# IMPLEMENTATION OF PRE-SIGNALS FOR BUS PRIORITY

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Institut für Verkehrsplanung und Transportsysteme
Institute for Transport Planning and Systems

# Outline

- **Introduction**
- Background
- Types of pre-signals
- Operation of pre-signals
- Analytical and Empirical Evaluations
- Bounds of application
  - Pre-signals vs. mixed use lanes
  - Pre-signals vs. dedicated lanes
- Conclusions

# Motivation

- Dedicated bus lanes can be used to give priority to buses to eliminate harmful interactions with cars
  - In urban setting this is typically done by converting an existing regular (i.e., car) lane to bus use only
  - However this might not always be feasible (or be the best solution)
- Bus delays can still be reduced without taking a lane fully away from cars, especially when bus flows are low.
  - Dynamic bus lanes

# Research Question

- *How can public transportation be prioritized while reducing the negative effects on general traffic?*

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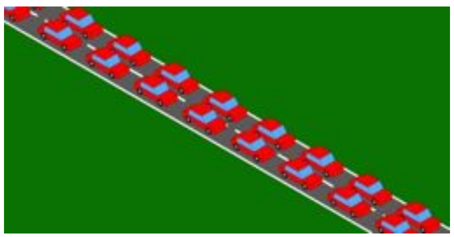
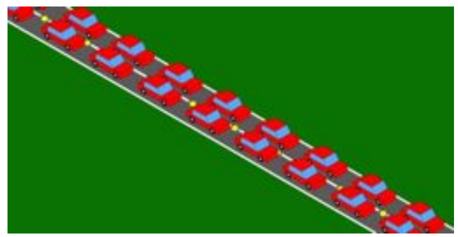
# Background

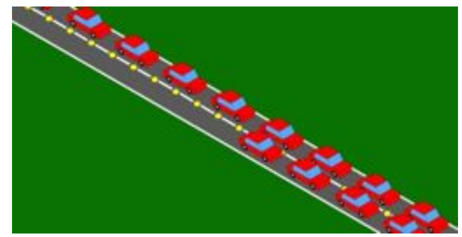
- Dynamic bus lane strategies targeted at roadways:
  - Intermittent bus lanes (IBL) (Viegas and Lu, 2001; 2004)
  - Bus lanes with intermittent priority (BLIP) (Eichler and Daganzo, 2008)



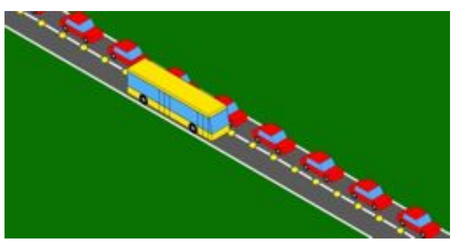
Normal operation



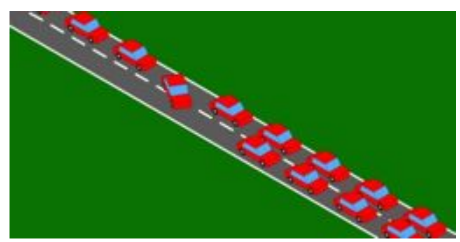
IBL activated



Car queue clears



Bus passes



IBL de-activated

Source: Viegas, Jose Manuel, et al. "The intermittent bus lane system: Demonstration in Lisbon." *Proceedings of the 86th Annual Meeting of the Transportation Research Board*. 2007.

# Background

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- Field tests:
  - Lisbon, Portugal → Increase bus speeds by 15-20 % (Viegas et al., 2007)
  - Melbourne, Australia → Increase in bus speeds not as significant as in Lisbon (Currie and Lai, 2008)

# Background

- Other types of bus lanes also exist.
  - e.g., bidirectional bus lanes
- Usedat a few locations in Switzerland:
  - Chamerstrasse, Zug

Source: Metron (2005): Beurteilung von Busbevorzugungsmassnahmen. Forschungsauftrag SSVI 2001/513, Brugg

# Goal

- Investigating the use of additional signals to provide priority to buses at signalized intersections.
  - i.e, pre-signals close to the main signal to allow buses to jump the car queues.
- Cars can still use all lanes at the main intersection to fully utilize the capacity of the signal when buses are not present

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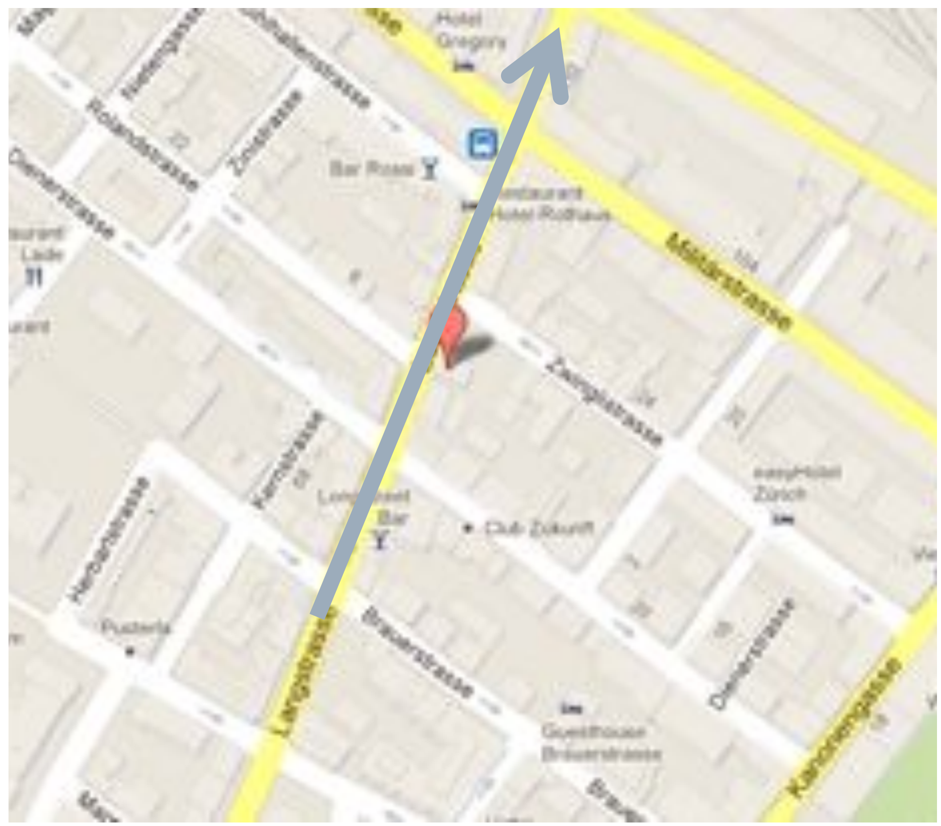
- Two implementations of such strategies found in Switzerland

  1) Langstrasse, Zurich - pre-signal which intermittently changes the *allocation* of one lane.



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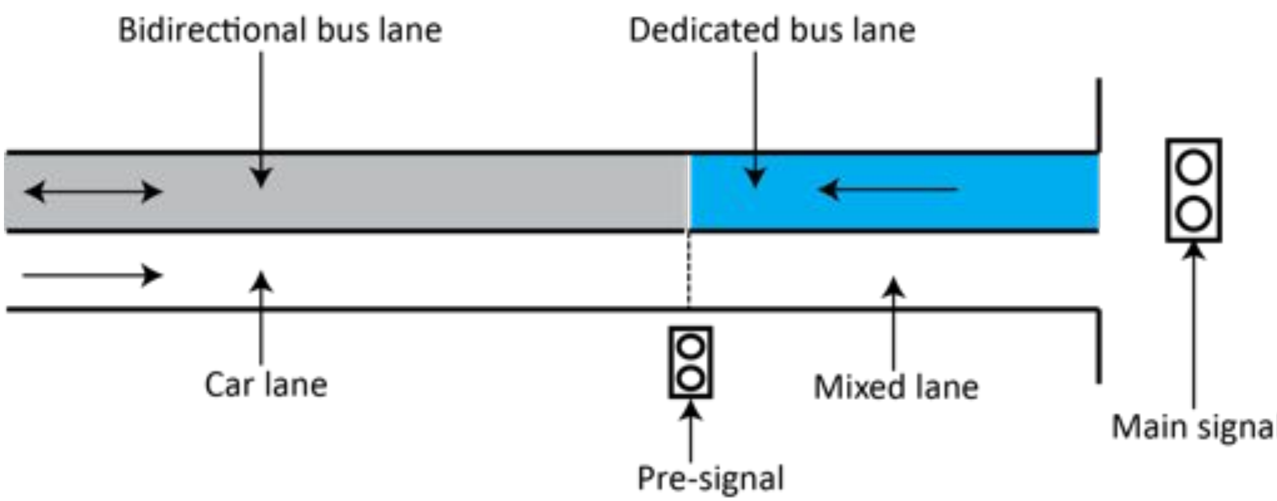

# Operation of pre-signal

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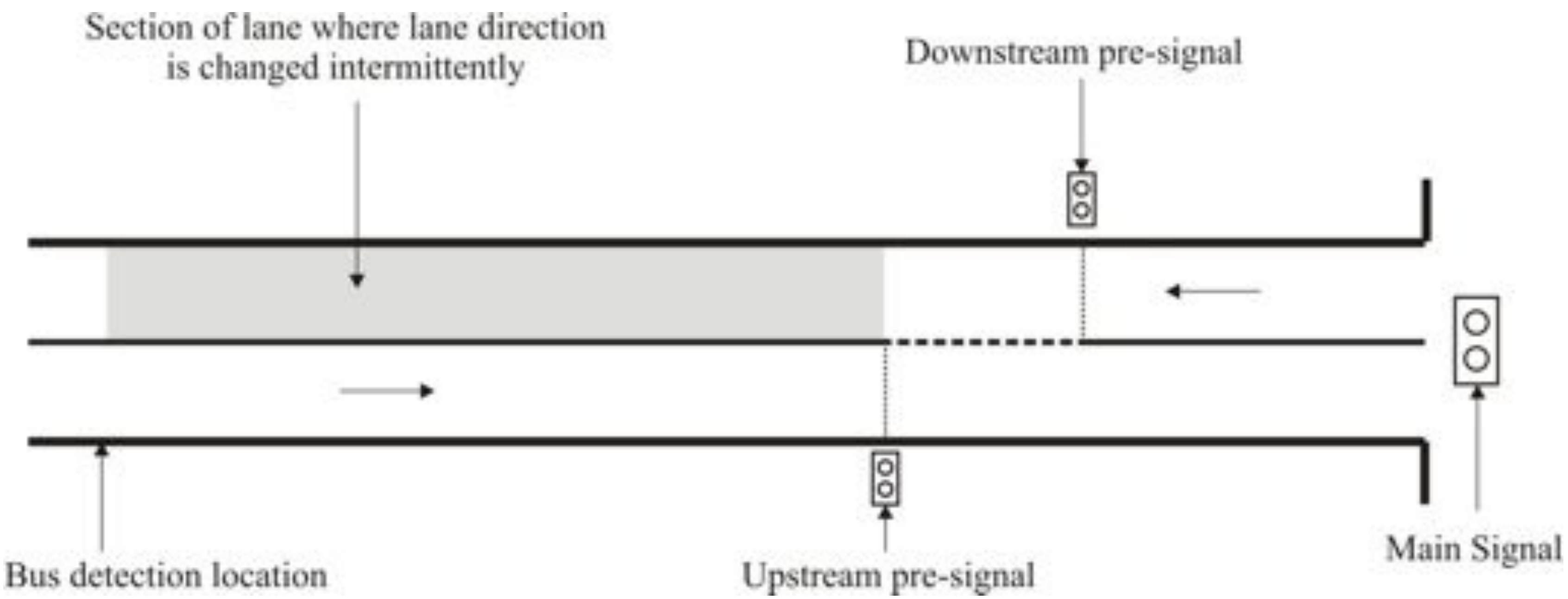

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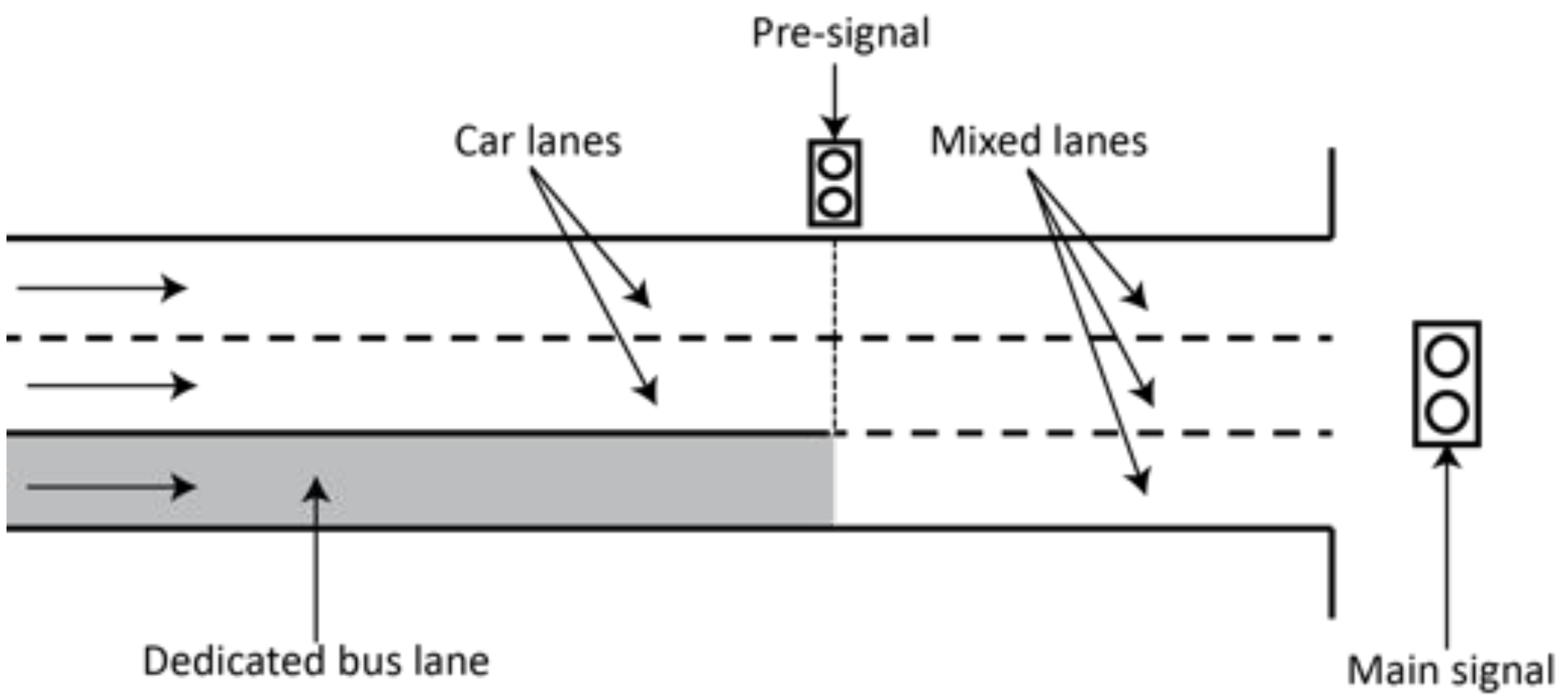
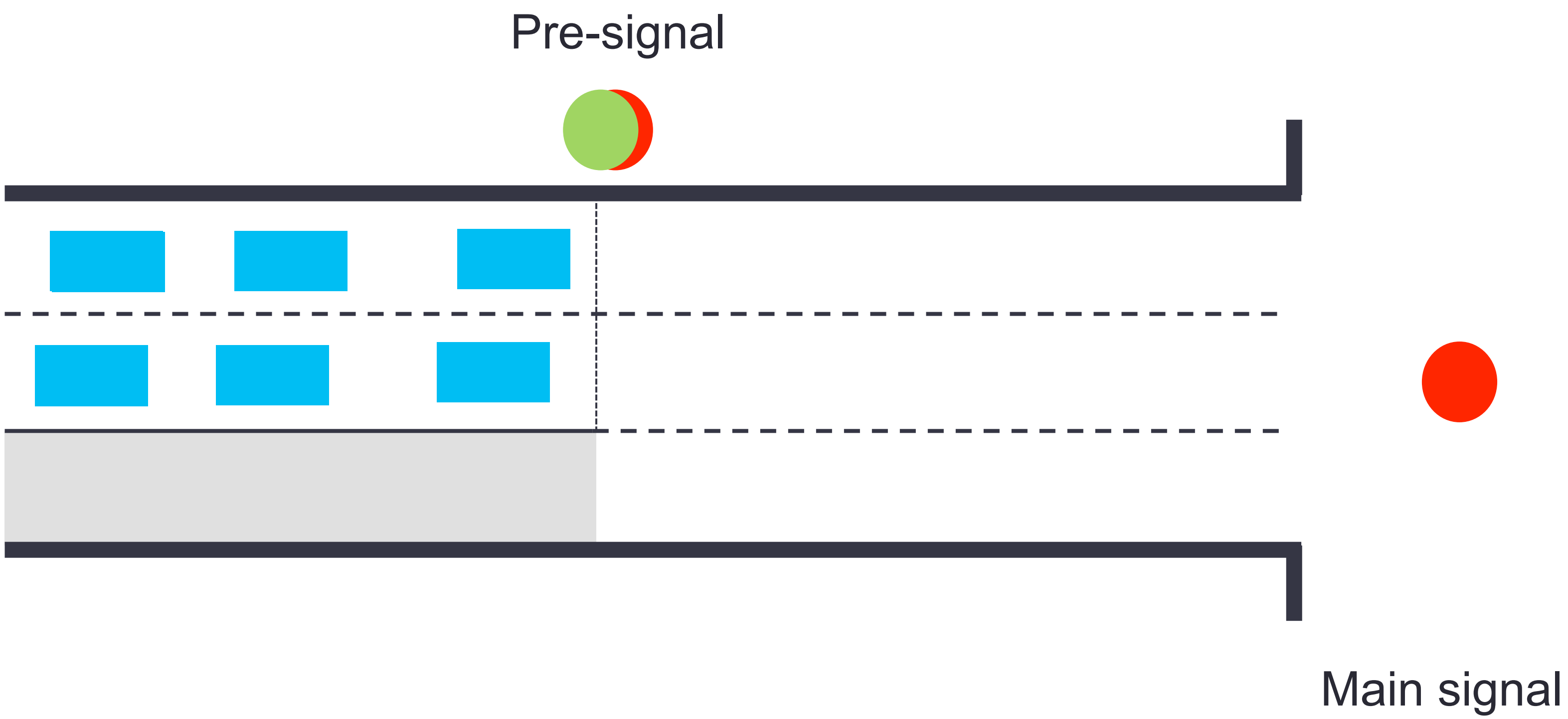
# Pre-signal

Example configuration for a mains signal with a pre-signal



# Operation of a pre-signal

**When no bus is present:**



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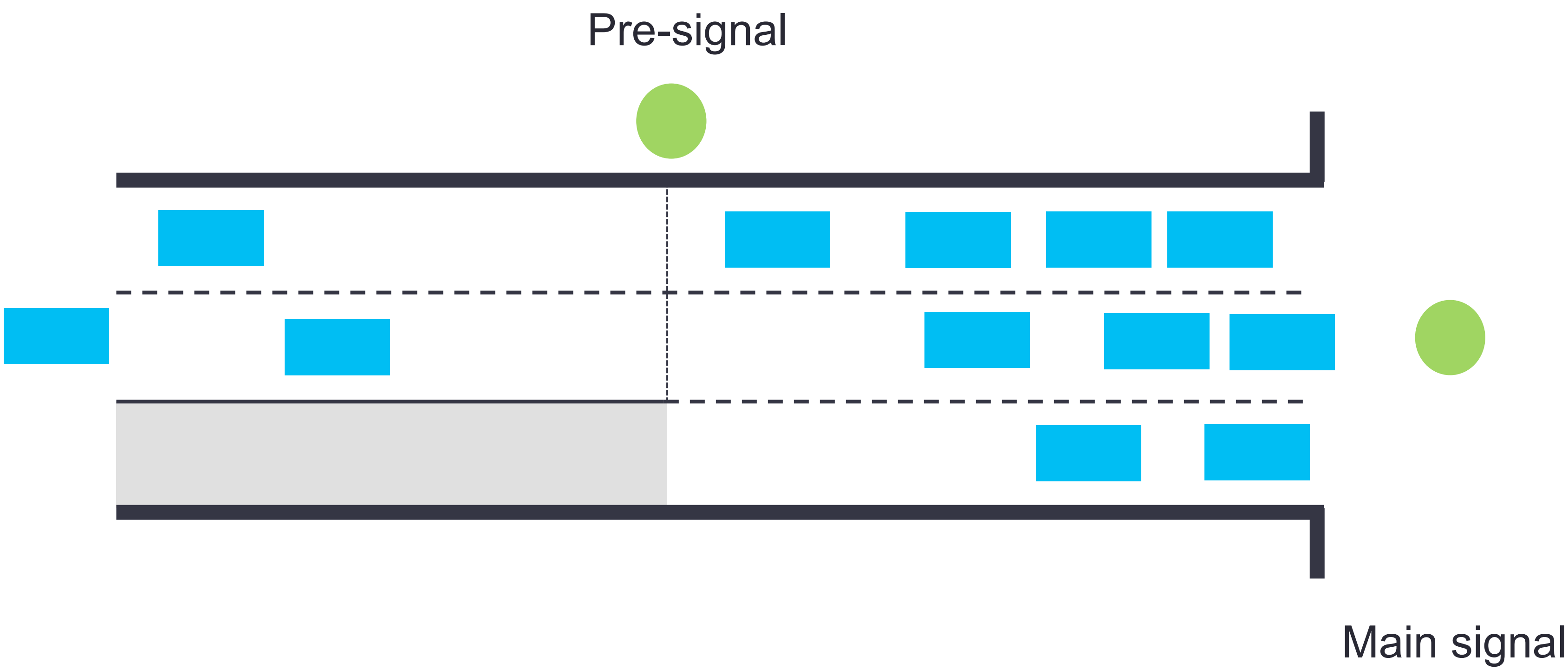

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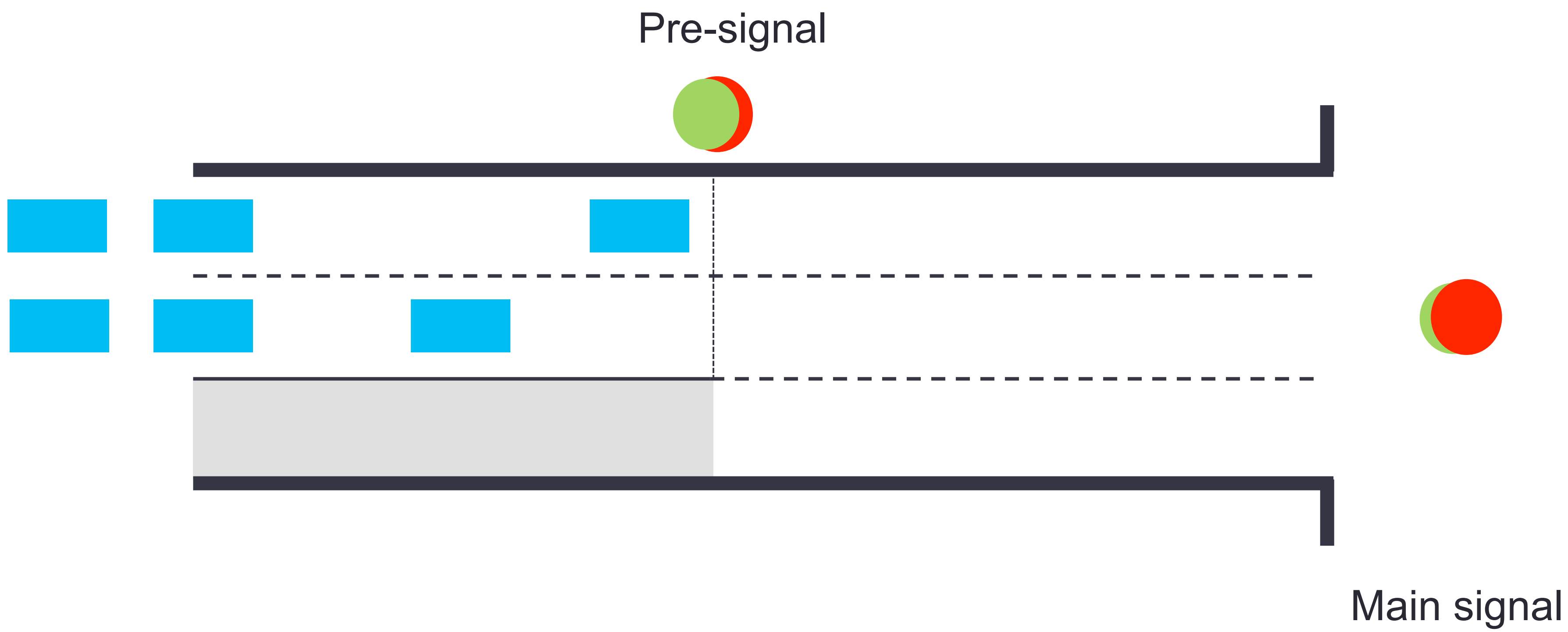

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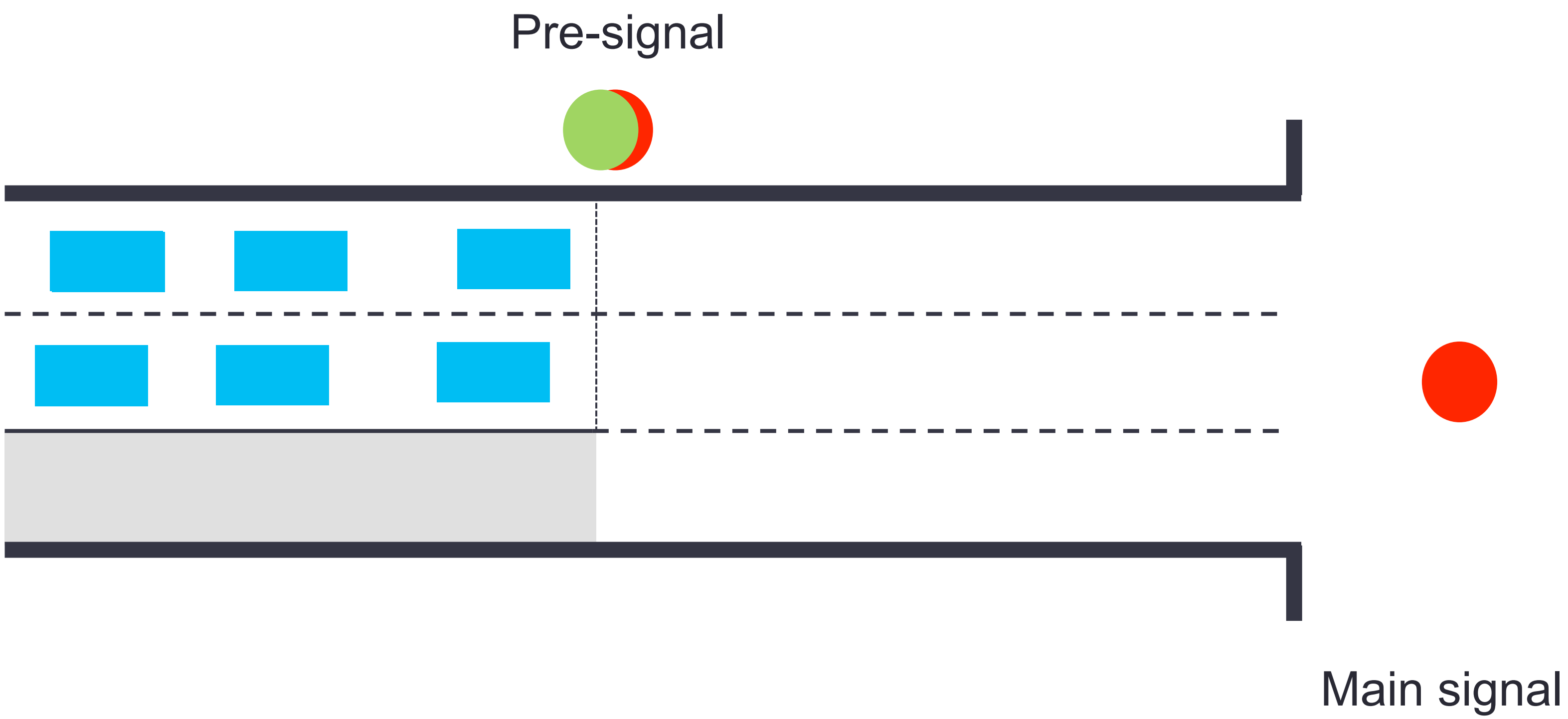

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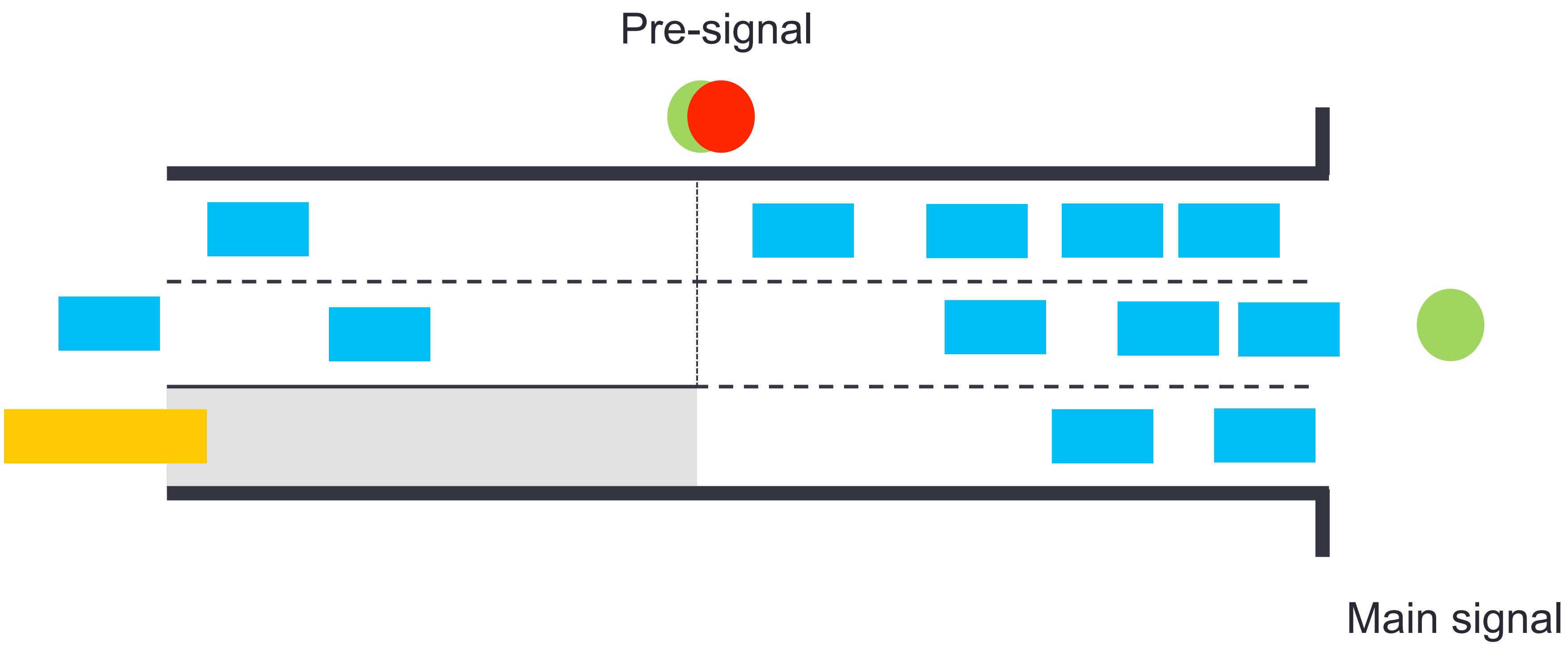

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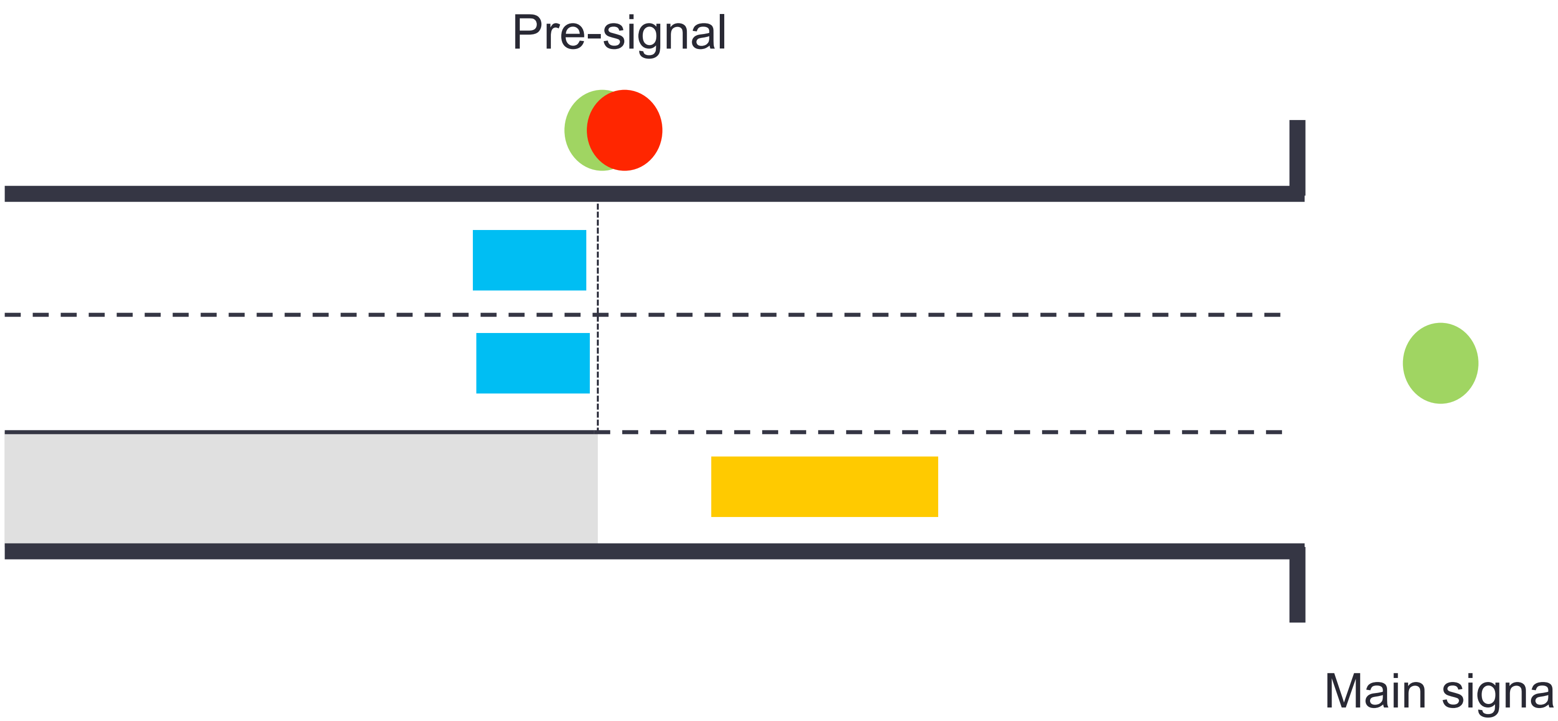

# Two parameters for implementation

Distance of the pre-signal from the main signal

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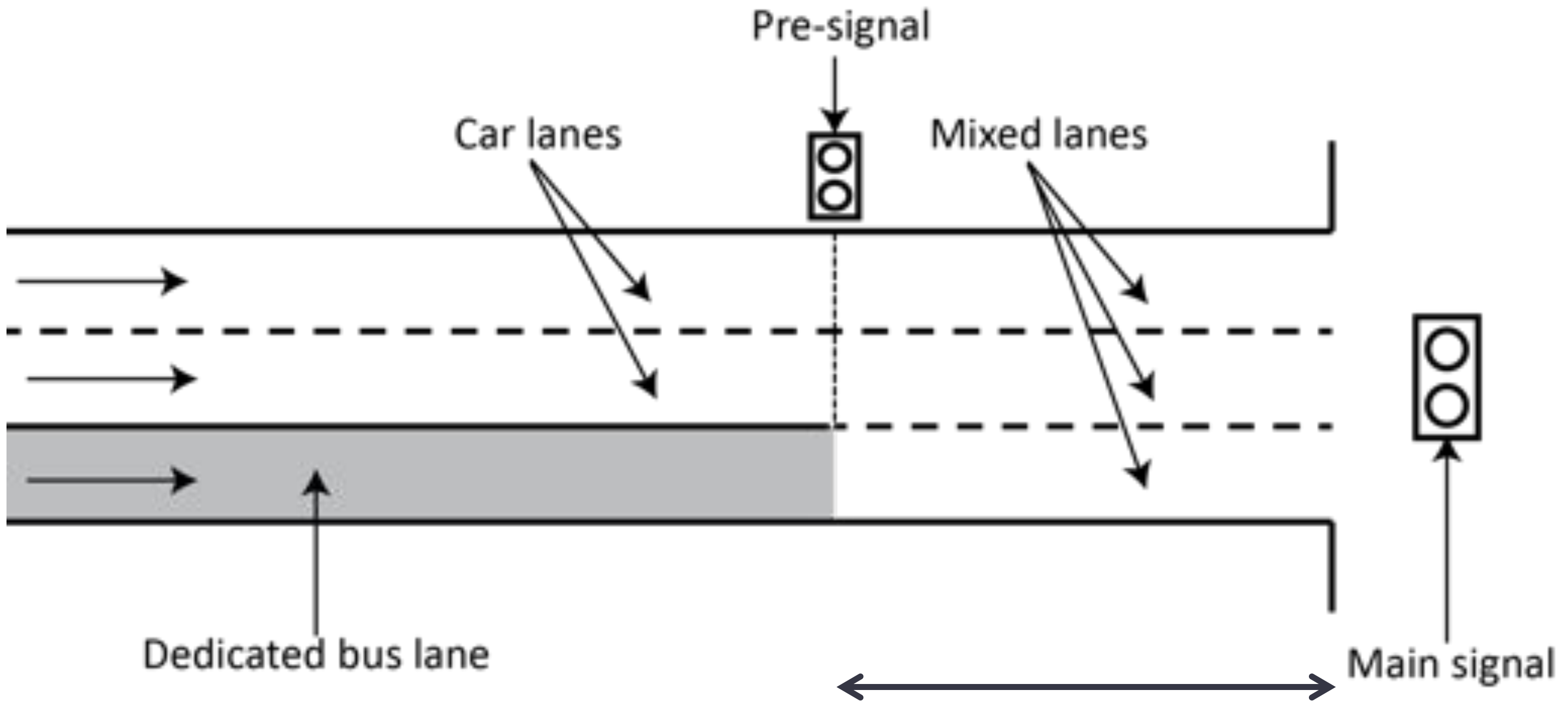


Such that the main signal capacity can be fully utilized

$d = Main\ signal\ capacity/jam\ density$

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Duration of the red time at the pre-signal:

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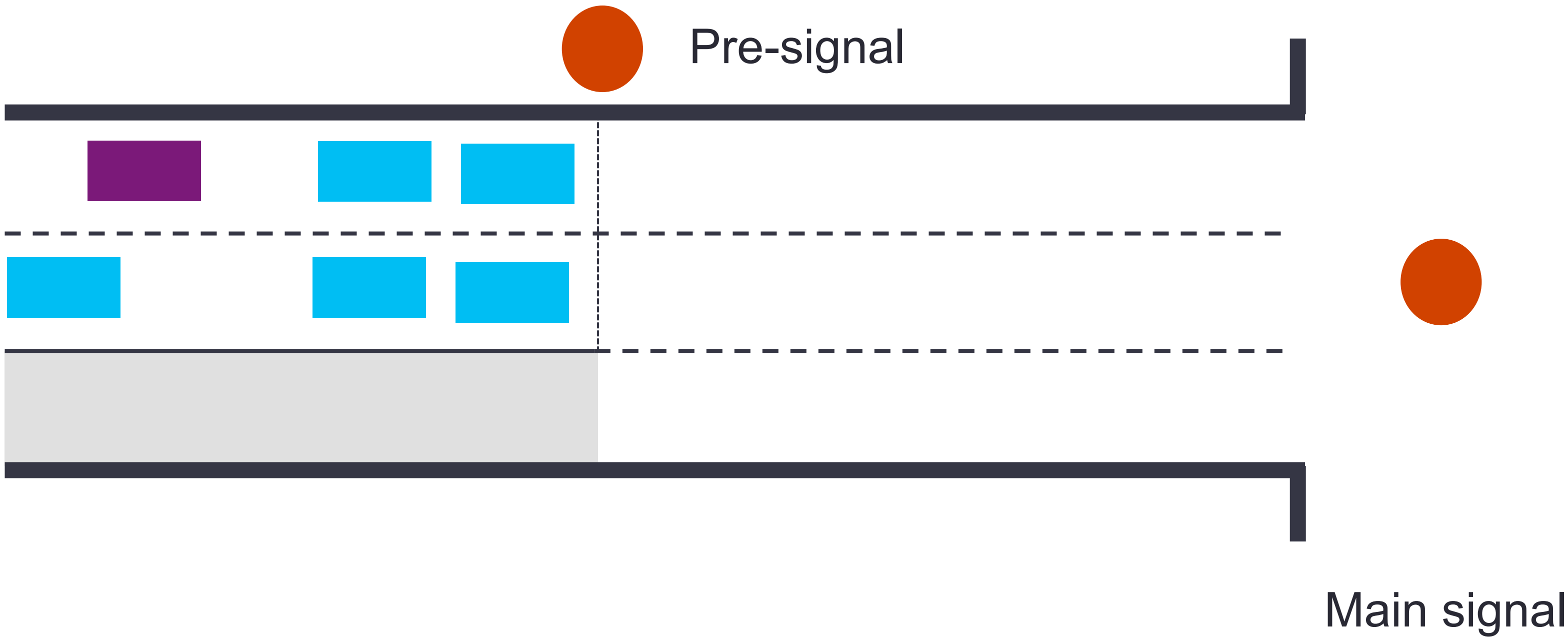
Such that the last queued car at the pre-signal will also be the last queued car at the main signal



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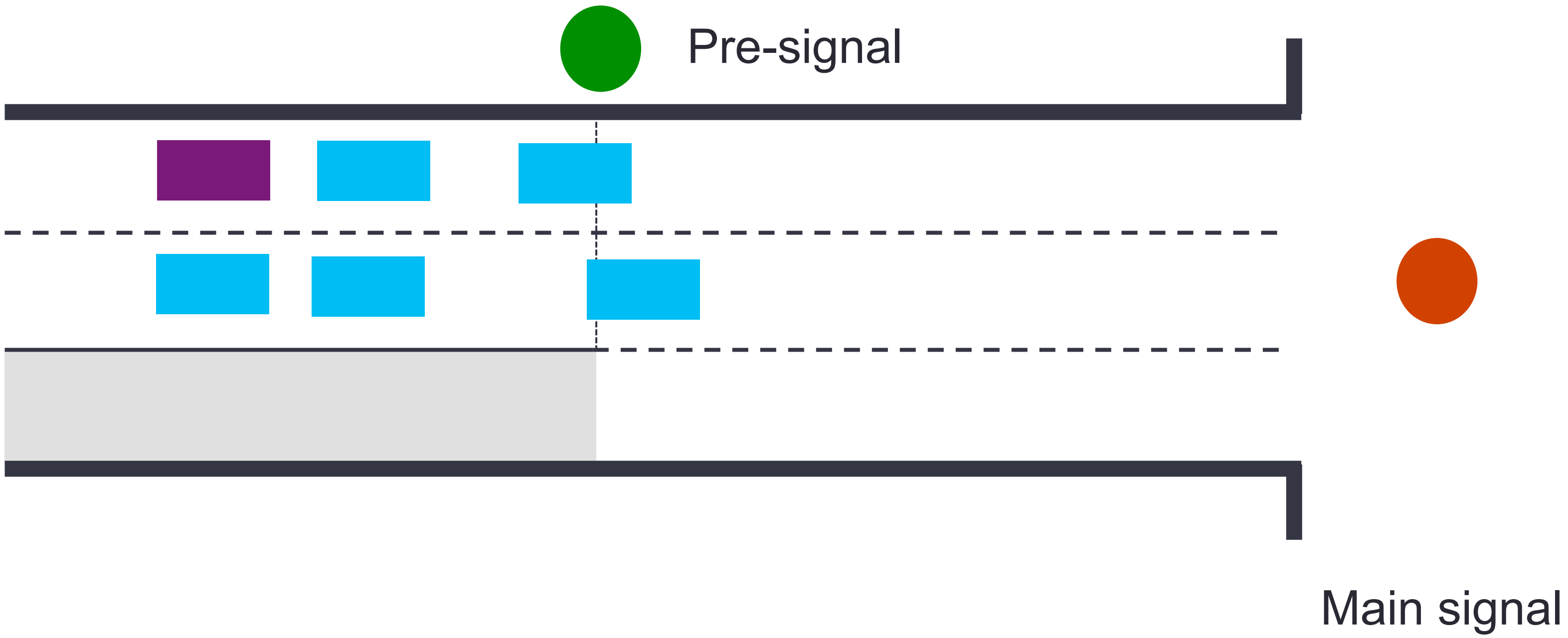

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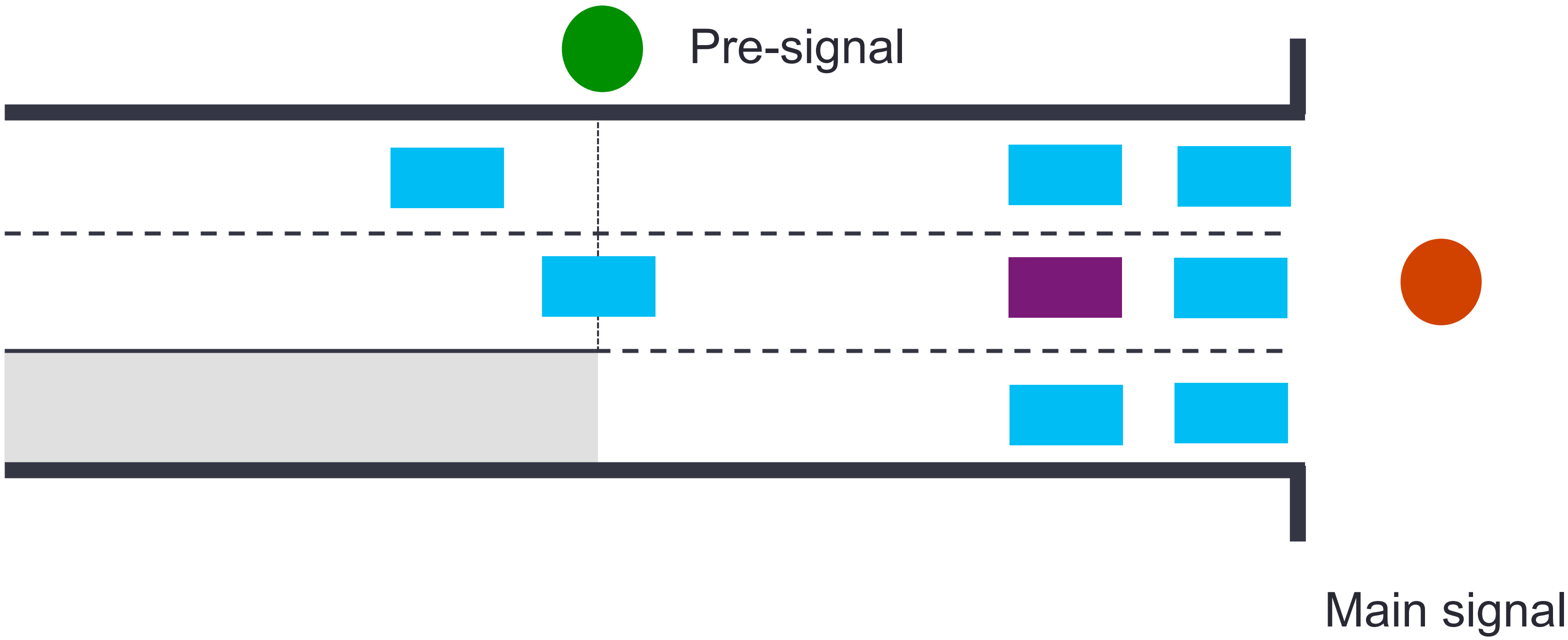

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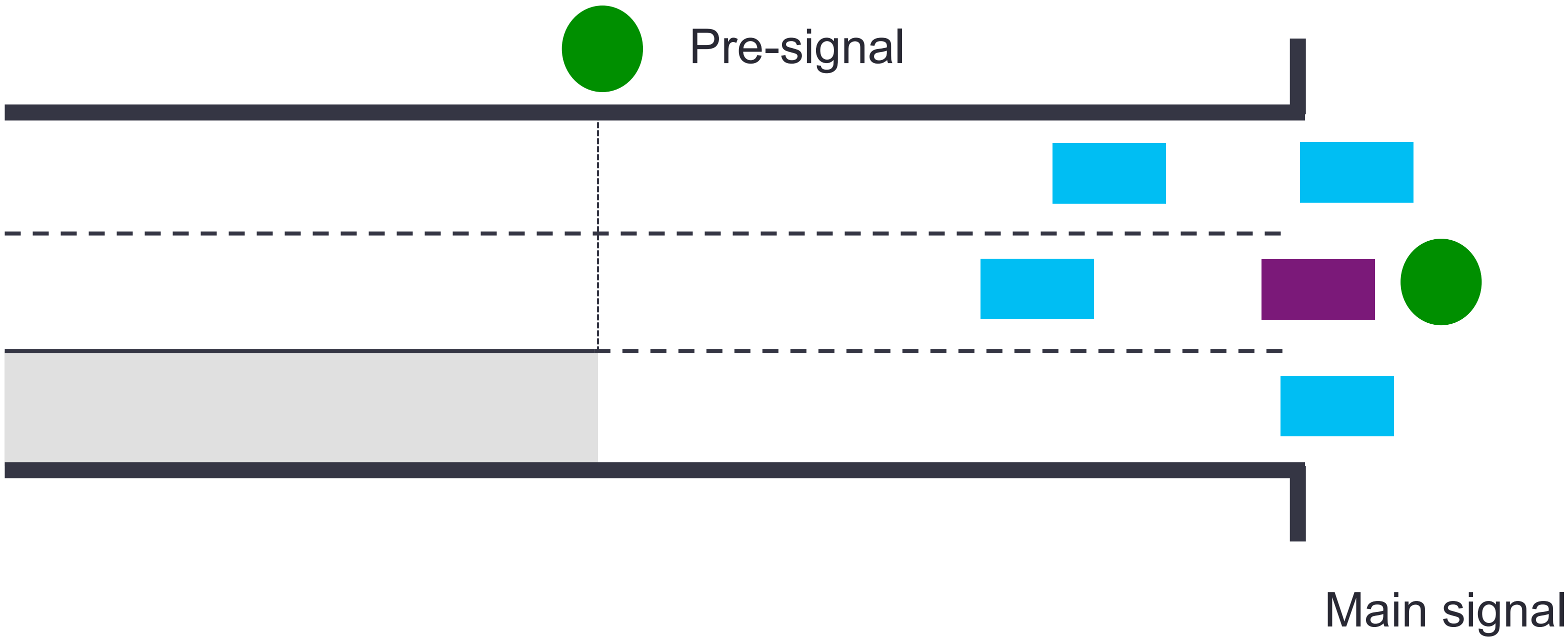

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*Red time at pre-signal* is then a function of:

- *Saturation flow at pre-signal*
- *Saturation flow at main signal*
- *Red time at main signal*
- *Demand rate*

Can be:

- Pre-determined
- Dynamically measured

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# Evaluation of pre-signals

- The theoretical car and bus delays incurred at an intersection with a pre-signal are theoretically determined with the use of:
  - Queuing theory
  - Kinematic wave theory
- A total of 11 different queuing patterns based on different bus arrival times are determined to model the car queues
- The theoretical model is then compared to data collected at Langstrasse, Zurich

# Comparison of theoretical model to empirical data

## Empirical Results

| | | Average Car Delay per Cycle (sec/veh) | | | Average bus delay (sec/bus) |
|---|---|---|---|---|---|
| | Number of cycles | Upstream of pre-signal | Between pre-signal and main signal | Total | |
| Bus not present | 57 | 20.3 | 6.0 | 26.3 | - |
| Bus present | 11 | 20.7 | 7.8 | 28.5 | 10.8 |

## Analytical Predictions

| | Average Car Delay per Cycle (sec/veh) | | | | Average bus delay (sec/bus) |
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| | Upstream of pre-signal | Between pre-signal and main signal | Stochastic (Webster's) Delay | Total | |
| Bus not present | 14.5 | 3.4 | 8.0 | 25.9 | - |
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**% of delay encountered upstream of the pre-signal:**

**77%**

**81%**

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**Error: -1.5 %**

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**Error: ~ 0%**

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**Error: 16%**

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- Compare the **total person hours of delays of the system (buses and cars)** :
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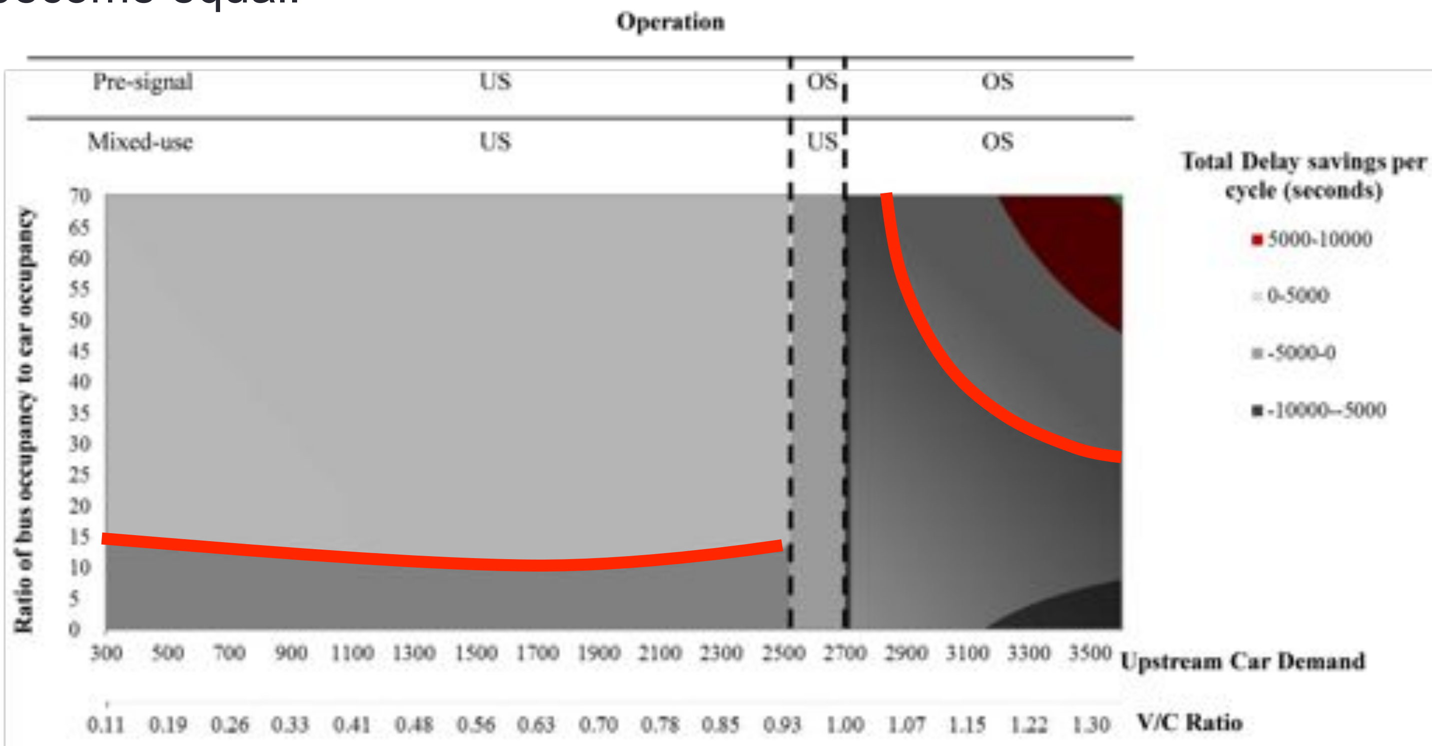


Headway = Cycle Length = 1.5 minutes, Total number of lanes = 3

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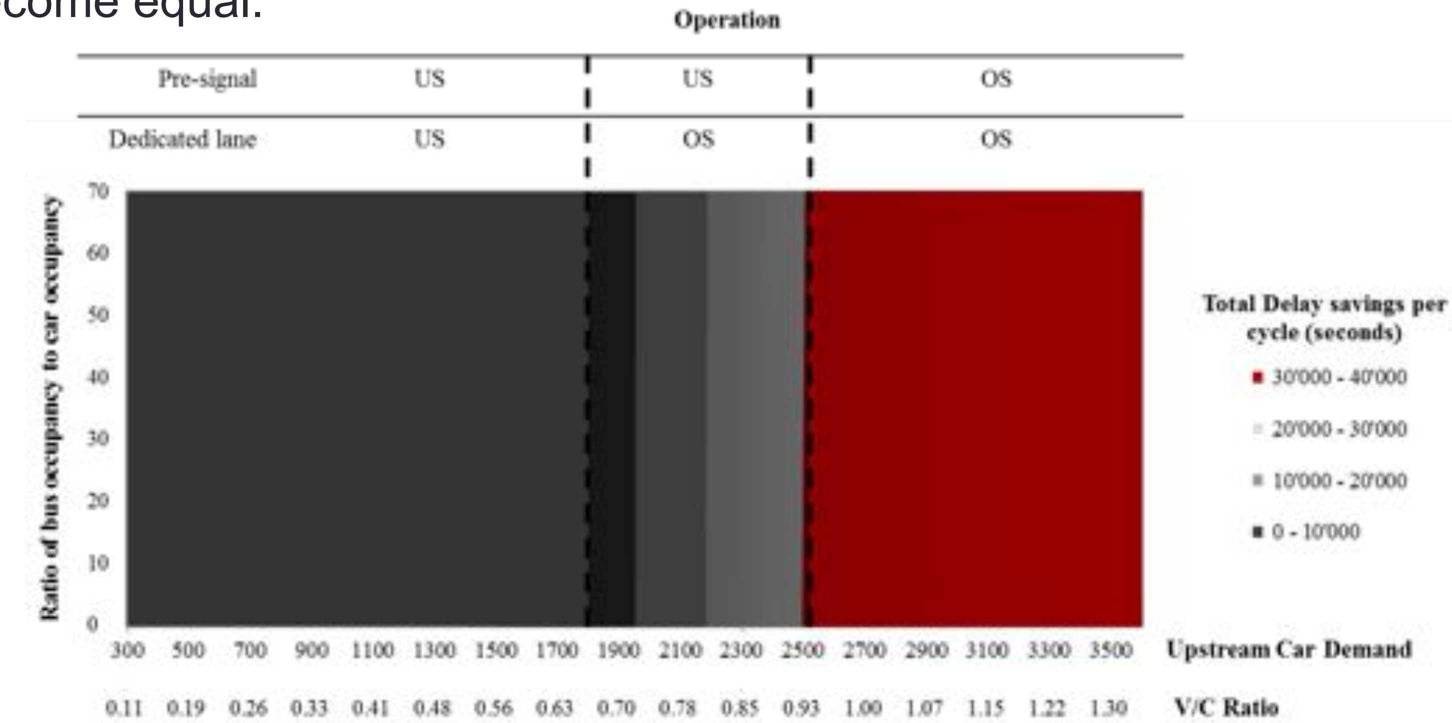


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# Conclusions

- Pre-signals can provide lowest overall system-wide person hours of delay for a wide range of bus occupancies
  - Even if not so, can improve bus operations not only in terms of travel times but also for reliability
- Barely over saturated situations are problematic for pre-signals
- The number of implementations of these strategies can be widely extended to provide bus priority

*Thank You*

*Questions?*