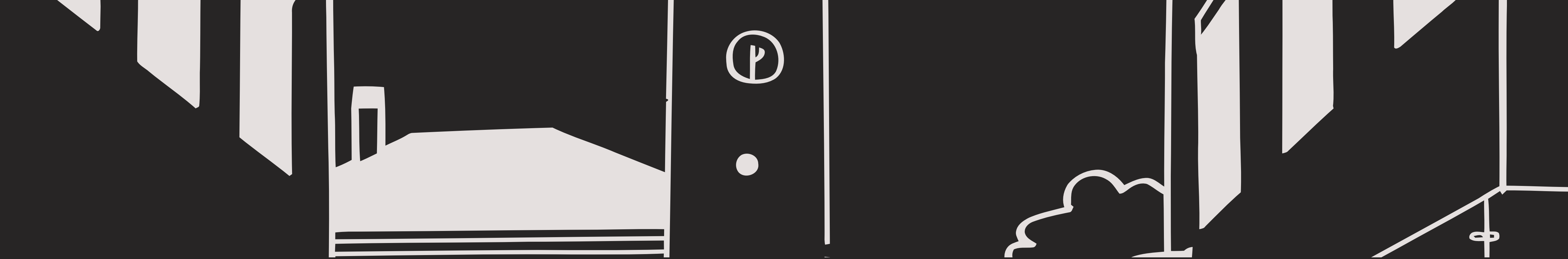
Smart Traffic Lights Powered by Reinforcement Learning

Transforming urban intersections into self-learning systems that optimize flow, reduce emissions, and increase safety through autonomous AI decision-making.

SkillMix - Tech consultancy specializing in AI and optimization.



The Urban Mobility Crisis

Outdated fixed-time traffic systems are failing European cities. The average city commuter loses over 70 hours per year to traffic congestion, while local governments face mounting pressure to modernize under the EU Green Deal.

Traditional fixed policies cannot adapt to irregular or stochastic arrival patterns during rush hours, special events, or emergencies.

The result: unnecessary delays, increased emissions, and frustrated citizens.

70+

Hours Lost

Per commuter annually in traffic in Paris, Brussels, Dublin, and Rome.[1]

10%

CO_2 Reduction

Potential with adaptive systems[2]

AI-Powered Adaptive Traffic Management

Our Reinforcement Learning agent continuously learns optimal light-phase switching policies, adapting in real-time to traffic conditions. The system uses SUMO simulations with real, non-homogeneous Poisson vehicle arrivals and learns from live traffic detector input including cameras and loop sensors. The simulation was perfomed on an intersection in New York.

Detection

Camera and loop sensors capture real-time traffic data

State Encoding

Queue lengths, phase timing, and wait times processed

Policy Action

RL agent decides optimal light phase

Model Update

System learns and improves continuously

Objective: Minimize total delay, queue length, and waiting time while maintaining fairness for all traffic directions.

Understanding Reinforcement Learning

Reinforcement Learning (RL) allows our traffic system to learn optimal behaviors by trial and error, much like how humans learn from experience. Instead of being explicitly programmed, it discovers the best actions through a continuous feedback loop.

The Agent

This is our AI – the decision-maker that chooses which traffic light phase to activate.

The Environment

This is the intersection itself, with its changing traffic conditions, vehicles, and pedestrians.

States

The current snapshot of the environment: queue lengths, vehicle speeds, and waiting times at the intersection.

Actions

The choices the agent can make: extending a green light, switching to red, or triggering a pedestrian phase.

Rewards

Feedback on how good an action was, e.g., reduced congestion (positive reward) or increased wait times (negative reward).

Benchmark and Reward Function

$$r_t = w_Q(Q_{t-1} - Q_t) + w_W(W_{t-1} - W_t) + w_T T_t + w_S S_t$$

$$Q_t : \text{total queue length at time } t,$$

$$W_t : \text{maximum vehicle waiting time at time } t,$$

$$T_t : \text{number of vehicles that exited the network at time } t \text{ (throughput)},$$

$$S_t : \begin{cases} 1, & \text{if the signal phase was switched at time } t, \\ 0, & \text{otherwise,} \end{cases}$$

$$w_Q,\ w_W,\ w_T,\ w_S : \text{weights controlling the importance of each term.}$$

The function prioritizes minimizing queue lengths (Q) and waiting times (W), while actively rewarding the throughput of vehicles (T). Our DDQN algorithm aims to maximize this reward function over time, learning the optimal traffic light control policy.

Baseline Comparisons

To evaluate the effectiveness of our new traffic management system, we compare its performance against 2 established methods:

01

Fixed-Time Policy

Traffic lights that switch at set intervals, following a fixed schedule regardless of current traffic volume or congestion.

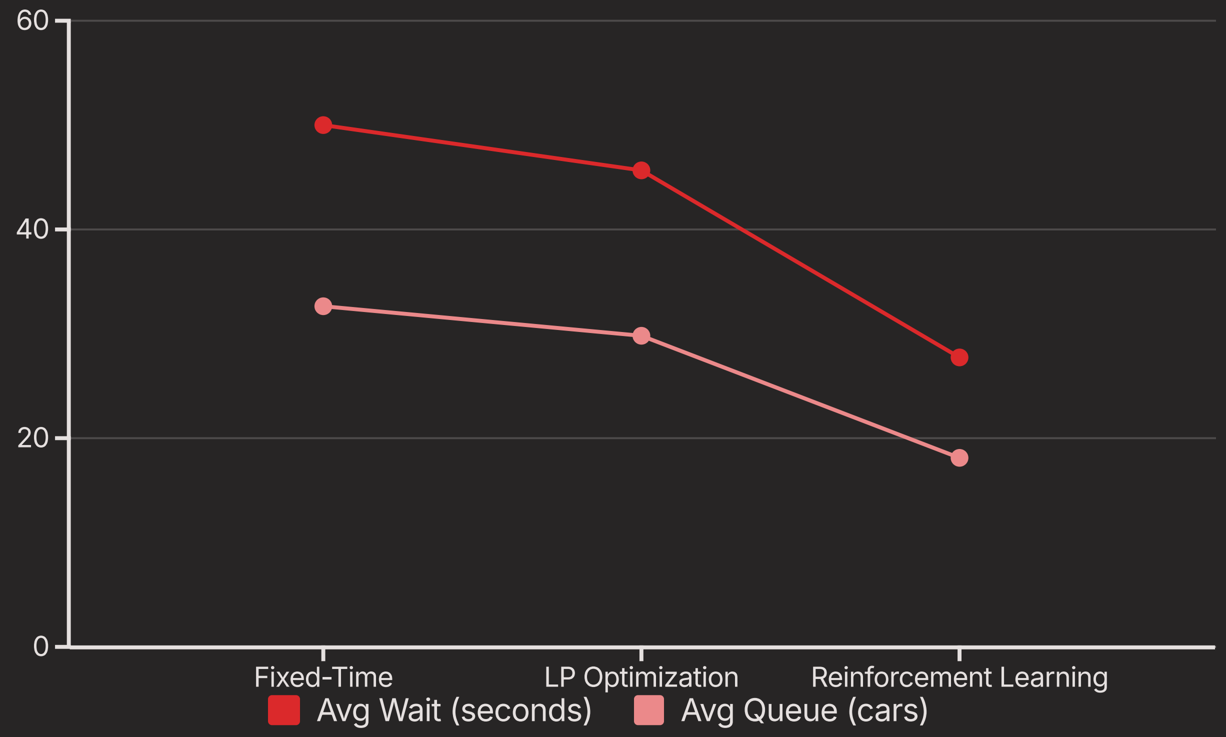
02

LP Heuristic

Calculates the best possible traffic light timings for a given traffic state. It is a heuristic controller that is reactive and myopic, only optimizing based on current queue lengths, not future consequences.

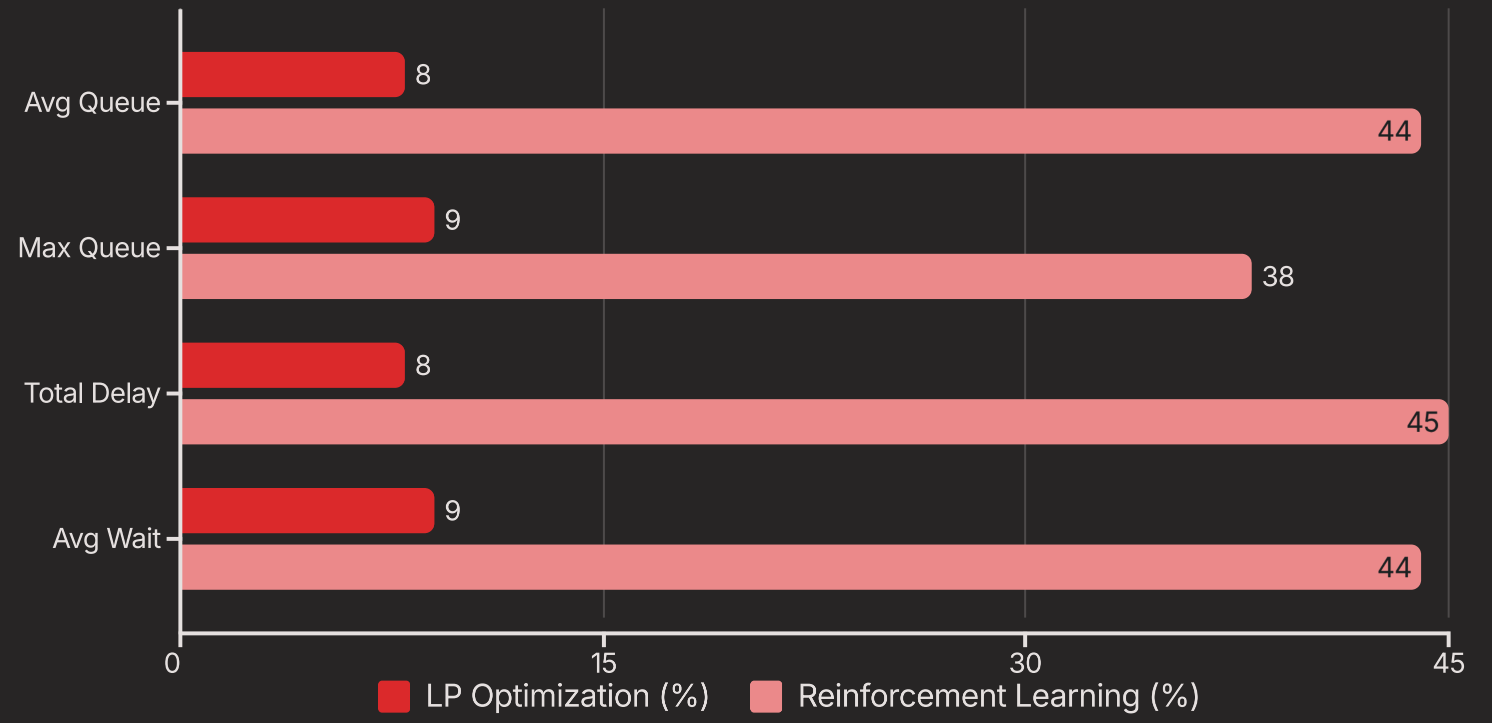
Proven Results in Simulation

Traffic Flow Optimization Performance



Based on real data from a New York intersection (4th avenue and Atlantic avenue intersection)

Percentage Improvement vs. Fixed-Time



Based on real data from a New York intersection.

Deployment & Compliance

Safety First

Fail-safe settings and backup systems guarantee continuous operation. Works smoothly with current traffic controllers through TraCI or standard API connections.

Edge Computing

Runs efficiently on NVIDIA Jetson edge hardware, enabling real-time inference without cloud dependency. Low latency, high reliability.

EU Compliant

Fully GDPR and EU AI Act compliant. Privacy-preserving architecture with transparent decision-making processes and audit trails.

Aligned with European Vision

EU Green Deal

Cutting urban CO_2 emissions through optimized traffic flow and reduced idling time at intersections.

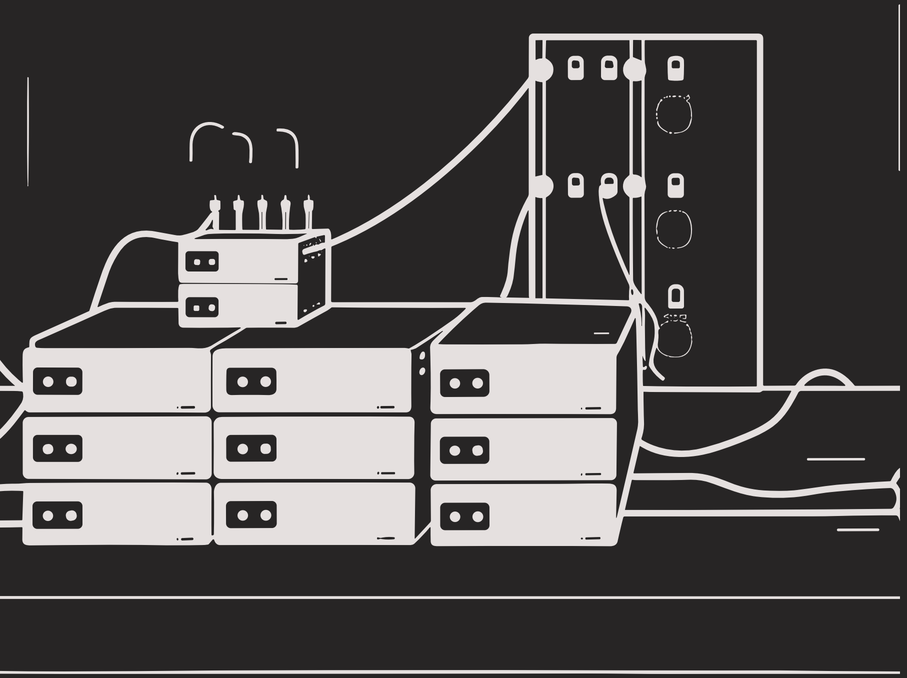
Smart Mobility Strategy

Enabling intelligent infrastructure that adapts to real-time conditions and citizen needs.

ERTICO Vision 2035

Connected, cooperative, and automated mobility systems for safer, cleaner cities.

Positioned as a **European alternative** to North American competitors like Miovision and Google Green Light, keeping critical infrastructure technology within EU control.



Deployment Roadmap

1

2025-2026: Pilot Launch

Initial deployment in mid-sized EU city. Single intersection proof-of-concept with full monitoring and data collection.

2

2026-2027: Regional Scale

Expansion to 25 interconnected intersections. Network-level optimization and coordination between traffic signals.

3

2027+: Multimodal

SaaS analytics dashboard for municipalities with emissions tracking and congestion heatmaps.

Let's build Europe's next smart mobility success story together.

Contact

Xander Pauwels
CEO, SkillMix

+32 475 819 967
xander@skillmix.nl

www.skillmix.nl