.3 Preconditions

Solar system assessment completed; Lemala 1 needs identified; budget allocated

10.15.4 Postconditions

Solar systems operational at off-grid locations; power reliability improved

10.15.5 Test Cases

| Id | Description | Weight |
|--------------------|---|--------|
| INFRA-SOLAR-TC-001 | Assess solar system condition at Lemala 1 | Medium |
| INFRA-SOLAR-TC-002 | Repair or upgrade solar system as needed | Medium |
| INFRA-SOLAR-TC-003 | Verify solar power sufficient for gate operations | Medium |

10.16 Ft Infra Cam Ip

10.16.1 Priority

Must Have

10.16.2 User Story

As a gate staff member, I want IP cameras for vehicle inspection so that automated vehicle detection and documentation is enabled

10.16.3 Preconditions

IP camera 1080p+ procured; PoE switch available; mounting location identified

10.16.4 Postconditions

Camera operational; vehicle detection working; images captured and archived

10.16.5 Test Cases

| Id | Description | Weight |
|------------------|--|--------|
| INFRA-CAM-TC-001 | Install IP camera with PoE power | High |
| INFRA-CAM-TC-002 | Configure camera for 1080p H.264/H.265 | High |
| INFRA-CAM-TC-003 | Test vehicle detection and image capture | High |
| INFRA-CAM-TC-004 | Verify weather-resistant housing | Medium |

10.17 Ft Infra Cam Mount

10.17.1 Priority

Must Have

10.17.2 User Story

As an IT administrator, I want adjustable camera mounts so that vehicles of varied heights (1.5m to 4m) can be captured

10.17.3 Preconditions

Adjustable mounting hardware procured; height range requirements documented

10.17.4 Postconditions

Camera mount adjustable; all vehicle heights capturable; stability verified

10.17.5 Test Cases

| Id | Description | Weight |
|------------------|--|--------|
| INFRA-CAM-TC-005 | Install adjustable camera mount | High |
| INFRA-CAM-TC-006 | Test capture of small cars (1.5m height) | High |
| INFRA-CAM-TC-007 | Test capture of large buses (4m height) | High |
| INFRA-CAM-TC-008 | Verify mount stability in wind | Medium |

10.18 Ft Infra Cam Multi

10.18.1 Priority

Should Have

10.18.2 User Story

As an IT administrator, I want multiple cameras at high-volume gates so that multiple angles (front, side) are captured at busy locations

10.18.3 Preconditions

2-3 cameras allocated for high-volume gates (Karatu, Seneto, Main Gate); PoE capacity verified

10.18.4 Postconditions

Multiple cameras operational; synchronized capture; comprehensive vehicle documentation

10.18.5 Test Cases

| Id | Description | Weight |
|------------------|--|--------|
| INFRA-CAM-TC-009 | Install 2-3 cameras at high-volume gates | Medium |
| INFRA-CAM-TC-010 | Synchronize camera capture timing | Medium |
| INFRA-CAM-TC-011 | Verify front and side angles captured | Medium |

10.19 Ft Infra Install Pilot

10.19.1 Priority

Must Have

10.19.2 User Story

As a project manager, I want to install and configure hardware at 3 pilot gates first so that I can validate setup and identify issues before full deployment

10.19.3 Preconditions

Hardware for 3 gates procured; pilot gates selected (Karatu, Seneto, Main Gate); installation team ready

10.19.4 Postconditions

3 pilot gates operational; issues documented; installation procedures refined

10.19.5 Test Cases

| Id | Description | Weight |
|----------------------|--------------------------------------|--------|
| INFRA-INSTALL-TC-001 | Complete installation at Karatu gate | High |
| INFRA-INSTALL-TC-002 | Complete installation at Seneto gate | High |
| INFRA-INSTALL-TC-003 | Complete installation at Main Gate | High |

| Id | Description | Weight |
|----------------------|---|--------|
| INFRA-INSTALL-TC-004 | Document lessons learned from pilot | High |
| INFRA-INSTALL-TC-005 | Refine installation procedures based on pilot | High |

10.20 Ft Infra Install Remote

10.20.1 Priority

Must Have

10.20.2 User Story

As a project manager, I want to plan installation at remote locations with logistics challenges so that hardware is successfully deployed at Ndutu, Lemala 1&2

10.20.3 Preconditions

4WD vehicle arranged; remote gate access coordinated; multi-day installation planned

10.20.4 Postconditions

Remote gates equipped despite access difficulties; hardware operational; logistics challenges overcome

10.20.5 Test Cases

| Id | Description | Weight |
|----------------------|---|--------|
| INFRA-INSTALL-TC-006 | Plan and execute Ndutu installation with 4WD access | High |
| INFRA-INSTALL-TC-007 | Plan and execute Lemala 1 installation | High |
| INFRA-INSTALL-TC-008 | Plan and execute Lemala 2 installation | High |
| INFRA-INSTALL-TC-009 | Coordinate multi-day installation with NCAA staff | Medium |

10.21 Ft Infra Install Config

10.21.1 Priority

Must Have

10.21.2 User Story

As an IT administrator, I want to pre-configure NUC and NAS units before deployment so that on-site configuration time at remote gates is minimized

10.21.3 Preconditions

Standard configuration documented; test environment at Old HQ available; all units received

10.21.4 Postconditions

All NUC and NAS units pre-configured; tested; ready for transport to gates

10.21.5 Test Cases

| Id | Description | Weight |
|---------------------|--|--------|
| INFRA-CONFIG-TC-001 | Configure OS and network settings on all NUCs | High |
| INFRA-CONFIG-TC-002 | Install PostgreSQL and PWA on all NUCs | High |
| INFRA-CONFIG-TC-003 | Configure NAS units with RAID 1 and backup scripts | High |
| INFRA-CONFIG-TC-004 | Test each unit before transport | High |

10.22 Ft Infra Install Docs

10.22.1 Priority

Must Have

10.22.2 User Story

As an IT administrator, I want installation procedures documented with photos so that future maintenance and troubleshooting is enabled

10.22.3 Preconditions

Documentation template prepared; camera available for photos; standard procedures defined

10.22.4 Postconditions

Complete installation manual with photos; network diagrams per gate; configuration checklists

10.22.5 Test Cases

| Id | Description | Weight |
|------------------|---|--------|
| INFRA-DOC-TC-001 | Create installation manual with step-by-step photos | High |
| INFRA-DOC-TC-002 | Document network topology for each gate | High |
| INFRA-DOC-TC-003 | Create configuration checklist for each gate | High |
| INFRA-DOC-TC-004 | Review and validate documentation completeness | Medium |

10.23 Ft Infra Maint Schedule

10.23.1 Priority

Must Have

10.23.2 User Story

As an IT manager, I want to establish maintenance schedule for all hardware so that failures are prevented and hardware lifespan is extended

10.23.3 Preconditions

Maintenance requirements documented; schedule template prepared; responsibilities assigned

10.23.4 Postconditions

Maintenance schedule established; staff trained; first maintenance cycle completed

10.23.5 Test Cases

| Id | Description | Weight |
|--------------------|---|--------|
| INFRA-MAINT-TC-001 | Document monthly maintenance tasks (dust cleaning, connections) | High |
| INFRA-MAINT-TC-002 | Document quarterly maintenance tasks (UPS battery test) | High |
| INFRA-MAINT-TC-003 | Document annual maintenance tasks (hardware inspection) | Medium |
| INFRA-MAINT-TC-004 | Train staff on maintenance procedures | High |
| INFRA-MAINT-TC-005 | Complete first maintenance cycle at all gates | High |

10.24 Ft Infra Maint Remote

10.24.1 Priority

Must Have

10.24.2 User Story

As an IT administrator, I want remote troubleshooting capabilities so that issues can be resolved without traveling to remote gates

10.24.3 Preconditions

SSH access configured; remote desktop setup; monitoring tools deployed

10.24.4 Postconditions

Remote access functional from Old HQ; troubleshooting successful; site visits reduced

10.24.5 Test Cases

| Id | Description | Weight |
|---------------------|---|--------|
| INFRA-REMOTE-TC-001 | Configure SSH access from Old HQ to all gates | High |
| INFRA-REMOTE-TC-002 | Configure remote desktop access | High |
| INFRA-REMOTE-TC-003 | Deploy system monitoring tools | High |
| INFRA-REMOTE-TC-004 | Test remote troubleshooting procedures | High |

10.25 Ft Infra Maint Spares

10.25.1 Priority

Must Have

10.25.2 User Story

As an IT manager, I want to maintain 10% spare parts buffer so that failed components can be quickly replaced

10.25.3 Preconditions

Spare parts inventory defined; storage at Old HQ prepared; procurement completed

10.25.4 Postconditions

Spare parts available; inventory tracking system in place; replacement procedures documented

10.25.5 Test Cases

| Id | Description | Weight |
|--------------------|---|--------|
| INFRA-SPARE-TC-001 | Procure and stock 2x spare NUCs at Old HQ | High |
| INFRA-SPARE-TC-002 | Stock spare hard drives, power supplies, cables | High |
| INFRA-SPARE-TC-003 | Create inventory tracking system | Medium |
| INFRA-SPARE-TC-004 | Test component replacement procedures | High |

10.26 Ft Infra Maint Training

10.26.1 Priority

Must Have

10.26.2 User Story

As an IT manager, I want to train local staff on basic hardware maintenance so that first-level troubleshooting is enabled at gates

10.26.3 Preconditions

Training materials prepared; laminated quick reference guides created; trainer identified

10.26.4 Postconditions

Staff trained on restart procedures, basic troubleshooting, escalation; confidence verified

10.26.5 Test Cases

| Id | Description | Weight |
|--------------------|--|--------|
| INFRA-TRAIN-TC-001 | Create training materials and quick reference guides | High |

| Id | Description | Weight |
|--------------------|---|--------|
| INFRA-TRAIN-TC-002 | Train staff on system restart procedures | High |
| INFRA-TRAIN-TC-003 | Train staff on basic network troubleshooting | High |
| INFRA-TRAIN-TC-004 | Train staff on when to escalate issues | High |
| INFRA-TRAIN-TC-005 | Verify staff confidence through practical tests | Medium |

10.27 Ft Infra Env Dust

10.27.1 Priority

Must Have

10.27.2 User Story

As an IT administrator, I want to protect hardware from dust in conservation area so that premature hardware failure is prevented

10.27.3 Preconditions

Dust protection strategy documented; enclosed racks or cabinets procured; cleaning schedule prepared

10.27.4 Postconditions

Hardware protected from dust; cleaning schedule implemented; filter maintenance routine

10.27.5 Test Cases

| Id | Description | Weight |
|------------------|---|--------|
| INFRA-ENV-TC-001 | Install enclosed racks or cabinets at each gate | High |
| INFRA-ENV-TC-002 | Install dust filters on equipment | High |

| Id | Description | Weight |
|------------------|---|--------|
| INFRA-ENV-TC-003 | Implement regular cleaning schedule | High |
| INFRA-ENV-TC-004 | Verify passive cooling adequate in enclosed racks | Medium |

10.28 Ft Infra Env Heat

10.28.1 Priority

Must Have

10.28.2 User Story

As an IT administrator, I want hardware to operate in high temperatures so that reliability is maintained in hot climate

10.28.3 Preconditions

Hardware temperature ratings verified (0-40°C); ventilation designed; monitoring configured

10.28.4 Postconditions

Hardware operates reliably in high temperatures; temperature monitoring active; cooling adequate

10.28.5 Test Cases

| Id | Description | Weight |
|------------------|--|--------|
| INFRA-ENV-TC-005 | Verify hardware rated for 0-40°C operation | High |
| INFRA-ENV-TC-006 | Ensure adequate ventilation in equipment racks | High |
| INFRA-ENV-TC-007 | Configure temperature monitoring and alerts | High |
| INFRA-ENV-TC-008 | Test hardware operation in peak temperatures | Medium |

10.29 Ft Infra Env Weather

10.29.1 Priority

Must Have

10.29.2 User Story

As an IT administrator, I want to protect outdoor equipment from weather so that WiFi and camera reliability is maintained

10.29.3 Preconditions

Weather-resistant enclosures procured; IP65+ rated equipment selected; lightning protection planned

10.29.4 Postconditions

Outdoor equipment protected; weather reliability verified; lightning protection installed

10.29.5 Test Cases

| Id | Description | Weight |
|------------------|--|--------|
| INFRA-ENV-TC-009 | Install weather-resistant enclosures for outdoor equipment | High |
| INFRA-ENV-TC-010 | Verify IP65+ rating on outdoor devices | High |
| INFRA-ENV-TC-011 | Install lightning protection for antennas | Medium |
| INFRA-ENV-TC-012 | Test equipment operation in rain/dust conditions | Medium |

10.30 Ft Infra Cost Budget

10.30.1 Priority

Must Have

10.30.2 User Story

As a project manager, I want to deliver project within ~\$22,600 budget for 9 gates so that financial constraints are met while achieving goals

10.30.3 Preconditions

Detailed budget prepared; procurement strategy defined; vendor quotes obtained

10.30.4 Postconditions

Project delivered within budget; cost tracking complete; savings documented

10.30.5 Test Cases

| Id | Description | Weight |
|-------------------|--|--------|
| INFRA-COST-TC-001 | Create detailed budget breakdown per gate | High |
| INFRA-COST-TC-002 | Track procurement costs against budget | High |
| INFRA-COST-TC-003 | Identify and document cost savings opportunities | Medium |
| INFRA-COST-TC-004 | Verify final project cost \leq \$22,600 | High |

10.31 Ft Infra Cost Tracking

10.31.1 Priority

Must Have

10.31.2 User Story

As a project manager, I want to track costs per gate during procurement so that budget compliance is ensured and cost savings are identified

10.31.3 Preconditions

Cost tracking spreadsheet prepared; procurement processes defined; approval workflow established

10.31.4 Postconditions

All costs tracked; budget compliance verified; cost savings identified and realized

10.31.5 Test Cases

| Id | Description | Weight |
|-------------------|--|--------|
| INFRA-COST-TC-005 | Create cost tracking spreadsheet for all gates | High |
| INFRA-COST-TC-006 | Track bulk purchase discounts achieved | Medium |
| INFRA-COST-TC-007 | Compare local vs international procurement costs | Medium |
| INFRA-COST-TC-008 | Report budget status weekly during procurement | Medium |

10.32 Ft Infra Cost Tco

10.32.1 Priority

Should Have

10.32.2 User Story

As a financial manager, I want to calculate total cost of ownership including maintenance so that ongoing operational costs are planned

10.32.3 Preconditions

TCO model prepared; maintenance cost estimates gathered; replacement cycle defined

10.32.4 Postconditions

TCO calculated; ongoing costs budgeted; 5-year financial plan prepared

10.32.5 Test Cases

| Id | Description | Weight |
|-------------------|---|--------|
| INFRA-COST-TC-009 | Calculate initial hardware costs (\$22,600) | Medium |
| INFRA-COST-TC-010 | Estimate annual maintenance costs (~\$2,000/year) | Medium |
| INFRA-COST-TC-011 | Plan UPS battery replacement costs (~\$150/year per gate) | Medium |
| INFRA-COST-TC-012 | Create 5-year TCO model with replacement cycle | Medium |



11 Additional Context

11.1 Cost Breakdown Per Gate

11.1.1 Intel Nuc

\$300

11.1.2 Nas 4Bay

\$700

11.1.3 Hdds 2X2Tb

\$150

11.1.4 Wifi Ap

\$175

11.1.5 Desktop Pc

\$350

11.1.6 Tablet

\$200

11.1.7 Network Switch

\$40

11.1.8 Ups 1000Va

\$175

11.1.9 Barcode Scanner

\$75

11.1.10 Cables Usb Drives

\$50

11.1.11 Subtotal Per Gate

\$2,215

11.2 Total Project Cost

11.2.1 Nine Gates

\$19,935 (9 × \$2,215)

11.2.2 Spare Nucs 2Units

\$600

11.2.3 Spare Parts 10Percent

\$2,000

11.2.4 Total Hardware

\$22,535

11.2.5 Cameras 15Units

\$3,000-4,500 (not included in base)

11.2.6 Grand Total

\$22,600 base + cameras if needed

11.3 Success Metrics

11.3.1 Hardware Uptime

≥ 99.5%

11.3.2 Ups Runtime

2-4 hours verified at all gates

11.3.3 Deployment On Budget

\$22,600 or less for 9 gates base infrastructure

11.3.4 Deployment On Time

All 9 gates operational within 22 weeks

11.3.5 Staff Satisfaction

≥ 90% staff satisfaction with hardware reliability and performance

