



Traffic Management in Urban Environments

using Artificial Intelligence

*Improving Mobility, Operations, and
Multimodal Safety Through
Data-Driven Transportation Systems*

Presenters

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Urban Transportation Challenges

65%

Increase in freeway delay
per commuter since 2000

134h

Hours drivers spend
annually in congestion

48%

Rise in traffic fatalities
since 2010

35%+

Of fatalities are
VRU's



Limited roadway
expansion
opportunities



Signal timing
inefficiencies



Incident-related
delays cause
unreliable travel
times



Safety

Why AI in Transportation?



What AI means in
transportation
engineering



AI applications in
traffic operations



Enhance multimodal
safety



Benefits and limitations of AI systems



Future opportunities

AI Transportation System

Traditional Systems

- Fixed-time signal timing
- Manual retiming cycles
- Reactive operations
- Limited data integration



AI-Based Systems

- Real-time optimization
- Predictive operations
- Automated detection
- Continuous learning
- Adaptive decision-making

DATA SOURCES

Signals

Cameras

Historical Data

Bluetooth / Wi-Fi

Connected Vehicles

AI-Powered Detections

Vehicle Classification



Automatic identification of vehicle types in real-time traffic streams

Pedestrian Detection



Vision-based detection of pedestrian presence and movement patterns

Bicycle Detection



Specialized detection algorithms for cyclists at intersections

Turning Movement Counts



Automated counting and classification of turning maneuvers

Near-Miss / Conflict Analysis



AI-driven identification of potential collision scenarios

Red-Light Violation Detection



Automated enforcement monitoring for signal compliance

AI Traffic Signal Optimization



Adaptive Signal Control

Continuously adjusts signal timing in response to real-time traffic conditions.



Dynamic Cycle Length

Modifies cycle lengths dynamically to accommodate fluctuating demand.



Corridor Coordination

Synchronizes signals across corridors for smooth green-wave progression.



Queue Management

Detects and mitigates queue buildup at downstream intersections.



Real-Time Split Optimization

Allocates green time dynamically between competing movements.

AI for VRU's Safety



Automated Leading Pedestrian Intervals (LPIs)

AI triggers LPIs automatically based on real-time pedestrian demand detection.



Bicycle Priority Detection

Detects cyclists and extends green phases to enable safe intersection crossing.



Dynamic Pedestrian Recall

Adjusts pedestrian recall patterns based on observed crossing activity.



Transit Signal Priority Integration

Coordinates pedestrian and bicycle safety with transit signal priority systems.



Conflict Prediction

Anticipates vehicle-pedestrian conflicts and adjusts signal phasing proactively.

City of Concord · Adaptive Signal System Implementation

Purpose: Improve corridor operations through real-time traffic-adaptive signal control.

Corridor Challenges

- Peak-period congestion
- Traffic demand variability
- Queue spillback at key intersections
- Need for improved progression
- Increasing multimodal activity

Project Overview

- Adaptive Signal Control Technology deployment
- Integration with existing signal infrastructure
- Real-time traffic monitoring
- Dynamic signal timing adjustments

City of Concord · Adaptive Signals — Analytics & Benefits

AI / Advanced Analytics

- Continuous collection of traffic data
- Real-time optimization algorithms
- Dynamic cycle, split, and offset adjustments
- Predictive traffic management capabilities

Benefits

- ✓ Reduced corridor delay
- ✓ Improved travel time reliability
- ✓ Reduced stop frequency
- ✓ Enhanced system responsiveness
- ✓ Improved operations without roadway widening

City of Concord · AI-Assisted Collision Dashboard

Purpose: Leverage AI and advanced analytics to identify locations with elevated crash risk and support proactive safety enhancement decisions.

IDENTIFIED NEED



Large volumes of collision data require automated processing



Time-consuming manual analysis limits actionable insight



Difficulty identifying systemic safety trends at scale



Need for data-driven prioritization of safety projects

City of Concord · Dashboard Development & Outputs

Data Sources

- SWITRS collision records
- Traffic volumes
- Speed data
- Roadway characteristics
- GIS layers

AI Tools

- Automated data processing
- Pattern recognition
- Spatial clustering analysis
- Data visualization generation
- Recurring crash factor identification

Dashboard Outputs

- Collision heat maps
- High Injury Network screening
- Collision severity summaries
- Trend analysis and emphasis areas
- Identification of countermeasures

How AI Can Help ???



Predictive Analytics

- Predict congestion before it occurs
- Incident detection and rapid response
- Event traffic management
- Evacuation route optimization
- Special event operations support



Connected Vehicles

- Vehicle-to-Infrastructure (V2I) communication
- V2X communication
- Connected signal systems
- Freight and transit vehicles prioritization
- Emergency vehicle response time
- Enhance safety

Benefits of AI in Transportation

Benefits

Operational

- Reduced delay
- Improved travel times
- Better signal coordination
- Faster incident response
- Data-driven decisions
- Resource efficiency

Safety

- Reduced conflicts
- Improved pedestrian safety
- Better multimodal operations

Challenges

- Data quality issues
- Cybersecurity concerns
- Privacy considerations
- Cost of implementation
- Infrastructure compatibility
- Staff training needs
- Algorithm transparency
- Maintenance requirements

Future Trends

Transportation systems are moving toward fully connected ecosystems

Autonomous Vehicles



Self-driving vehicles integrate with smart intersection systems.

Edge AI Processing



AI computation at the signal level for lower latency decisions.

AI-Powered Curb Management



Smart allocation of curb space for ride-share, delivery, and transit.

Smart Intersections



Fully instrumented intersections with real-time multimodal safety awareness.

Integrated Multimodal Mgmt.



Unified management of vehicles, transit, pedestrians, and cyclists.

Generative AI for Operations



LLM-powered tools for signal planning, reporting, and decision support.

Key Takeaways

Conclusions

- ✓ AI is becoming essential in urban traffic management
- ✓ AI improves both mobility and safety outcomes
- ✓ Adaptive signal control is the most mature AI application today
- ✓ AI-assisted analytics accelerate safety project prioritization
- ✓ Transportation engineers remain central to decision-making

Recommended Steps

- 1 Improve data collection infrastructure
- 2 Pilot AI applications
- 3 Prioritize safety-focused deployments
- 4 Integrate multimodal considerations
- 5 Establish cybersecurity standards



Questions?

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