

## **COS 214 Project**

### **Functional Requirements**

**22547747**

**22644106**

**22527533**

**22598473**

**19194839**

**19364742**

**21740012**

### **Transportation**

The transportation system is responsible for facilitating travel between different locations. To keep citizens satisfied, it must handle a variety of transport options, control availability, and guarantee efficiency.

#### **Core Functionalities:**

##### **1. Transport Mode Management**

- FR 1.1: Citizens should be able to select between different modes of transport.
- FR 1.2: The system should track the availability of each transportation mode.

##### **2. Commute Time Management**

- FR 2.1: The transportation system should calculate the commute time for each citizen based on the selected transport mode and current transport conditions (e.g., traffic, availability).

##### **3. Route and Traffic Management**

- FR 3.1: The system should calculate the most efficient routes for citizens, considering traffic, transport availability, and distance.
- FR 3.2: To lessen congestion, the government should be able to expand routes, optimize traffic, and construct new transportation infrastructure.

##### **4. Public and Private Transportation**

- FR 4.1: The system must manage both public and private transportation modes to give citizens travel alternatives.
- FR 4.2: It should allow citizens to switch between public and private transport options.

## 5. Citizen Satisfaction

- FR 5.1: The system must contribute to overall citizen satisfaction, allowing the government to make improvements accordingly.

### Interactions:

#### 1. Interaction with Government

- FR 6.1: The government sets transportation policies and allocates funds, affecting transportation efficiency and infrastructure.
- FR 6.2: The transportation system must adapt to government policy changes and communicate these to citizens.

#### 2. Interaction with Citizens

- FR 7.1: Citizens select preferred transport modes, impacting how services are provided.
- FR 7.2: Citizen feedback directly influences transport system adjustments and improvements.

#### 3. Interaction with Buildings

- FR 8.1: Transportation routes must connect residential, commercial, and landmark buildings.

#### 4. Interaction with Utilities

- FR 9.1: Public transport modes rely on utility services (e.g., electricity for trains).
- FR 9.2: Transportation services must monitor utility statuses and adjust accordingly.

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## Buildings

Buildings represent residential, commercial, industrial, and landmark locations that interact with various city systems like transportation, utilities, and government policies.

### Core Functionalities:

#### 1. Building Type Management

- FR 1.1: The system must classify buildings by type (residential, commercial, industrial, landmark).
- FR 1.2: Each building type must influence interactions with citizens and services.
- FR 1.3: The system should allow construction, modification, and demolition of buildings.

#### 2. Building Capacity and Occupancy

- FR 2.1: Each building must have a maximum capacity (citizens or workers).
- FR 2.2: The system should track building occupancy and enforce capacity limits.

### **3. Maintenance and Upkeep**

- FR 3.1: Buildings require regular maintenance to ensure safety and functionality.
- FR 3.2: The government must allocate funds for building maintenance.

### **4. Utility Integration**

- FR 4.1: Buildings should interact with utility systems (e.g., power, water).
- FR 4.2: Buildings must adjust functionality based on utility availability.

### **5. Taxation and Revenue**

- FR 5.1: Buildings must contribute to city revenue through property taxes.
- FR 5.2: The system should calculate taxes based on building value and policies.

### **6. Building Satisfaction Contribution**

- FR 6.1: The system should track how building conditions affect citizens' quality of life.

## **Interactions:**

### **1. Interaction with Government**

- FR 7.1: Government departments must influence building conditions, upgrades, and taxation.
- FR 7.2: Zoning and safety regulations must impact building functionality and satisfaction.

### **2. Interaction with Citizens**

- FR 8.1: Residential buildings must accommodate citizens, affecting quality of life.

### **3. Interaction with Utilities**

- FR 9.1: Buildings must integrate with utility systems for power, water, and waste management.

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## **City Growth**

City growth is a dynamic process influenced by multiple interconnected factors. The simulation must model these aspects to ensure realistic and interdependent urban development.

### **1. Population Growth**

- **FR 1.1:** The system must simulate population growth based on birth rates, migration, and economic opportunities.
- **FR 1.2:** The system must dynamically adjust the city's population size as citizens are born, migrate into the city, or leave.
- **FR 1.3:** The system must increase demand for residential buildings as the population grows.

### **2. Housing Needs**

- **FR 2.1:** The system must allow the construction and expansion of residential buildings to accommodate the growing population.
- **FR 2.2:** The system must track the number of available housing units and ensure they are sufficient for the population.
- **FR 2.3:** The system must generate alerts or trigger actions if the population outgrows the available housing capacity (e.g., need for new residential zones).
- **FR 2.4:** The system must reduce population growth if housing demand exceeds supply, creating a realistic bottleneck.

### **3. Economic Development**

- **FR 3.1:** The system must support the growth of the commercial and industrial sectors to create jobs for citizens.
- **FR 3.2:** The system must dynamically adjust the number of available jobs in the city based on the expansion of commercial and industrial buildings.
- **FR 3.3:** The system must simulate economic prosperity by linking job availability with population growth in the city.
- **FR 3.4:** The system must provide the ability to expand industrial areas, triggering a cascading effect on job creation, which in turn influences population growth.

### **4. Infrastructure Expansion**

- **FR 4.1:** The system must allow for the development of utilities (e.g., power plants, water supply, waste management, sewage systems) to support city growth.

- **FR 4.2:** The system must provide transportation infrastructure development (e.g., roads, public transit, airports) to facilitate mobility within the city and between other regions.
- **FR 4.3:** The system must dynamically adjust the utility demand based on population and building expansion (e.g., more power is needed as the population and buildings grow).
- **FR 4.4:** The system must link the infrastructure to economic and population growth, where inadequate infrastructure can hinder growth or cause a decline in population or industry (e.g., lack of transportation or utilities reduces the attractiveness of the city).

## **5. Interconnected Growth**

- **FR 5.1:** The system must ensure that changes in one sector (e.g., population growth, economic development) have a cascading effect on other sectors (e.g., housing needs, infrastructure expansion).
- **FR 5.2:** The system must ensure that economic growth influences population growth, housing demand, and utility needs.
- **FR 5.3:** The system must simulate a feedback loop where a growing population increases demand for infrastructure and services, which in turn supports further population and economic growth.
- **FR 5.4:** The system must automatically balance the growth process based on available resources and services (e.g., lack of resources, infrastructure, or jobs slows down growth).

## **6. Growth Management**

- **FR 6.1:** The system must allow city administrators (players) to manage and control the growth process by adjusting policies, taxes, and budgets.
- **FR 6.2:** The system must allow for prioritization of different aspects of growth (e.g., focusing on industrial development over residential expansion).
- **FR 6.3:** The system must provide mechanisms to manage resources and allocate them toward expanding buildings, infrastructure, or economic sectors.
- **FR 6.4:** The system must allow for monitoring the city's growth progress and impact on citizen satisfaction (e.g., quality of life metrics).

Managing resources is essential for sustaining the operations of the city. The simulation must track and manage the consumption and allocation of resources to ensure efficient city expansion, service provision, and economic development.

### **1. Materials Management**

- **FR 1.1:** The system must track various construction materials, including wood, steel, concrete, and other relevant resources.
- **FR 1.2:** The system must manage the supply of materials for the construction and expansion of buildings, infrastructure, and public services.
- **FR 1.3:** The system must update the material inventory dynamically based on construction projects and city expansion.
- **FR 1.4:** The system must trigger alerts when material levels are low and provide mechanisms to replenish or acquire more materials.
- **FR 1.5:** The system must allow the user or AI to allocate materials toward different projects based on priority (e.g., building homes, expanding industry, or infrastructure development).

### **2. Energy Management**

- **FR 2.1:** The system must track the generation and consumption of energy, including power generated from power plants.
- **FR 2.2:** The system must provide a way to allocate energy to various city components (e.g., residential buildings, commercial zones, industrial sectors, and public services).
- **FR 2.3:** The system must dynamically adjust energy demands based on city expansion and population growth.
- **FR 2.4:** The system must simulate energy shortages if the demand exceeds supply and provide mechanisms for the construction of additional power plants or the import of energy.
- **FR 2.5:** The system must track energy efficiency and provide mechanisms to implement energy-saving measures (e.g., renewable energy sources, energy-efficient buildings).

### **3. Water Management**

- **FR 3.1:** The system must track the availability, supply, and consumption of water for residential, commercial, industrial, and public services.

- **FR 3.2:** The system must ensure water distribution to all parts of the city and allow for the expansion of the water supply system as the city grows.
- **FR 3.3:** The system must simulate water shortages if the demand exceeds supply and provide mechanisms to develop new water sources (e.g., reservoirs, water treatment plants).
- **FR 3.4:** The system must manage water consumption and allow for water conservation strategies to reduce waste and optimize usage.
- **FR 3.5:** The system must simulate the consequences of insufficient water supply, such as decreased citizen satisfaction and economic slowdown.

#### ***4. Budget Management***

- **FR 4.1:** The system must track the city's financial budget, including income (e.g., taxes, fees, subsidies) and expenditures (e.g., infrastructure development, public services).
- **FR 4.2:** The system must provide a way to allocate budget resources across different city sectors, including housing, commercial, industrial, utilities, and transportation systems.
- **FR 4.3:** The system must simulate budget deficits and surpluses, allowing for corrective actions such as adjusting taxes, reallocating funds, or borrowing money.
- **FR 4.4:** The system must allow users to set financial policies that affect the city's income and expenses (e.g., tax rates, budget distribution).
- **FR 4.5:** The system must link the budget with city growth, ensuring that financial constraints affect expansion plans, resource management, and service provision.

#### ***5. Efficient Resource Management***

- **FR 5.1:** The system must simulate the efficient allocation of resources (materials, energy, water, budget) based on the city's needs and development plans.
- **FR 5.2:** The system must ensure that a shortage in one resource impacts city growth and services, triggering a cascading effect (e.g., lack of materials delays construction, insufficient energy affects economic productivity).
- **FR 5.3:** The system must provide mechanisms to balance the resource allocation to ensure sustainable growth, avoiding rapid expansion that depletes resources too quickly.
- **FR 5.4:** The system must provide feedback to users about the current resource status, offering options for optimizing consumption, upgrading facilities, or acquiring additional resources.

- **FR 5.5:** The system must integrate resource management with other city mechanics (e.g., population growth, economic development, infrastructure expansion) to create a realistic simulation of interdependent urban systems
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## **Citizens**

Citizens interact with the city's economy, services, and government, influencing city growth and satisfaction.

### **Core Functionalities:**

#### **1. Population Management**

- FR 1.1: Citizens should dynamically join or leave the population based on employment opportunities and quality of life.

#### **2. Employment Interaction**

- FR 2.1: Citizens should actively seek jobs influenced by industrial and commercial buildings.

#### **3. Service Utilization**

- FR 3.1: Citizens should interact with services (e.g., healthcare, education) based on personal needs.

#### **4. Satisfaction Measurement**

- FR 4.1: Citizens must track satisfaction levels influenced by taxes, services, and quality of life.

### **Interactions:**

#### **1. Interaction with Government**

- FR 5.1: Citizens should respond to government policies such as tax changes and service quality.

#### **2. Interaction with Buildings**

- FR 6.1: Citizens should seek housing and employment from buildings, impacting population distribution.
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## **Government**

The government system acts as the overseer of the city and is responsible for managing taxation, public services, the city's budget, and enacting policies.

### **Core Functionalities:**



## **1. Taxation Management**

- FR 1.1: The government should issue tax rates to generate revenue for the city but ensure that rates are reasonable to maintain citizen satisfaction and business profits.
- FR 1.2: The system should allow the government to set and modify tax rates, notify the city and its citizens of the tax rate, and track both the tax revenue generated and citizen satisfaction.

## **2. Public Services**

- FR 2.1: The government should ensure that citizens are provided with necessary public services, such as health, education, and law enforcement.
- FR 2.2: The system should take requests for public services, execute commands for those requests, and track and maintain citizen satisfaction with the services.

## **3. Budget Management**

- FR 3.1: The government is responsible for managing the city's budget and allocating funds to resources, services, and developments where necessary.
- FR 3.2: The system should set the city's budget and allocate resources based on monitoring of available resources, service requests, population growth, and citizen satisfaction.

## **4. Policies**

- FR 4.1: The government should be able to enact policies that the city and its citizens must follow.
- FR 4.2: The system should execute policy commands for the city, notify citizens of the enforced policies, and monitor the impact on citizen satisfaction based on these policies.

## **Interactions:**

### **1. Interactions with Citizens**

- FR 5.1: The government must execute commands for public service requests from citizens.
- FR 5.2: The government should collect tax revenue from citizens.
- FR 5.3: The government must notify citizens of adjustments to taxation and new policies.
- FR 5.4: Government decisions on taxation and policies should influence citizen satisfaction.

### **2. Interaction with the City**

- FR 6.1: The government issues commands related to taxation, policies, public services, and budget allocation to the city.
- FR 6.2: The city should provide feedback on the various commands issued by the government.

### **3. Interaction with Transportation**

- FR 7.1: Transportation should be influenced by the policies issued by the government.
- FR 7.2: The government should be able to expand and close routes as necessary, impacting transportation strategies and traffic states.

### **4. Interaction with Buildings**

- FR 8.1: Government policies, including taxation, should influence buildings and serve as a revenue source for the city.
- FR 8.2: The government should track building developments and job creation to influence employment rates.

### **5. Interaction with Utilities**

- FR 9.1: The government must ensure that the city has access to all necessary utilities.
- FR 9.2: The government should issue policies that influence the usage of utilities in the city.

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## **Utilities**

Utilities provide essential resources required for city operations, including power, water, waste management, and sewage systems.

### **Core Functionalities:**

#### **1. Resource Generation**

- FR 1.1: Utilities must generate resources required for city operations, including:
  - Power Plants: Generate electricity to supply buildings and transportation systems.
  - Water Supply: Provide a steady supply of water to buildings and public spaces.
  - Waste Management: Handle waste removal, recycling, and proper disposal.
  - Sewage Systems: Manage sewage disposal and treatment to maintain environmental health.

## **2. Resource Distribution**

- FR 2.1: Utilities must distribute generated resources (e.g., electricity, water) to buildings and public services across the city based on demand.
- FR 2.2: Each utility type must have capacity constraints, influencing how resources are allocated when demand is high.

## **3. Resource Monitoring**

- FR 3.1: Utilities must continuously monitor resource levels and usage to ensure adequate supply across the city.
- FR 3.2: When resource levels are low, utilities must prioritize distribution based on building type or resource consumption patterns.

## **4. Impact on Citizen Satisfaction**

- FR 4.1: Utilities must influence citizen satisfaction by providing essential services.
- FR 4.2: Power outages or water shortages must decrease citizen satisfaction.
- FR 4.3: Efficient waste management and sewage treatment must improve citizen satisfaction by maintaining a clean environment.

## **5. Support for City Growth**

- FR 5.1: Utilities must scale resource generation and distribution to meet the growing needs of the city.
- FR 5.2: New infrastructure (e.g., additional power plants, expanded sewage systems) should be built as the city expands.

## **6. Environmental Management**

- FR 6.1: Waste management and sewage systems must minimize environmental impact by handling waste and sewage properly.
- FR 6.2: Utilities should implement recycling mechanisms where applicable (e.g., recycling water, composting waste).

### **Interactions:**

#### **1. Interaction with Buildings**

- FR 7.1: Buildings send requests for resources (electricity, water) to utilities.
- FR 7.2: Utilities allocate resources based on availability and building priority.
- FR 7.3: Utilities must track resource consumption for each building type (e.g., Residential, Commercial) and adjust supply based on usage patterns.

- FR 7.4: When resources are limited, utilities must prioritize critical buildings (e.g., hospitals) and notify other buildings of reduced supply, impacting building operations and citizen satisfaction.

## **2. Interaction with Resources**

- FR 8.1: Utilities generate resources and check with the Resources component to ensure availability.
- FR 8.2: If resources are low, utilities must adjust generation capacity or notify the city government for additional resources.
- FR 8.3: Waste management interacts with the Resources component to recycle materials, minimizing resource wastage and contributing to sustainable city management.

## **3. Interaction with Citizens**

- FR 9.1: Utilities must impact citizen satisfaction by providing essential services.
- FR 9.2: Efficient and reliable utilities must increase satisfaction, while disruptions (e.g., power outages) reduce satisfaction.
- FR 9.3: Citizens provide feedback on utility services, which utilities use to improve services or expand capacity. This feedback may influence government decisions on utility funding and expansion.

## **4. Interaction with City Growth**

- FR 10.1: As the city grows, utilities must collaborate with the City Growth component to expand infrastructure.
- FR 10.2: This may include building new power plants or extending water supply networks to accommodate more buildings and citizens.
- FR 10.3: Utilities must work with City Growth to forecast future resource demand and plan for necessary expansions or upgrades to utility systems.

## **5. Interaction with Government**

- FR 11.1: Utilities must comply with regulations set by the government, such as environmental standards for waste management and energy consumption limits.
  - FR 11.2: Utilities must receive funding from the government for infrastructure projects, such as building new facilities or upgrading existing systems to improve service quality.
  - FR 11.3: The government may influence utilities by setting resource pricing or taxation policies, impacting how resources are distributed and priced for citizens and businesses.
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## **Taxation Component**

The taxation component is responsible for collecting revenue from citizens and buildings while balancing tax generation and citizen satisfaction. It allows for flexible tax strategies, depending on the tax type (citizen or building), and tracks the effects of taxation on the city's economy and citizen morale.

### **Core Functionalities:**

#### **1. Tax Strategy Management**

- FR 1.1: The taxation component must use a flexible strategy pattern to collect taxes from citizens and buildings.
- FR 1.2: The system must allow for setting and modifying the tax collection strategy dynamically for different entities (e.g., income tax for citizens, property tax for buildings).
- FR 1.3: The component must track the total tax revenue generated from both citizens and buildings.

#### **2. Citizen Taxation**

- FR 2.1: The system must apply income taxes to citizens based on their employment status and income.
- FR 2.2: The taxation component should adjust citizen satisfaction based on the tax burden, reflecting how tax policies influence overall citizen morale.

#### **3. Building Taxation**

- FR 3.1: The system must calculate and collect property taxes from buildings based on property value and maintenance costs.
- FR 3.2: The system should ensure that building tax collection influences the financial resources of building owners, affecting job creation and building development in the city.

#### **4. Satisfaction Impact**

- FR 4.1: Tax collection must influence citizen and building owner satisfaction, which will be monitored and adjusted as needed.
- FR 4.2: The taxation system should provide feedback to the government on the impact of tax policies and rates on overall satisfaction.

### **Interactions:**

#### **1. Interaction with Government**

- FR 5.1: The taxation component must execute commands issued by the government, such as setting new tax rates or modifying existing ones.

- FR 5.2: It must notify the government of the total revenue collected and the satisfaction levels of citizens and building owners.
- FR 5.3: The component must respond to government policies (e.g., tax cuts or increases) by updating tax strategies accordingly.

## **2. Interaction with Citizens**

- FR 6.1: The taxation component must apply the selected tax strategy to citizens, calculating their tax liabilities and adjusting their satisfaction based on their tax burden.
- FR 6.2: It must notify citizens of changes in tax rates and their tax obligations.

## **3. Interaction with Buildings**

- FR 7.1: The taxation component must calculate and collect property taxes from buildings based on their assessed value.
- FR 7.2: It must monitor and adjust tax rates on buildings based on government policies and track the effects on building development and maintenance.

## **4. Interaction with Public Services**

- FR 8.1: Tax revenue collected from citizens and buildings must fund public services like healthcare, education, and law enforcement.
- FR 8.2: The system must monitor the relationship between tax collection and public service funding, ensuring that citizens receive necessary services while maintaining a balanced budget.

## **5. Interaction with City Budget Management**

- FR 9.1: The tax revenue generated by the taxation component must be fed into the city's overall budget management system.
- FR 9.2: The system must allow for adjusting tax rates in response to budgetary requirements, ensuring enough revenue is collected to sustain public services and development projects.

## **6. Interaction with Policy Management**

- FR 10.1: Taxation is influenced by government policies, such as tax exemptions for specific groups or industries.
- FR 10.2: The taxation component must adjust strategies according to these policies and provide feedback on how policies affect tax revenue and satisfaction levels.