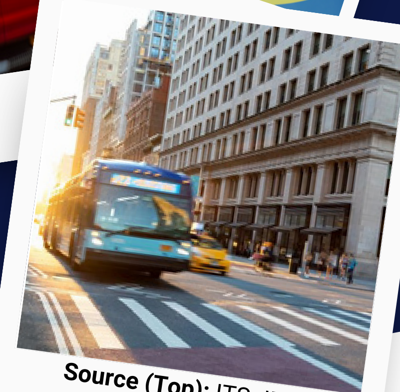
U.S. Department of Transportation

Snapshot

Active Traffic Management: Signal Priority & Preemption

A quick glance at benefits from traffic signal priority and preemption deployments around the United States.

Source: iStock/ bodrumsurf



Source (Top): ITS JPO
Source (Bottom): shutterstock/Ryan DeBerardinis

WHAT IS SIGNAL PRIORITY AND PREEMPTION?

Active traffic management (ATM) is the ability to dynamically manage recurrent and non-recurrent congestion based on current and predicted traffic conditions [1]. Traffic signal priority, one of the key components of ATM, alters a traffic signal's normal timing to reduce delay for special types of vehicles, such as buses. Another approach is signal preemption, which enables vehicles, often emergency vehicles, to send messages to a traffic signal to grant immediate right-of-way [2].

EXAMPLE TRAFFIC SIGNAL PRIORITY & PREEMPTION USE CASES AND BENEFITS

Click on each use case below from recent ITS for ATM: Signal Priority and Preemption deployments, based on ITS project evaluations contained in the ITS Deployment Evaluation Database.

Use Case	Example Benefit
Emergency Vehicle Preemption	In southwestern Pennsylvania, 37 sound-activated emergency vehicle preemption (EVP) systems installed as part of a regional traffic signal program **helped reduce emergency response times by 14% to 23%**.
Connected School Buses	Two school buses in Alpharetta, Georgia were equipped with a connected vehicle (CV) traffic signal priority system that **reduced the number of stops at red signals by 40.4% and travel time by 13.3%**.
Transit Signal Priority	Transit signal priority (TSP) deployed at three Boston, Massachusetts intersections **reduced bus waiting time at red light signals by 21%. TSP resulted in 8% faster travel times**.
TSP Data for Signal Retiming	Data collected from a CV TSP application on an 11-mile corridor in Salt Lake County, Utah was used to retime traffic signals, helping to **improve bus run-time reliability by up to 2.7%**.
V2X Emergency Vehicle Preemption	Vehicle-to-Everything (V2X) EVP deployed in Seminole County, Florida led to **average response time reductions of 90 seconds. and annual maintenance costs are expected to decrease by $200,000**.

Emergency Vehicle Preemption

PROBLEM

To reach the scene of an incident, first responders may need to drive through congested intersections and proceed through red traffic signals. They rely on sirens and flashing lights as alerts, which can confuse nearby drivers and result in response delays or even collisions.

TECHNOLOGY

When emergency vehicle preemption systems detect light, audio, or radio signals from emergency vehicles, they override normal traffic signal operations. This gives approaching emergency vehicles a priority green signal, allowing them to more quickly respond to incidents.

BENEFITS

Across southwestern Pennsylvania, 37 emergency preemption systems triggered by sound were installed, which helps reduce emergency response time by 14 to 23% (2023-B01807).

Source: iStock/Matt Gush

Connected Vehicle School Buses

PROBLEM

School buses often travel long and complex routes with numerous stops to transport students to and from school. Stops, whether for loading and unloading students or at traffic signals, impact mobility, safety, and fuel consumption.

TECHNOLOGY

The Fulton County School System (FCSS) in Alpharetta, Georgia deployed traffic signal priority at 62 intersections. When a CV-equipped bus approaches a CV-equipped intersection, the signal phase shifts to green, allowing the school bus to pass through the intersection without stopping.

BENEFITS

The combined results for the two FCSS school buses showed a 13.3% decrease in travel time, an 18% increase in speed, and a 40.4% decrease in the number of stops (2023-B01804).

Source: iStock/leekris

"Less time on the road and fewer bus stops equates to direct safety and mobility benefits for the bus driver, students, parents, nearby motorists, and FCSS [3]."

Transit Signal Priority

PROBLEM

Up to 50% of transit delay consists of waiting at red lights in signalized intersections [4]. These signal-related delays reduce bus reliability and make travel times longer and less predictable for riders.

TECHNOLOGY

The Massachusetts Bay Transportation Authority (MBTA) and City of Boston worked with a traffic signal vendor that uses machine-learning TSP technology to track and predict transit bus locations, enabling the system to prioritize green signals for the bus as it approaches a TSP equipped intersection.

BENEFITS

After a year of deployment across the three intersections, buses spent an average of 21% less time waiting at red lights, indicating 8% faster travel time for buses (2025-B01960).

Source: MBTA

"The MBTA and the City of Boston aim to improve bus speed and reliability citywide with a major transit signal priority upgrade as a part of the MBTA's Better Bus Project. [4]."

TSP Data for Signal Retiming

PROBLEM

As growing travel demand outpaces available road space, increasing congestion is creating significant hurdles for public transit. Buses are frequently delayed at traffic signals and struggle to stay on schedule, which ultimately makes the service less reliable for commuters.

TECHNOLOGY

A project in Salt Lake City developed a TSP algorithm based on CV technology that enables real-time communication between traffic signals and buses, providing access to real-time signal status and bus travel information. This meant signals could be retimed to better align green signals with bus movements.

BENEFITS

After signal retiming, bus travel times had a 11.7% reduction in northbound (NB) travel times and a 2.3% reduction in southbound (SB) travel times. Bus time reliability also improved after signal retiming by 2.7% (NB) and 1.2% (SB) (2023-B01721).

Source: ITS JPO

"After signal retiming, TSP service was activated during the red interval, which resulted in less stop time at intersections. Therefore, both travel and running time were reduced after signal retiming [5]."

V2X Emergency Vehicle Preemption

Source: FHWA

PROBLEM

Emergency vehicles may face delays at congested intersections because line-of-sight or audible emergency vehicle preemption systems prevent vehicles from requesting signal priority until they are very close to the intersection. Ultimately this causes delays and slower response times.

TECHNOLOGY

Florida DOT (FDOT) deployed a dedicated short-range communication (DSRC)-based V2X solution to enhance the effective radius from which an emergency vehicle could place a request for preemption.

BENEFITS

The FDOT pilot in Seminole County found that by implementing this V2X system, average response times improved by approximately 90 seconds, and annual maintenance costs are expected to decrease by $200,000 (2025-B01994).

"The Department is spreading the word about the potential cost savings and improved performance compared to other options ... Performance achieved; under budget; with lower O&M; and it is scalable [6]."

SAMPLE COSTS: TRAFFIC SIGNAL PRIORITY AND PREEMPTION

An Atlanta-area deployment of intersection priority technology on school buses cost $5,000 per vehicle and $5,000 per intersection. This technology and associated signal priority algorithms support multiple use cases, including signal priority for emergency vehicles. (2023-SC00546).

$5,000 per Vehicle for Intersection Priority

$4,000 per Intersection Emergency Preemption

Texas DOT (TxDOT) provided the estimated cost of selected traffic incident management components based on recent TxDOT and municipal project cost estimates. This includes $4,000 per traffic signal for emergency vehicle preemption (2022-SC00523).

The City of San Jose implemented a city-wide EVP system by upgrading and integrating fleet tracking systems with a network of traffic signal controllers for between $600,000 and $750,000 (2018-SC00407).

Between $600,000 and $750,000 for an EVP System

LESSONS LEARNED: TRAFFIC SIGNAL PRIORITY AND PREEMPTION

In Tennessee, 1,655 traffic signals were ranked based on the results of a performance evaluation. Machine learning can fine-tune the weighting of different ranked choice factors in the calculation of signal priority and refine the algorithm (2023-L01170).

The Smart Columbus Program included the CV Environment study, which deployed wireless technology at 85 intersections and in 1,000 vehicles to test applications including EVP and TSP. Lessons learned from this deployment include (2022-L01145):

1. Understand differences in vendor implementations of road-side units (RSUs). RSUs receive requests for TSP and EVP so subtle differences in vendor implementation affects the reliability and timing of priority granted by the traffic signal.
2. Understand time requirements for integration testing of CV applications. Hundreds of hours of repeated fine tuning and testing was required to obtain consistent and satisfactory application performance.
3. Utilize a secure IPv6 connection to allow on-board unit (OBU) vendors to connect to their respective remote services so they can perform firmware updates with a scalable and non-proprietary solution. Reliable firmware is critical for accurate TSP and EVP requests.

When developing TSP systems, consider using traffic simulation models as a cost-effective means of comparing the impacts of different TSP strategies on transit and non-transit vehicle travel time (2012-L00615).

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