AI-Powered Parking Management System

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1. Company / Project Short Presentation

Project Overview

The **AI-Powered Parking Management System (AIPMS)** is a smart urban mobility solution designed to optimize parking space utilization using artificial intelligence, computer vision and real-time data analytics. The system detects vehicle presence, predicts parking availability, manages payments and provides decision support for operators and city authorities.

Main Issues Addressed

- Inefficient use of parking spaces
- Traffic congestion caused by drivers searching for parking
- Lack of real-time parking availability information
- Manual enforcement and revenue leakage
- Poor user experience in traditional parking systems

Goals and Objectives

Strategic Goals

- Improve parking efficiency and utilization rates
- Reduce traffic congestion and CO_2 emissions
- Increase parking revenue transparency
- Support smart city infrastructure development

Operational Objectives

- Real-time detection of occupied/free spaces
- Automated payment and enforcement
- Data-driven decision-making for operators
- Scalable and secure system architecture

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2. SMART Analysis & PESTEL Analysis

2.1 SMART Objectives

SMART Element	Description
Specific	Deploy an AI-based system to monitor and manage parking spaces in urban areas
Measurable	Increase parking utilization by **20%** and reduce search time by **30%**
Achievable	Uses existing AI, camera and cloud technologies
Relevant	Addresses urban congestion, sustainability and smart city needs
Time-bound	Full deployment within **12–18 months**

2.2 PESTEL Analysis

Factor	Impact
Political	Government support for smart cities, urban mobility policies
Economic	Revenue optimization for municipalities, reduced operational costs
Social	Improved driver experience, reduced stress and time loss
Technological	AI, computer vision, IoT, cloud platforms enable automation
Environmental	Reduced emissions from less driving for parking
Legal	Data privacy regulations (GDPR), surveillance and compliance laws

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3. Basic SWOT Analysis

Strengths

- AI-driven real-time monitoring
- Scalable architecture
- Reduced human intervention
- Data analytics for optimization

Weaknesses

- High initial investment
- Dependence on camera accuracy
- Maintenance and infrastructure costs

Opportunities

- Smart city initiatives
- Integration with EV charging and navigation apps
- Expansion to private parking facilities

Threats

- Data privacy concerns
- Resistance to technology adoption
- Competition from established parking platforms

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4. Correlation SWOT (Strategic Matrix)

Strategy Type	Description
SO (Strength–Opportunity)	Use AI analytics to integrate with smart city platforms
WO (Weakness–Opportunity)	Reduce deployment cost via phased implementation
ST (Strength–Threat)	Use robust encryption and anonymization to address privacy risks
WT (Weakness–Threat)	Pilot projects to reduce risk and user resistance

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5. Enterprise Strategy

Business Strategy

- **Differentiation Strategy**: Advanced AI features and real-time insights
- Focus on municipalities, airports, malls and smart campuses

Technology Strategy

- Modular microservices architecture
- Cloud-based AI processing
- Edge computing for camera analytics

Growth Strategy

- Start with pilot deployments
- Expand geographically
- Offer SaaS-based subscription model

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6. Tree of Goals & KPIs

Tree of Goals (Hierarchical)

Main Goal:
Efficient, intelligent and sustainable parking management

→ **Operational Efficiency**
→ **User Experience Improvement**

→ **Revenue Optimization**
→ **Environmental Sustainability**

Key Performance Indicators (KPIs)

Goal	KPI
Parking efficiency	Space utilization rate (%)
User experience	Average parking search time
System accuracy	Detection accuracy (%)
Revenue	Revenue per parking space
Sustainability	CO_2 reduction estimate
System reliability	System uptime (%)

SMART Analysis

SMART Objectives

Specific
Implement an AI-based parking management system that provides real-time parking space detection, automated payment, and data analytics for operators and users.

Measurable

- Increase parking space utilization by **15–25%**
- Reduce average parking search time by **25–35%**
- Achieve vehicle detection accuracy of at least **95%**
- Reduce operational management costs by **20%**

Achievable
The objectives are achievable using existing technologies such as computer vision, IoT sensors, cloud computing, and machine learning models that are already mature and widely adopted.

Relevant
The project directly addresses urban traffic congestion, inefficient parking usage, environmental sustainability, and smart city development goals.

Time-Bound

- Prototype development: **3–4 months**
- Pilot deployment: **6–9 months**
- Full-scale implementation: **12–18 months**

S **Specific**	M **Measurable**	A **Achievable**	R **Relevant**	T **Time-Bound**
Implement an AI-based parking management system that provides real-time parking space detection, automated payment, and data analytics for operators and users.	• Increase parking space utilization by **15–25%** • Reduce average parking search time by **25–35%** • Achieve vehicle detection accuracy of at least **95%** • Reduce operational management costs by **20%**	The objectives are achievable using existing technologies such as computer vision, IoT sensors, cloud computing, and machine learning models that are already mature and widely adopted.	The project directly addresses urban traffic congestion, inefficient parking usage, environmental sustainability, and smart city development goals.	• Prototype development: **3–4 months** • Pilot deployment: **6–9 months** • Full-scale implementation: **12–18 months**

PESTEL Analysis

The PESTEL framework evaluates external environmental factors that influence the project's success.

Political Factors

- Government support for smart city and digital infrastructure projects
- Urban mobility and traffic management policies
- Public–private partnership opportunities with municipalities

Economic Factors

- Reduction of operational costs through automation
- Increased parking revenue due to better utilization and reduced fraud
- Initial investment costs for AI infrastructure and cameras

Social Factors

- Improved driver convenience and reduced stress
- Increased acceptance of smart mobility solutions
- Potential public concerns regarding surveillance and privacy

Technological Factors

- Advances in AI, computer vision, and edge computing
- Availability of cloud platforms for scalability
- Integration with mobile apps, navigation systems, and payment platforms

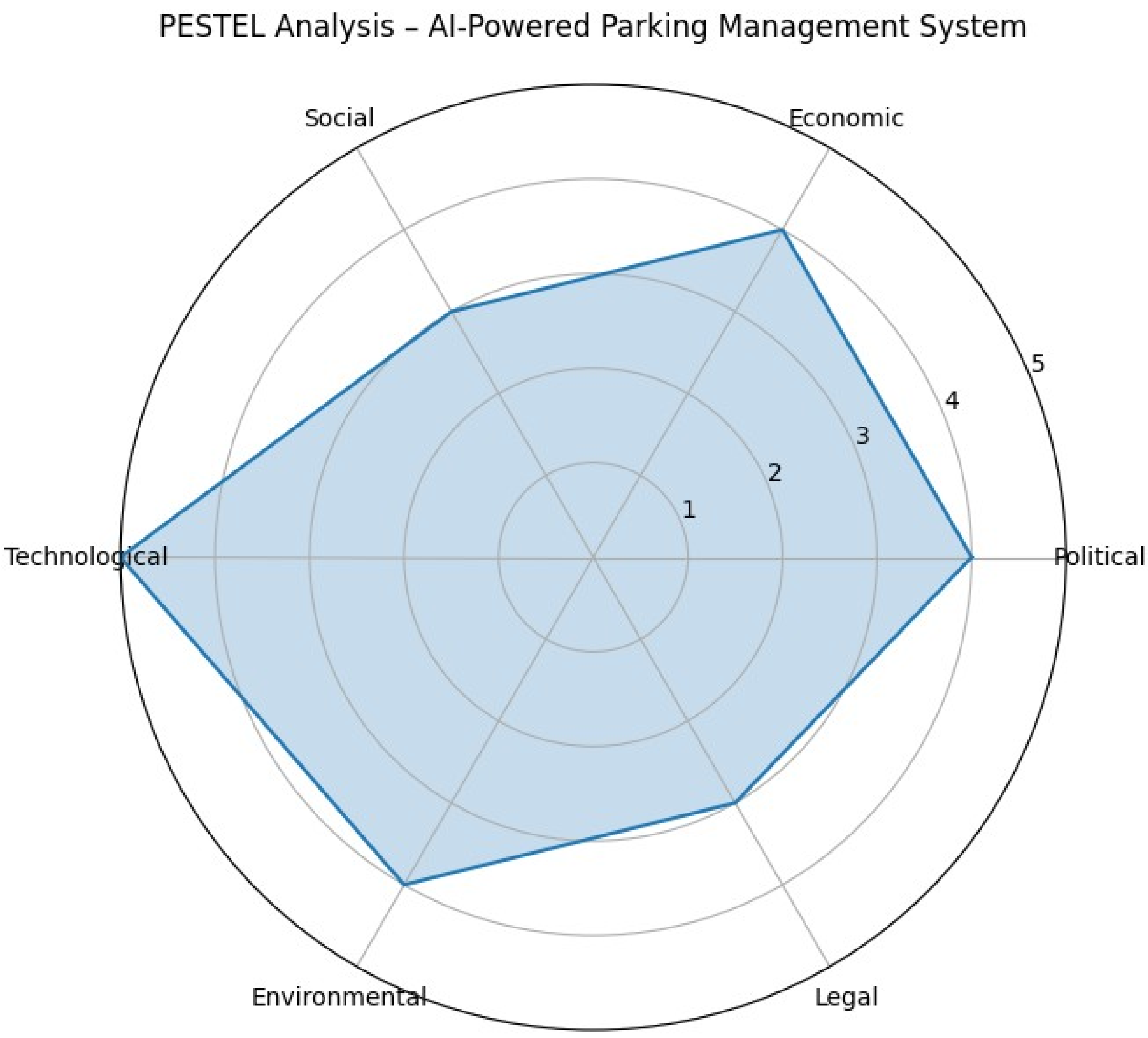
Environmental Factors

- Reduced CO_2 emissions due to less time spent searching for parking
- Contribution to sustainable urban transportation systems
- Support for green city initiatives

Legal Factors

- Compliance with data protection and privacy regulations (e.g., GDPR)
- Regulations related to video surveillance in public spaces
- Contractual and liability issues with municipalities and private operators

Political Factors	Government support for smart city and digital infrastructure projects /// Urban mobility and traffic management policies /// Public–private partnership opportunities with municipalities
Economic Factors	Reduction of operational costs through automation /// Increased parking revenue due to better utilization and reduced fraud /// Initial investment costs for AI infrastructure and cameras
Social Factors	Improved driver convenience and reduced stress /// Increased acceptance of smart mobility solutions /// Potential public concerns regarding surveillance and privacy
Technological Factors	Advances in AI, computer vision, and edge computing /// Availability of cloud platforms for scalability /// Integration with mobile apps, navigation systems and payment platforms
Environmental Factors	Reduced CO_2 emissions due to less time spent searching for parking /// Contribution to sustainable urban transportation systems /// Support for green city initiatives
Legal Factors	Compliance with data protection and privacy regulations (e.g., GDPR) /// Regulations related to video surveillance in public spaces /// Contractual and liability issues with municipalities and private operators



Basic SWOT Analysis

Strengths

- AI-based real-time parking space detection
- Improved parking utilization and traffic reduction
- Automated payment and enforcement mechanisms
- Scalable architecture for cities and private facilities
- Data analytics for operational and strategic decisions

Weaknesses

- High initial deployment and infrastructure costs
- Dependence on camera quality and AI model accuracy
- Need for continuous maintenance and system updates
- Limited effectiveness in poor lighting or weather conditions

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Opportunities

- Growth of smart city and intelligent transport initiatives
- Integration with navigation apps and EV charging systems
- Expansion to airports, malls, universities, and corporate campuses
- Use of collected data for urban planning and mobility optimization

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Threats

- Data privacy and surveillance concerns
- Legal and regulatory restrictions on video monitoring
- Resistance from users unfamiliar with smart parking systems
- Competition from established parking and mobility platforms

Correlation SWOT (TOWS) analysis

SO Strategies (Strengths × Opportunities)

Growth & Expansion Strategies

Use strengths to exploit opportunities.

- Integrate AI analytics with **smart city platforms** and urban traffic systems
- Leverage scalable architecture to expand into **airports, malls, universities**
- Use real-time data to offer **value-added services** (navigation, EV charging integration)

📌 *Focus*: Innovation, expansion, market leadership

WO Strategies (Weaknesses × Opportunities)

Improvement & Investment Strategies

Use opportunities to overcome weaknesses.

- Apply **phased deployment** to reduce high initial investment costs
- Use government smart city programs to **co-finance infrastructure**
- Improve AI models using real-world data collected during pilot projects

📌 *Focus*: Cost reduction, learning, gradual scaling

ST Strategies (Strengths × Threats)

Protection & Risk Mitigation Strategies

Use strengths to reduce external threats.

- Apply **data anonymization and encryption** to address privacy concerns
- Use high detection accuracy to comply with **legal and regulatory standards**
- Differentiate through advanced AI features to compete with existing platforms

📌 *Focus*: Security, compliance, competitive advantage

WT Strategies (Weaknesses × Threats)

Defensive & Survival Strategies

Minimize weaknesses and avoid threats.

- Start with **limited pilot zones** to reduce legal and financial risk
- Provide user education to reduce resistance to new technology
- Outsource maintenance to reduce operational complexity

📌 *Focus*: Risk control, sustainability, damage limitation

Summary Table (Compact Version)

Strategy Type	Strategic Direction
SO	Expansion through AI-driven smart city integration
WO	Phased deployment and public funding

Strategy Type	Strategic Direction
ST	Strong security and legal compliance
WT	Pilot-based rollout and conservative growth

	Opportunities (O)	Threats (T)
Strengths (S)	Use AI analytics to integrate with smart city platforms	Use robust encryption and anonymization to address privacy risks
Weaknesses (W)	Reduce deployment cost via phased implementation	Pilot projects to reduce risk and user resistance

VISION

To become a leading smart parking platform that improves urban mobility by reducing parking search time by **30–40%**, increasing parking space utilization to over **85%**, and contributing to a **15–20% reduction in traffic-related emissions** in deployed areas within the next **5 years**.

MISSION

To design, deploy, and operate an AI-powered parking management system that provides **real-time parking availability with at least 95% detection accuracy**, reduces operational costs for parking operators by **20–25%**, and supports **municipalities and private operators** through scalable, secure, and regulation-compliant solutions.

Enterprise Strategy

AI-Powered Parking Management System

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1. Strategic Alignment

The enterprise strategy is designed to achieve the project **Vision** and **Mission** by aligning business objectives, technology capabilities, operational execution and governance.

Alignment Logic:

Vision (5 years)
→ Reduce search time **30–40%**, utilization **>85%**, emissions **15–20%**

Mission (1–3 years)
→ Accuracy ≥**95%**, cost reduction **20–25%**, uptime ≥**99%**

Enterprise Strategy
→ Defines *how* these targets will be achieved

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2. Business Strategy

Strategic Positioning

- **Differentiation strategy** through AI accuracy, real-time analytics, and automation
- Compete on **value and performance**, not price

Target Markets

- Phase 1 (Year 1): Municipal pilot zones (50–300 parking spaces)
- Phase 2 (Year 2–3): Airports, malls, universities (1,000+ spaces)
- Phase 3 (Year 4–5): City-wide deployments

Revenue Model

- Subscription (SaaS): **€1–3 per parking space/month**
- Setup & integration fees for large facilities
- Optional analytics dashboards for municipalities

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3. Technology Strategy

Core Technologies

- Computer vision (vehicle detection ≥ **95% accuracy**)

- AI prediction models (availability forecasting accuracy ≥ **85%**)
- Edge processing to reduce latency below **500 ms**
- Cloud analytics for scalability

Architecture Principles

- Modular microservices
- API-first integration with city systems
- Horizontal scalability to **10,000+ spaces**

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4. Operational Strategy

Deployment Approach

- Pilot deployment: **6–9 months**
- Phased rollout to minimize risk and cost
- Continuous AI retraining using real data

Operational Targets

Metric	Target
System uptime	≥ **99%**
Incident response time	< **2 hours**
Maintenance cost reduction	**−20%**

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5. Data, Security & Compliance Strategy

- Privacy-by-design architecture
- Video data anonymization within **1–2 seconds**
- GDPR-compliant data retention policies
- Role-based access control for operators

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6. Growth & Innovation Strategy

Short-Term (1–2 years)

- Improve detection accuracy to **≥97%**
- Integrate mobile apps and payment systems

Mid-Term (3–4 years)

- AI-based congestion prediction
- Integration with EV charging and navigation apps

Long-Term (5 years)

- City-scale mobility analytics
- Support autonomous vehicle parking systems

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7. Risk Management Strategy

Risk	Strategic Response
High initial costs	Phased deployment & public funding
Privacy concerns	Anonymization & transparency
User resistance	UX optimization & education
Market competition	Continuous AI innovation

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8. Strategic Success Indicators

The enterprise strategy is considered successful if:

- Parking utilization exceeds **85%**
- Average search time is reduced by ≥**30%**
- Operational costs drop by ≥**20%**
- System uptime remains above **99%**

AI-Powered Parking Management System (AIPMS) — Tree of Goals with KPIs

Ultimate Goal:
Improve urban parking efficiency and customer experience

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1. Operational Efficiency

- **Goal 1.1:** Reduce time drivers spend searching for parking
  - **KPI 1.1.1:** Average search time per vehicle → **from 12 min to 5 min**
  - **KPI 1.1.2:** Parking lot occupancy rate → **maintain 85–95%**
- **Goal 1.2:** Maximize space utilization

    - **KPI 1.2.1:** Space utilization rate → **target 90%**
    - **KPI 1.2.2:** Empty spaces per peak hour → **less than 10%**

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2. Revenue Optimization

- **Goal 2.1:** Increase parking revenue
    - **KPI 2.1.1:** Average revenue per spot → **$8/day**
    - **KPI 2.1.2:** Monthly revenue growth → **+10%**
- **Goal 2.2:** Reduce revenue leakage
    - **KPI 2.2.1:** Unpaid parking events → **less than 1% of total**
    - **KPI 2.2.2:** Payment compliance rate → **>99%**

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3. User Satisfaction

- **Goal 3.1:** Improve ease of parking
    - **KPI 3.1.1:** Average app rating → **4.7/5**
    - **KPI 3.1.2:** Complaints about parking availability → **<2 per 1000 users**
- **Goal 3.2:** Enhance payment experience
    - **KPI 3.2.1:** Average payment time → **<5 seconds**
    - **KPI 3.2.2:** Failed transactions → **<0.5%**

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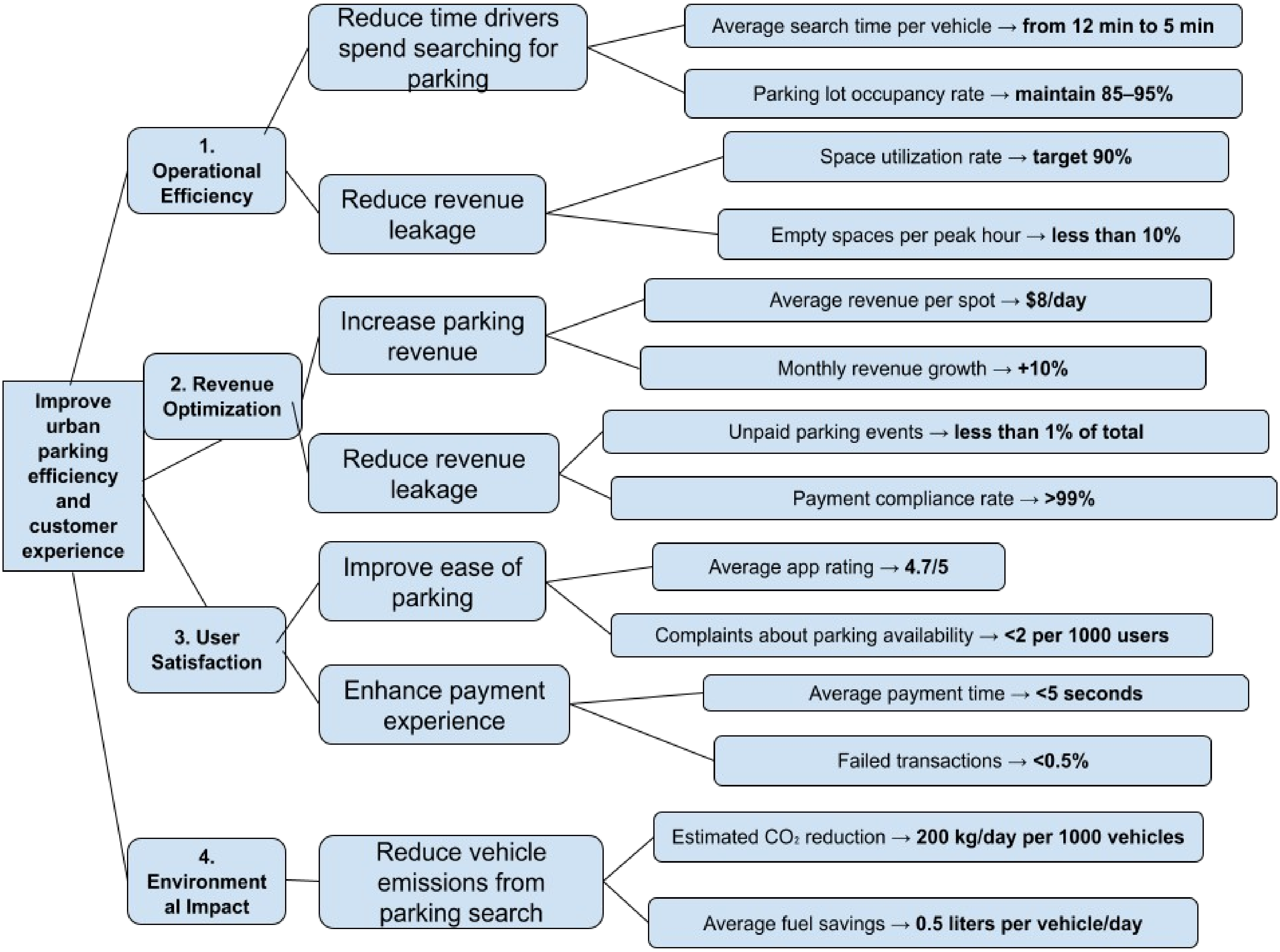
4. Environmental Impact

- **Goal 4.1:** Reduce vehicle emissions from parking search
    - **KPI 4.1.1:** Estimated CO_2 reduction → **200 kg/day per 1000 vehicles**
    - **KPI 4.1.2:** Average fuel savings → **0.5 liters per vehicle/day**

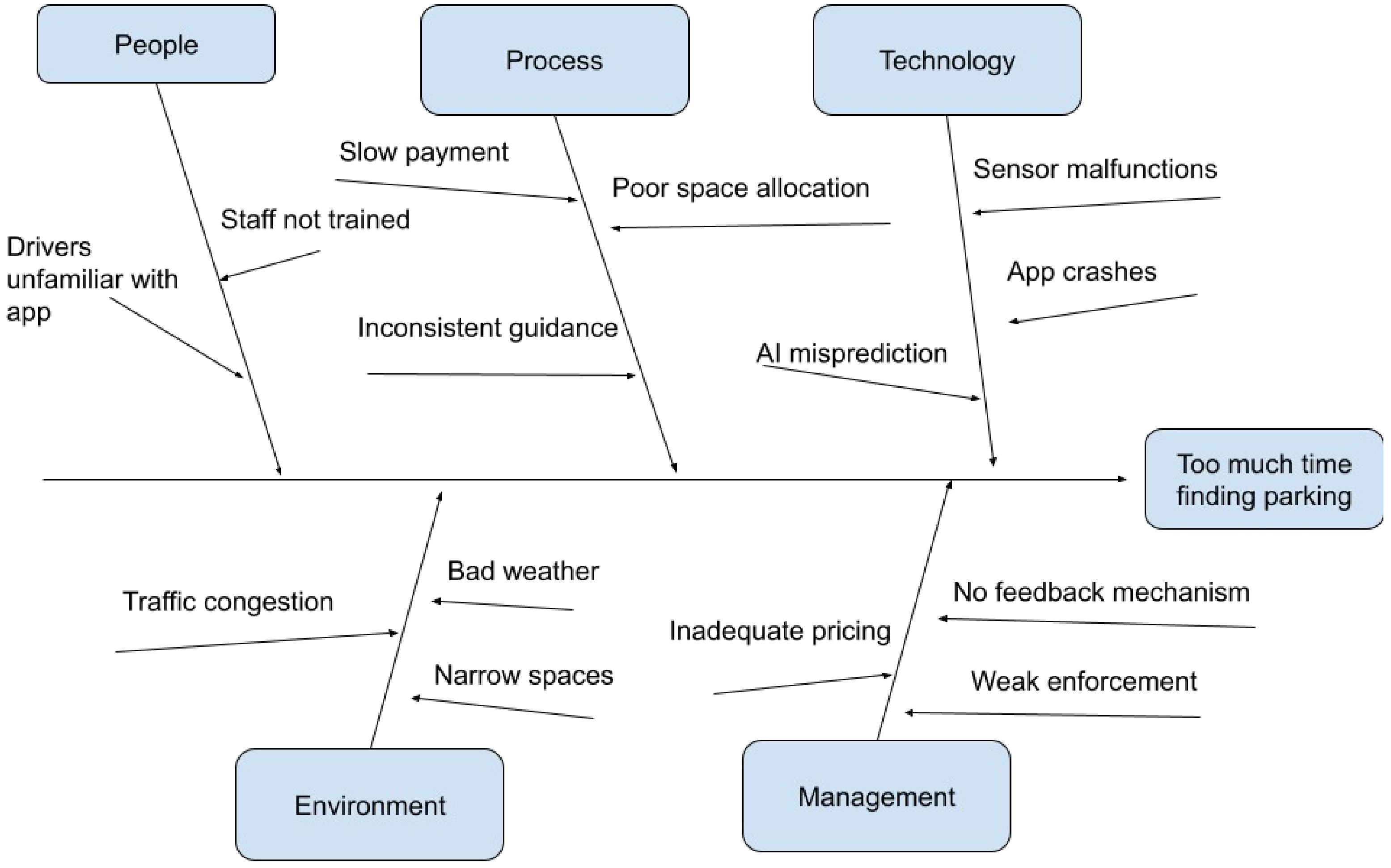


Improve urban parking efficiency and customer experience
1. Operational Efficiency
Reduce time drivers spend searching for parking
Average search time per vehicle → from 12 min to 5 min
Parking lot occupancy rate → maintain 85–95%
Reduce revenue leakage
Space utilization rate → target 90%
Empty spaces per peak hour → less than 10%
2. Revenue Optimization
Increase parking revenue
Average revenue per spot → $8/day
Monthly revenue growth → +10%
Reduce revenue leakage
Unpaid parking events → less than 1% of total
Payment compliance rate → >99%
3. User Satisfaction
Improve ease of parking
Average app rating → 4.7/5
Complaints about parking availability → <2 per 1000 users
Enhance payment experience
Average payment time → <5 seconds
Failed transactions → <0.5%
4. Environmental Impact
Reduce vehicle emissions from parking search
Estimated CO₂ reduction → 200 kg/day per 1000 vehicles
Average fuel savings → 0.5 liters per vehicle/day

Ishikawa (Fishbone) Analysis

Problem Statement:

“Drivers spend too much time finding parking, leading to user dissatisfaction and revenue loss.”



SIPOC

S (Suppliers)	**I** (Inputs)	**P** (Process)	**O** (Outputs)	**C** (Customers)
Parking lot owners	Parking sensors	Detect available spaces	Real-time parking data	Car drivers
App developers	User app & backend	Process requests & bookings	Booking confirmation	Drivers & Parking operators
Payment providers	Payment info	Process payments	Payment receipt	All users
Traffic authorities	Traffic data	Guide drivers	Reduced search time	
Maintenance teams	Hardware	Maintain system	Reliable system	

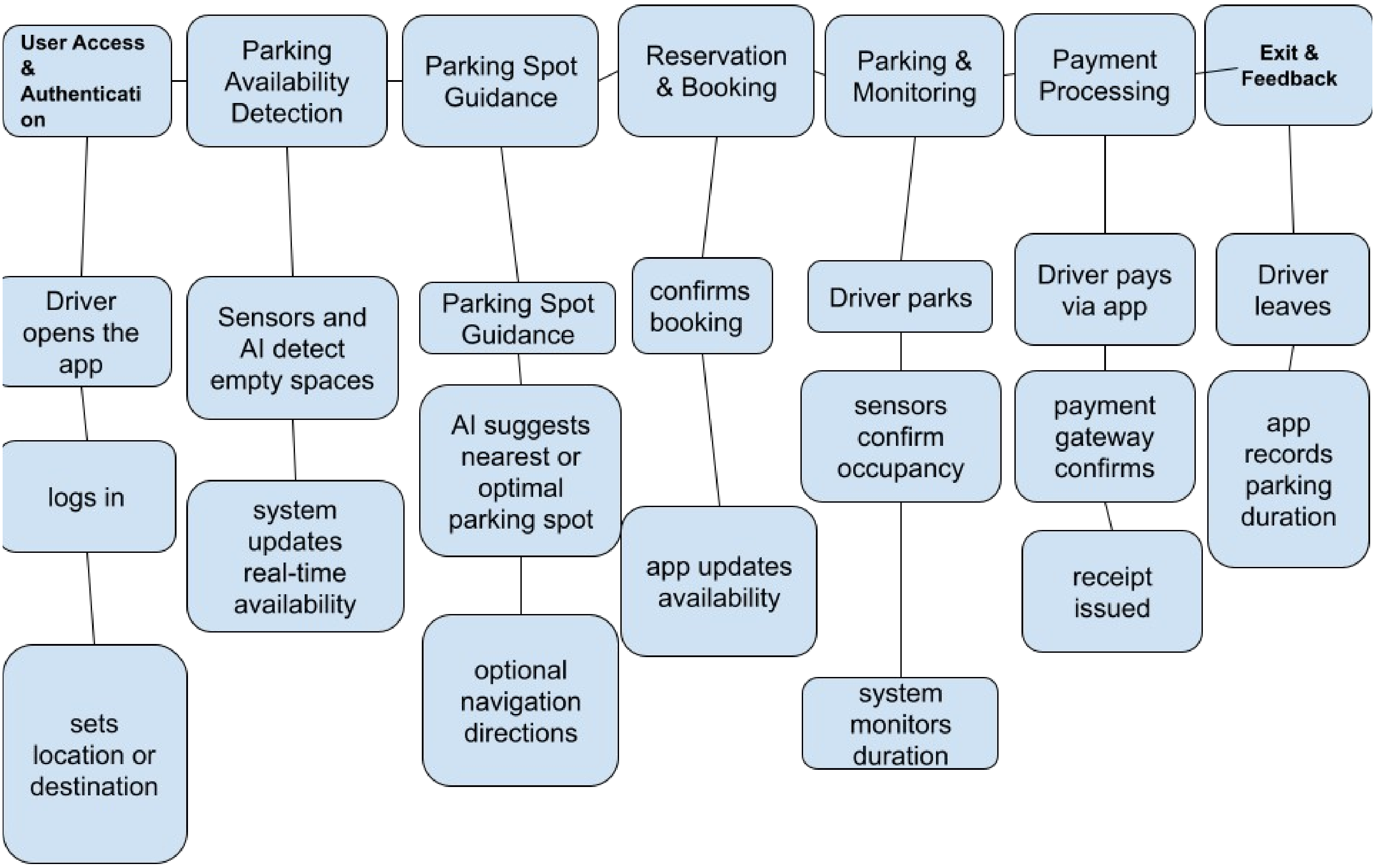
Top-Level Process Steps

Main Goal: Enable drivers to find, park and pay efficiently while optimizing parking operations.

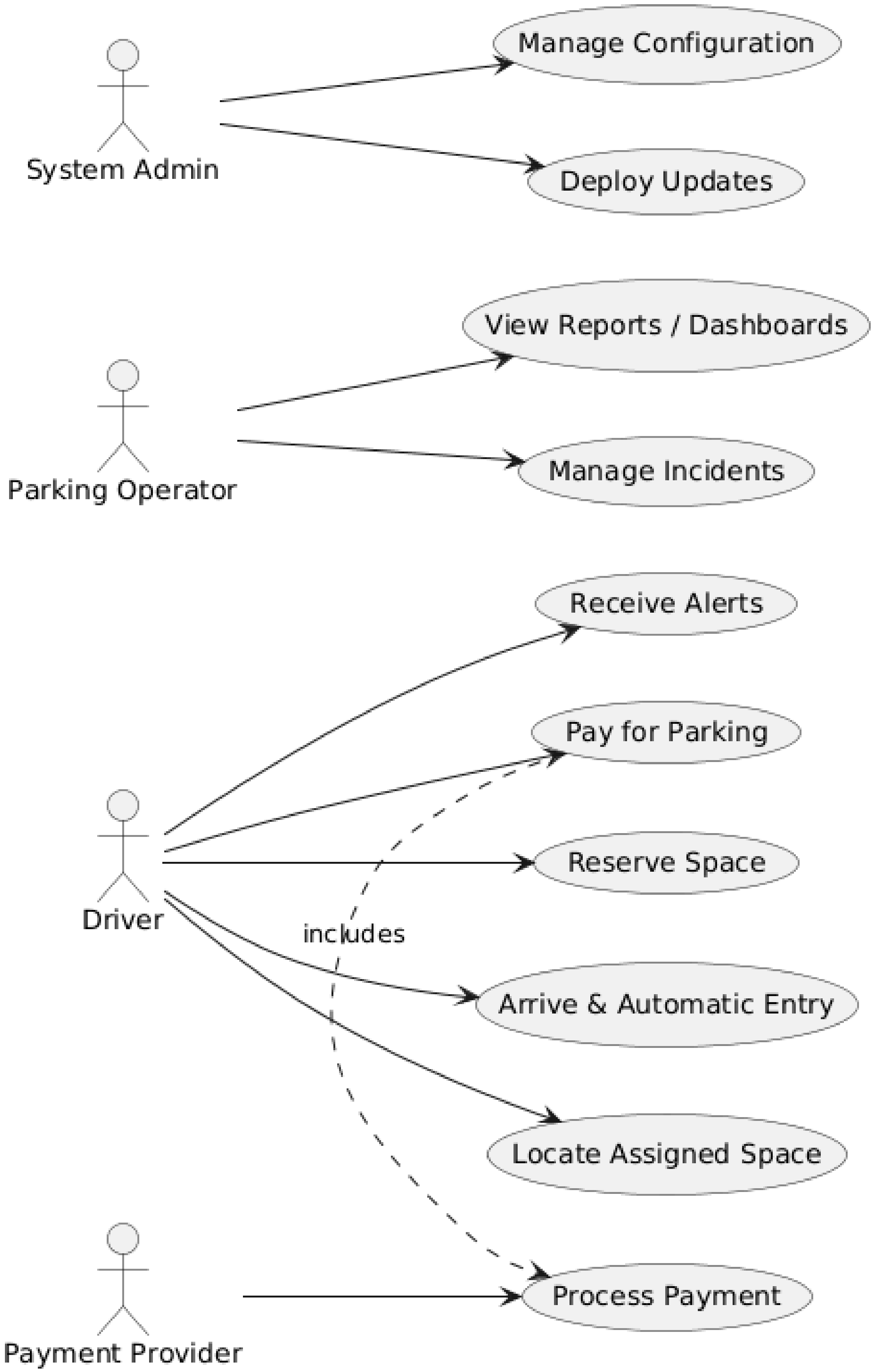
High-Level Steps

1. **User Access & Authentication**
    - Driver opens the app → logs in → sets location or destination.
2. **Parking Availability Detection**
    - Sensors and AI detect empty spaces → system updates real-time availability.
3. **Parking Spot Guidance**
    - AI suggests nearest or optimal parking spot → optional navigation directions.

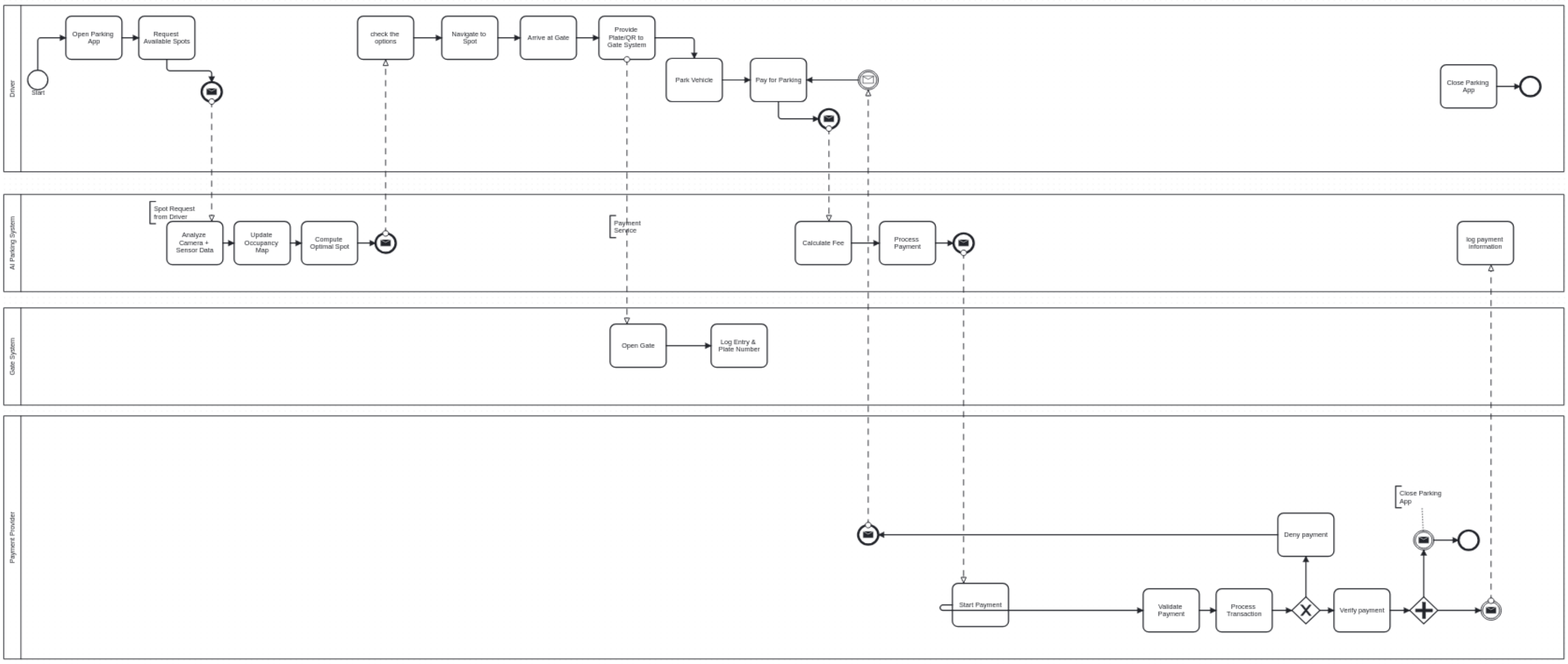
4. **Reservation & Booking**
    - Driver reserves spot (optional) → confirms booking → app updates availability.
5. **Parking & Monitoring**
    - Driver parks → sensors confirm occupancy → system monitors duration.
6. **Payment Processing**
    - Driver pays via app → payment gateway confirms → receipt issued.
7. **Exit & Feedback**
    - Driver leaves → app records parking duration → optional user feedback collected.
8. **Data & Analytics**
    - System aggregates occupancy, revenue, and traffic patterns → dashboards for management.



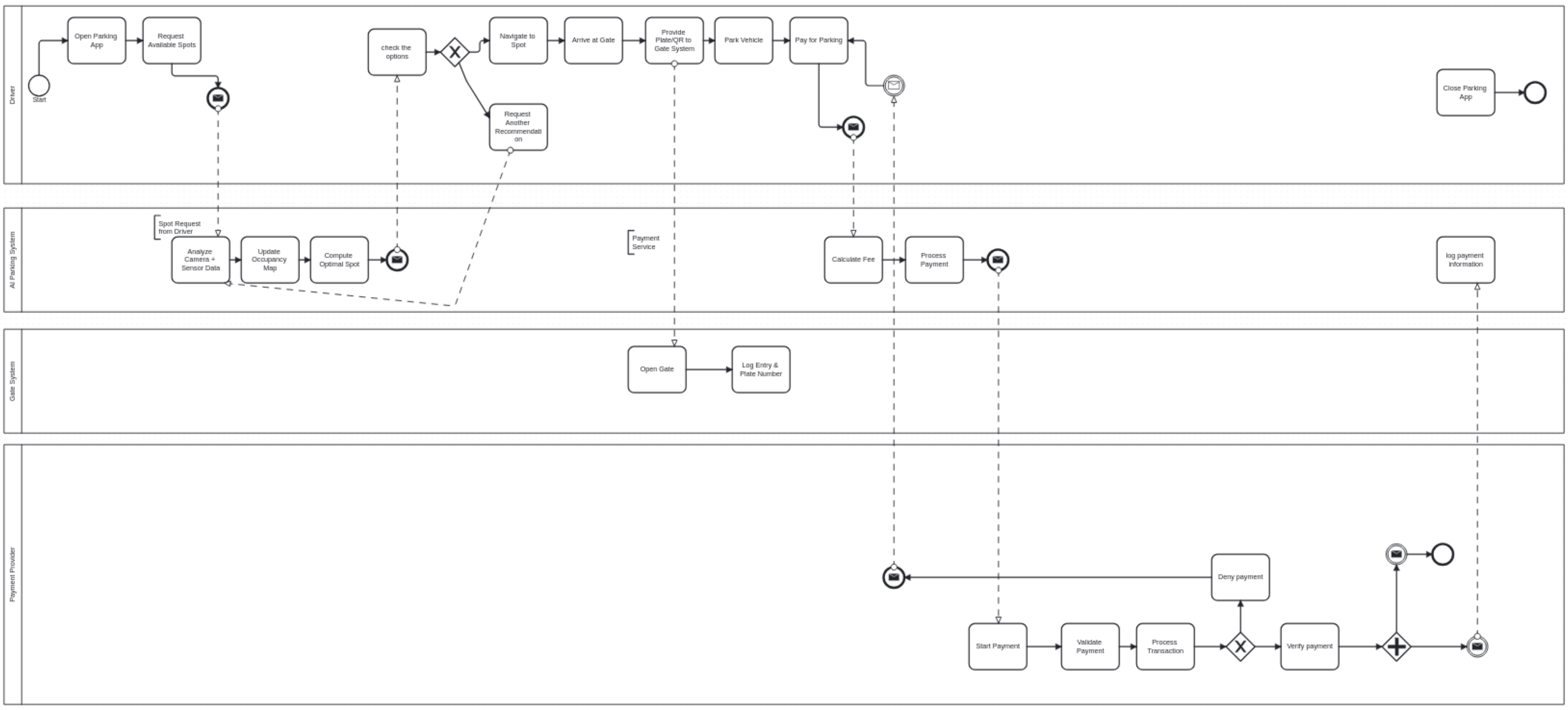
UML: use case diagrams



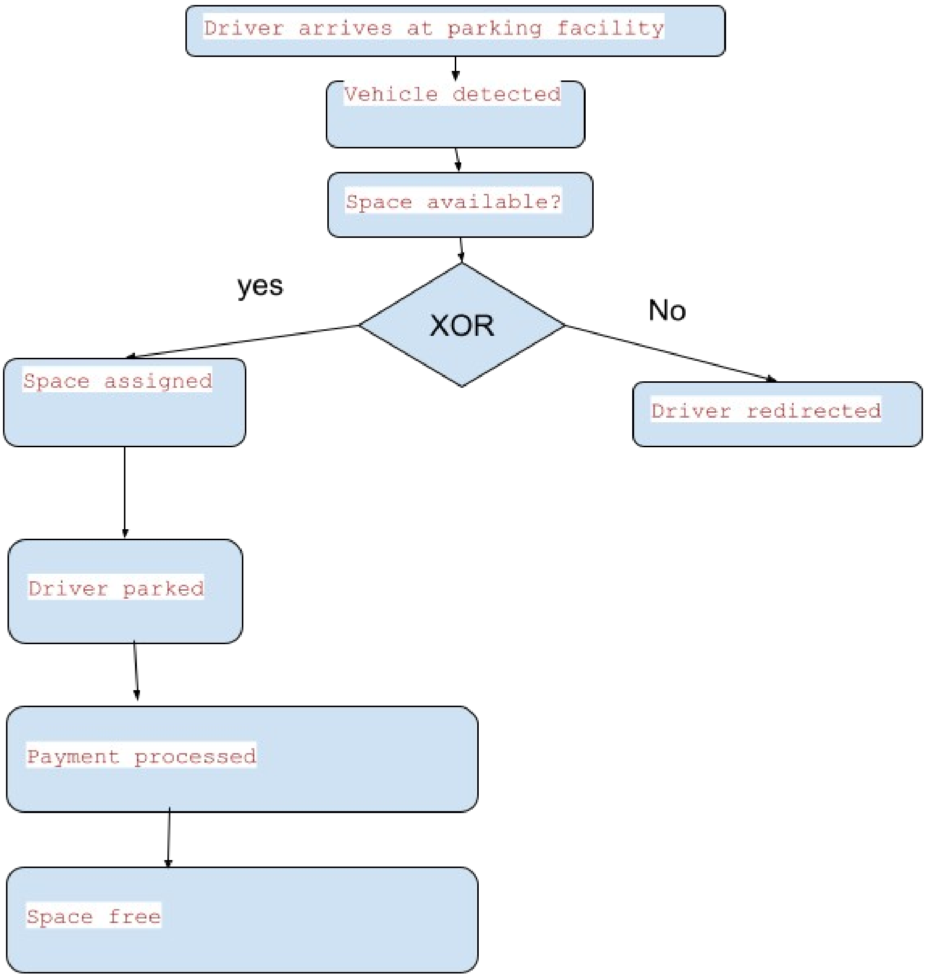
AS-IS processes with BPMN



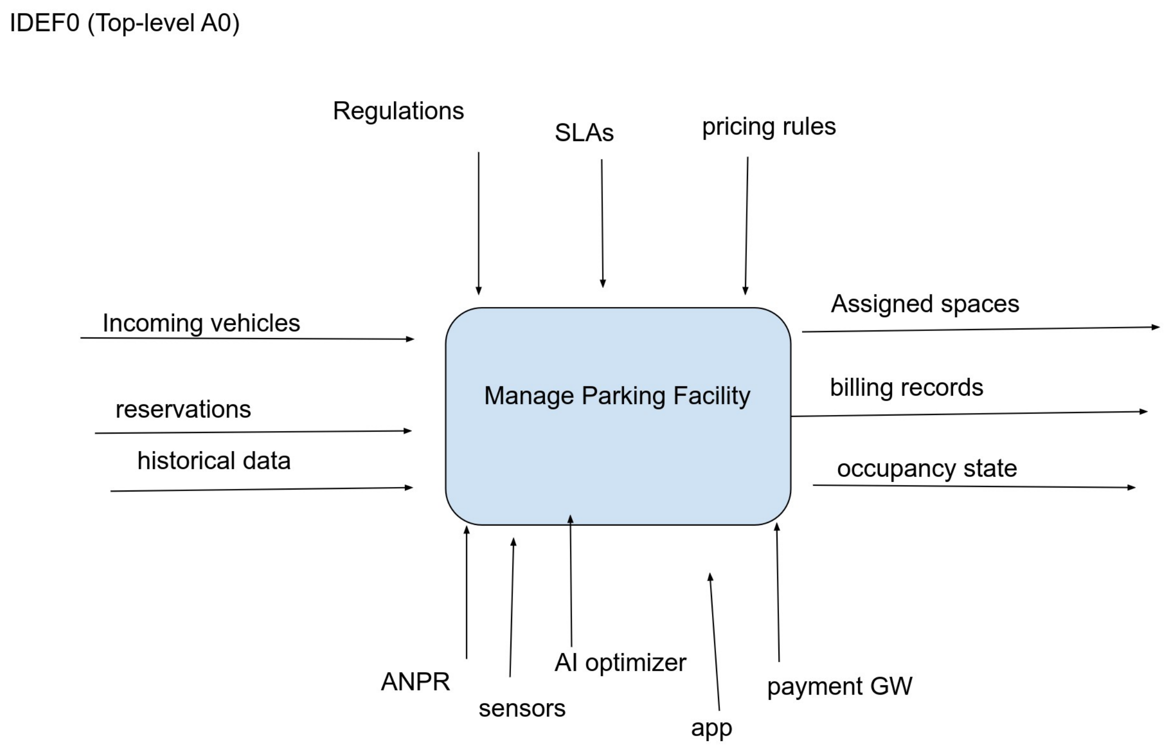
TO-BE processes with BPMN



AI-Powered Parking Management EPC flow

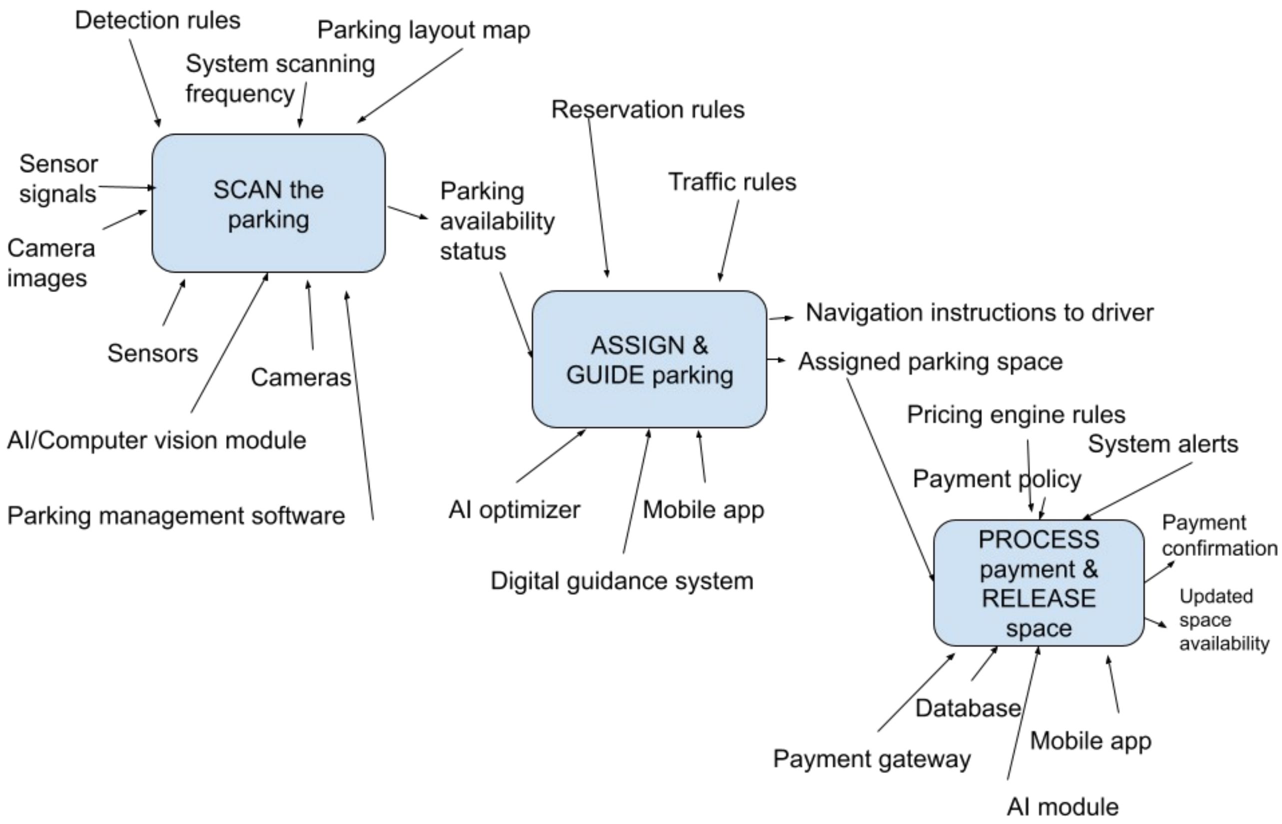


IDEF0



IDEF0 (Top-level A0)
Regulations
SLAs
pricing rules
Incoming vehicles
reservations
historical data
Manage Parking Facility
Assigned spaces
billing records
occupancy state
ANPR
sensors
AI optimizer
app
payment GW

IDEF3


Detection rules
Parking layout map
System scanning frequency
Sensor signals
Camera images
SCAN the parking
Sensors
Cameras
AI/Computer vision module
Parking management software
Parking availability status
Reservation rules
Traffic rules
ASSIGN & GUIDE parking
Navigation instructions to driver
Assigned parking space
AI optimizer
Mobile app
Digital guidance system
Pricing engine rules
System alerts
Payment policy
PROCESS payment & RELEASE space
Payment confirmation
Updated space availability
Database
Payment gateway
Mobile app
AI module

RACI MATRIX

RACI Matrix (Key activities)

Activity	Parking Operator	System Admin	AI Team	Maintenance	Finance	External Vendor
Setup & install sensors	A	R	C	C	I	R
Configure pricing rules	I	C	R	I	A	C
Day-to-day monitoring	R	A	C	I	I	C
Incident response	A	R	C	R	I	C
Billing reconciliation	I	I	I	I	A	C
Feature deployment	I	C	R	I	I	A

Legend: R = Responsible, A = Accountable, C = Consulted, I = Informed.

Balanced Scorecard

Perspective	Strategic objective/ critical factor Goals	Critical Factor Goals	Efficiency objective / critical factors	Real time data platform modernizatio n	Back office process optimization
Finance	Increase revenue from parking operations Reduce operational and labor costs through automation Improve asset utilization (maximaze occupancy per square meter) Enhance financial predictability via analytics and demand forecasting	Increase overall revenue by 10-30% with dynamic pricing and higher occupancy Reduce manual enforcement and staff costs by 20-40% via LPR automation. Achieve >= 90% peak-hour occupancy across the parking network Operational cost reduction 20% by decreasing hardware downtime/ maintenance.	0.2 0.5 0.7 0.6	4 6 5 7	9 5 4 8
Customer / Stakeholder	Improve user satisfaction throught frictionless parking Reduce parking search time& congestion	Maintain app satisfaction at >=4.5 stars Reduce time to park by 40-60% using	0.7	6	7

		guidance and predictions	0.4	5	4
	Increase trust in real-timeavailable accuracy	Deliver real_time availability accuracy of >=98%	0.8	6	8
	Ensure safety, accessibility and regulatory aligment for city stakeholders	>= 95% satisfaction rating from municipalityies or property managers	1	9	7
Internal process	Ensure reilble real-time data collection and processing	End to end data latency < 2 seconds	0.3	6	6
	Maximize system uptime (hardware +software)	Overall system uptime >= 99.9%	0.2	5	7
	Automate enforcement and operations	LPR accuracy >= 95% in all conditions	0.7	6	8
	Optimize parking flow through AI routing & predictions	Predictive models for occupancy >= 90% accurancy	0.6	7	9
	Maintaining high cybersecurity & privacy standards	100% compliance with GDPR/CCPA + encrypted data flows	0.7	3	6
Partners	Build strong relationships with technology vendors(sensor, cameras etc.)	Vendor |SLA compliance >=99%	0.6	5	6
	Strengthen collaboration with municipalities & parking	Reduce hardware installation time by 30%	0.5	3	7

	operators Ensure high_quality installation & maintenance services Enable interoperability via APIs and standards Create long-term, mutually beneficial partnerships	Achived 95% partner satisfaction Ensure 100% compatibility with major smart-city APIs Reduce maintenance response time to < 24 hours via partner coordination	0.9 0.6 0.5 0.4	7 5 3 4	9 7 5 2
Employee	Build a skilled, motivated workforce Improve employee productivity through tools & automation Encourage innovation and continuous improvement culture Increase engagement and retention Ensure safety, compliance and technical readiness	Provide ongoing training -> min. 20 hours per employee per year Employee satisfaction score >= 85% Reduce employee turnover by 15-30% Skill certification: 90% of tech staff certified in system operation	0.6 0.8 0.9 0 0.3	6 5 6 7 6	1 5 7 8 7
Learning, inovations and	Foster continuous AI model	Update and retrain AI models	0.3	6	6

development	improvement	quarterly with new sensor data			
	Increase staff AI/tech competency	Train 80-100% of operational staff in AI system usage	0.4	3	2
	Accelerate R&D for new features (dynamic pricing, autonomous valet, etc	Release 3-5 innovative features per years	0.6	8	7
	Support scalability and adaptability for smart_city integration	System scales to 100K+ spaces without performance degradation	0.7	9	6

Cost Structure (Parking Scan Process)

One-Time (Capital) Costs

Cost Item	Description	Unit Cost	Quantity	Total
Parking sensors	IoT sensors per parking space	$45	200	$9,000
ANPR cameras	Entry/exit vehicle detection	$800	4	$3,200
Edge devices	Local processing units	$500	2	$1,000
Installation	Hardware & wiring	—	—	$2,000
AI model development	Occupancy detection & validation	—	—	$4,500
Total CAPEX				**$19,700**

Operational (Annual) Costs

Cost Item	Description	Annual Cost
Cloud computing	Data processing & storage	$2,400
System maintenance	Sensors & cameras	$1,800
Software updates	AI model tuning	$1,200
Network connectivity	IoT data transmission	$900
Total OPEX (per year)		**$6,300**

Total Project Duration: 18 weeks
Total Staff Cost: $62,000 (100%)

Role	Core Responsibilities	Main Process	Hours	Rate ($/h)	Cost ($)	% of Total
Project Manager	Planning, coordination, milestones, risk	All processes	200	45	9,000	14.5%
AI Engineer	Occupancy detection, optimizer, AI tuning	Scan, Assign	320	55	17,600	28.4%
Backend Developer	APIs, DB, system integration	All processes	280	40	11,200	18.1%
IoT / Hardware Engineer	Sensors, cameras, calibration	Parking Scan	200	35	7,000	11.3%
Mobile App Developer	App UI, navigation, guidance	Assign & Guide	220	38	8,360	13.5%
QA / Test Engineer	Testing, validation, KPIs	All processes	160	30	4,800	7.7%
DevOps / Cloud Engineer	Deployment, monitoring, scaling	Payment & Exit	120	42	5,040	8.1%
TOTAL			**1,500**		**62,000**	**100%**

JIRA_ROADMAP- LINK

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