CivicSandbox: Gamified Public Works Engagement Platform

Software Requirements Specification (SRS)

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Project: CivicSandbox - Gamified Civic Simulation Platform

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1. Introduction

1.1 Purpose

This SRS defines the requirements for CivicSandbox, a gamified civic simulation platform that democratizes urban planning and public works engagement. The system enables citizens to co-design infrastructure using real-world GIS data while contributing to actual policy decisions.

1.2 Scope

CivicSandbox encompasses:

- Transport infrastructure planning (trains, buses, trams, roads)
- Multi-sector public engagement (water, energy, waste, housing, digital infrastructure, climate adaptation)
- Real-time simulation and impact modeling
- Gamification mechanics for sustained civic participation
- Integration with government decision-making processes

1.3 Definitions and Acronyms

- **GIS:** Geographic Information System
- **TOD:** Transit-Oriented Development
- **AR:** Augmented Reality
- **API:** Application Programming Interface
- **SaaS:** Software as a Service
- **ROI:** Return on Investment

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2. Overall Description

2.1 Product Perspective

CivicSandbox is a standalone web-based platform with mobile compatibility, integrating with:

- Government GIS systems
- Real-time transport data feeds
- Municipal planning databases

- Public consultation platforms

2.2 Product Functions

- Interactive infrastructure design and simulation
- Multi-scenario impact modeling
- Gamified civic engagement mechanics
- Real-time collaboration tools
- Policy integration and feedback loops
- Educational content delivery

2.3 User Classes

1. **Citizens/Residents** - General public engaging in civic planning
2. **Students** - Learning urban planning and civic processes
3. **Local Government** - Officials seeking public input
4. **Urban Planners** - Professional planners testing scenarios
5. **NGOs/Advocacy Groups** - Organizations promoting specific causes
6. **Educators** - Teachers using platform for civic education

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3. System Features

3.1 Transport Infrastructure Module

3.1.1 Trackless Tram System

Description: Interactive tram route planning and simulation **Priority:** High

Functional Requirements:

- **TR-001:** User shall be able to design tram routes using legacy rail corridors
- **TR-002:** System shall simulate ridership patterns based on demographic data
- **TR-003:** Platform shall calculate carbon impact of proposed routes
- **TR-004:** System shall model land value uplift around stations
- **TR-005:** Platform shall optimize route efficiency using AI algorithms
- **TR-006:** System shall provide real-time cost calculations per kilometer

Input/Output:

- **Input:** GPS coordinates, existing rail data, demographic information
- **Output:** Route visualizations, impact reports, cost estimates

3.1.2 Bus Network Planning

Description: Bus route optimization and service planning **Priority:** High

Functional Requirements:

- **BUS-001:** User shall design bus routes on existing road networks
- **BUS-002:** System shall simulate passenger flow and capacity requirements
- **BUS-003:** Platform shall calculate optimal bus frequencies
- **BUS-004:** System shall model accessibility improvements
- **BUS-005:** Platform shall integrate with real-time traffic data

3.1.3 Train Network Integration

Description: Integration with existing rail infrastructure **Priority:** Medium

Functional Requirements:

- **RN-001:** System shall import existing rail network data
- **RN-002:** Platform shall model intermodal connections
- **RN-003:** System shall simulate capacity improvements
- **RN-004:** Platform shall calculate electrification costs and benefits

3.1.4 Road Infrastructure

Description: Road maintenance and improvement planning **Priority:** Medium

Functional Requirements:

- **RD-001:** User shall report road conditions through mobile interface
- **RD-002:** System shall prioritize repairs based on usage and condition
- **RD-003:** Platform shall simulate traffic flow improvements
- **RD-004:** System shall calculate maintenance schedules and costs

3.2 Multi-Sector Public Engagement

3.2.1 Water & Sanitation Module

Description: Community-led water infrastructure planning **Priority:** High

Functional Requirements:

- **WS-001:** Users shall map local water quality monitoring points
- **WS-002:** System shall simulate water conservation scenarios
- **WS-003:** Platform shall enable citizen science data collection
- **WS-004:** System shall model flood risk and drainage improvements
- **WS-005:** Platform shall calculate infrastructure investment needs

3.2.2 Energy Infrastructure Module

Description: Renewable energy siting and planning **Priority:** High

Functional Requirements:

- **EN-001:** Users shall identify potential renewable energy sites
- **EN-002:** System shall model solar/wind potential using GIS data
- **EN-003:** Platform shall simulate community energy sharing networks
- **EN-004:** System shall calculate energy justice metrics
- **EN-005:** Platform shall model grid integration challenges

3.2.3 Waste Management Module

Description: Recycling and waste system co-design **Priority:** Medium

Functional Requirements:

- **WM-001:** Users shall design recycling collection routes
- **WM-002:** System shall model composting program effectiveness
- **WM-003:** Platform shall simulate zero-waste scenarios
- **WM-004:** System shall calculate waste reduction targets
- **WM-005:** Platform shall optimize collection schedules

3.2.4 Housing & Urban Renewal Module

Description: Participatory housing development planning **Priority:** High

Functional Requirements:

- **HR-001:** Users shall participate in virtual design charrettes
- **HR-002:** System shall implement participatory budgeting tools
- **HR-003:** Platform shall model gentrification risk
- **HR-004:** System shall simulate affordable housing scenarios
- **HR-005:** Platform shall calculate community benefit ratios

3.2.5 Digital Infrastructure Module

Description: Broadband and digital equity planning **Priority:** Medium

Functional Requirements:

- **DI-001:** Users shall map broadband coverage gaps
- **DI-002:** System shall model mesh network deployments
- **DI-003:** Platform shall simulate digital inclusion programs
- **DI-004:** System shall calculate infrastructure costs
- **DI-005:** Platform shall prioritize underserved areas

3.2.6 Climate Adaptation Module

Description: Community resilience and green infrastructure **Priority:** High

Functional Requirements:

- **CA-001:** Users shall map local climate risks
- **CA-002:** System shall model green infrastructure benefits
- **CA-003:** Platform shall simulate flood management scenarios
- **CA-004:** System shall calculate resilience improvements
- **CA-005:** Platform shall integrate climate projections

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4. Gamification System

4.1 Achievement System

Description: Badge and point system to encourage engagement **Priority:** High

Functional Requirements:

- **GM-001:** System shall award points for completed planning activities
- **GM-002:** Platform shall provide tiered achievement badges
- **GM-003:** System shall track user progression and expertise levels
- **GM-004:** Platform shall offer NFT certificates for major achievements
- **GM-005:** System shall display leaderboards for friendly competition

4.2 Challenge System

Description: Structured missions and objectives **Priority:** High

Functional Requirements:

- **CH-001:** System shall provide guided tutorial challenges
- **CH-002:** Platform shall offer sector-specific missions
- **CH-003:** System shall enable time-limited community challenges
- **CH-004:** Platform shall provide collaborative group challenges
- **CH-005:** System shall adapt difficulty based on user skill

4.3 Multiplayer Features

Description: Collaborative and competitive planning **Priority:** Medium

Functional Requirements:

- **MP-001:** Users shall collaborate on shared planning projects
- **MP-002:** System shall enable city vs. city planning competitions

- **MP-003:** Platform shall provide real-time co-editing capabilities
- **MP-004:** System shall support team formation and management
- **MP-005:** Platform shall enable peer review and voting

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5. Core Platform Features

5.1 GIS Integration

Description: Geographic information system integration **Priority:** High

Functional Requirements:

- **GIS-001:** System shall integrate with OpenStreetMap data
- **GIS-002:** Platform shall support multiple GIS data formats
- **GIS-003:** System shall provide real-time map updates
- **GIS-004:** Platform shall enable custom layer overlays
- **GIS-005:** System shall support offline map caching

5.2 Simulation Engine

Description: Real-time impact modeling and simulation **Priority:** High

Functional Requirements:

- **SIM-001:** System shall model environmental impact scenarios
- **SIM-002:** Platform shall simulate economic effects
- **SIM-003:** System shall calculate social equity metrics
- **SIM-004:** Platform shall provide sensitivity analysis
- **SIM-005:** System shall support Monte Carlo simulations

5.3 Policy Integration

Description: Connection to real government decision-making **Priority:** High

Functional Requirements:

- **POL-001:** System shall export planning proposals in standard formats
- **POL-002:** Platform shall track proposal implementation status
- **POL-003:** System shall provide transparent voting mechanisms
- **POL-004:** Platform shall integrate with consultation processes
- **POL-005:** System shall maintain audit trail of decisions

5.4 Data Management

Description: Secure handling of user and system data **Priority:** High

Functional Requirements:

- **DM-001:** System shall encrypt all user data
- **DM-002:** Platform shall provide GDPR-compliant data handling
- **DM-003:** System shall enable data export and portability
- **DM-004:** Platform shall maintain data backup and recovery
- **DM-005:** System shall provide anonymized data aggregation

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6. External Interface Requirements

6.1 User Interface Requirements

- Responsive web design compatible with desktop and mobile
- Accessibility compliance (WCAG 2.1 AA)
- Multilingual support (minimum: English, Spanish, French, Mandarin)
- Intuitive drag-and-drop planning interface
- Real-time collaborative editing indicators

6.2 Hardware Interface Requirements

- GPS integration for mobile devices
- Camera access for AR features
- Accelerometer for mobile interactions
- Minimum 2GB RAM for full functionality
- WebGL-compatible graphics processing

6.3 Software Interface Requirements

- RESTful API for government system integration
- OAuth 2.0 authentication
- Integration with social media platforms
- Export capabilities (PDF, KML, GeoJSON)
- Webhook support for real-time notifications

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7. Non-Functional Requirements

7.1 Performance Requirements

- Page load time: < 3 seconds on standard broadband
- Concurrent users: Support for 10,000+ simultaneous users

- Real-time simulation: Results within 5 seconds
- Map rendering: Smooth 60fps interaction
- Data synchronization: < 1 second for collaborative features

7.2 Security Requirements

- End-to-end encryption for sensitive data
- Multi-factor authentication option
- Regular security audits and penetration testing
- Secure API endpoints with rate limiting
- Privacy-by-design data architecture

7.3 Reliability Requirements

- System uptime: 99.9% availability
- Automatic failover and disaster recovery
- Graceful degradation during high load
- Data integrity verification
- Regular automated backups

7.4 Scalability Requirements

- Horizontal scaling capability
- Auto-scaling based on demand
- CDN integration for global performance
- Database sharding for large datasets
- Microservices architecture

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8. System Architecture

8.1 Technology Stack

- **Frontend:** React.js with TypeScript
- **Backend:** Node.js with Express.js
- **Database:** PostgreSQL with PostGIS extension
- **Game Engine:** Unity WebGL for 3D simulations
- **Maps:** Mapbox GL JS
- **Authentication:** Auth0
- **Cloud Platform:** AWS or Google Cloud

- **CI/CD:** Docker with Kubernetes

8.2 Database Design

- User profiles and authentication
- Project data and version control
- GIS layers and geographic data
- Simulation results and analytics
- Gamification data (points, badges, achievements)
- Policy integration and tracking

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9. Implementation Plan

Phase 1: Core Platform (Months 1-6)

- Basic GIS integration
- User authentication and profiles
- Transport planning module (trams/buses)
- Basic gamification system

Phase 2: Enhanced Features (Months 7-12)

- Multi-sector modules implementation
- Advanced simulation engine
- Multiplayer and collaboration features
- AR integration (mobile)

Phase 3: Government Integration (Months 13-18)

- Policy integration APIs
- Government dashboard
- Advanced analytics and reporting
- Public consultation tools

Phase 4: Scale and Optimize (Months 19-24)

- Performance optimization
- Advanced AI features
- International expansion
- Enterprise features

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10. Acceptance Criteria

10.1 Functional Acceptance

- All core user stories successfully completed
- Integration testing with sample government data
- Performance benchmarks met
- Security audit passed
- Accessibility compliance verified

10.2 User Acceptance

- User testing with representative groups
- Minimum 4.0/5.0 user satisfaction rating
- Successful pilot with local government partner
- Community engagement metrics achieved
- Educational effectiveness validated

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11. Risks and Mitigation

11.1 Technical Risks

- **Risk:** GIS data integration complexity
- **Mitigation:** Prototype with standard datasets first
- **Risk:** Real-time simulation performance
- **Mitigation:** Implement progressive enhancement approach

11.2 Business Risks

- **Risk:** Government adoption hesitancy
- **Mitigation:** Start with progressive municipalities
- **Risk:** User engagement sustainability
- **Mitigation:** Continuous gamification refinement

11.3 Regulatory Risks

- **Risk:** Data privacy compliance
- **Mitigation:** Privacy-by-design architecture
- **Risk:** Government procurement requirements
- **Mitigation:** Early engagement with procurement teams

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12. Appendices

A. User Story Examples

As a resident, I want to design a tram route in my neighborhood so that I can contribute to improving local transport options.

As a student, I want to learn about urban planning through gamified challenges so that I can understand how cities work.

As a city planner, I want to gather citizen input on infrastructure projects so that I can make more informed decisions.

B. API Specifications

Detailed REST API endpoints for:

- User management
- Project CRUD operations
- GIS data access
- Simulation triggers
- Gamification systems

C. Data Models

Entity relationship diagrams for:

- User and authentication data
- Geographic and planning data
- Simulation and analysis results
- Gamification and achievement data