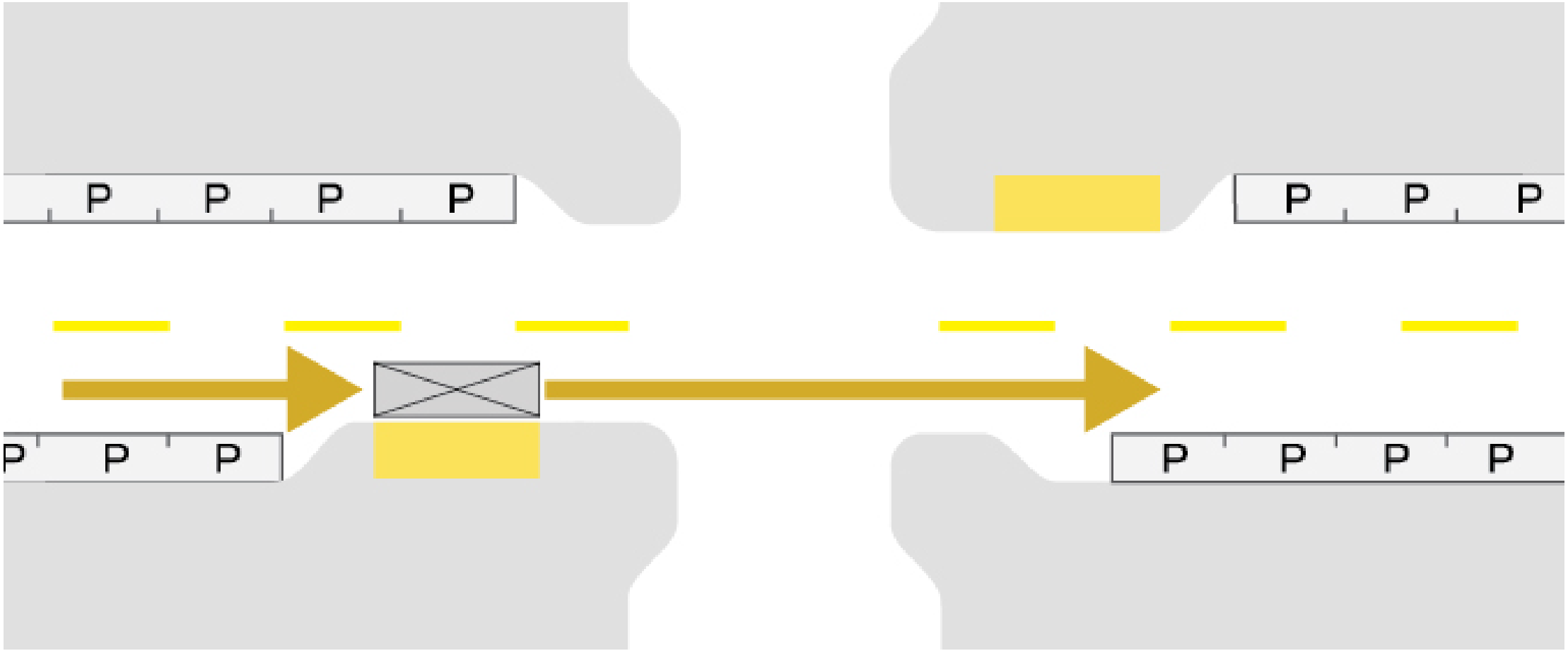
Operating Signals for Transit

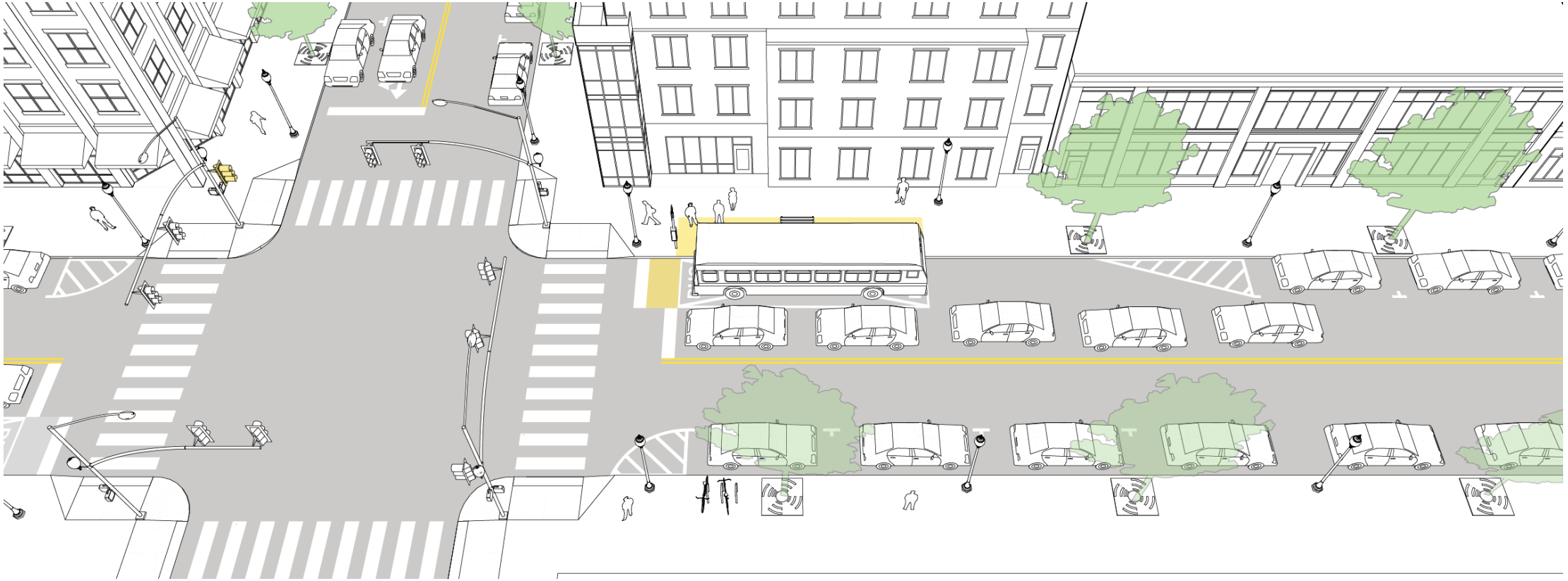
Signal Design Toolbox

Key Terms

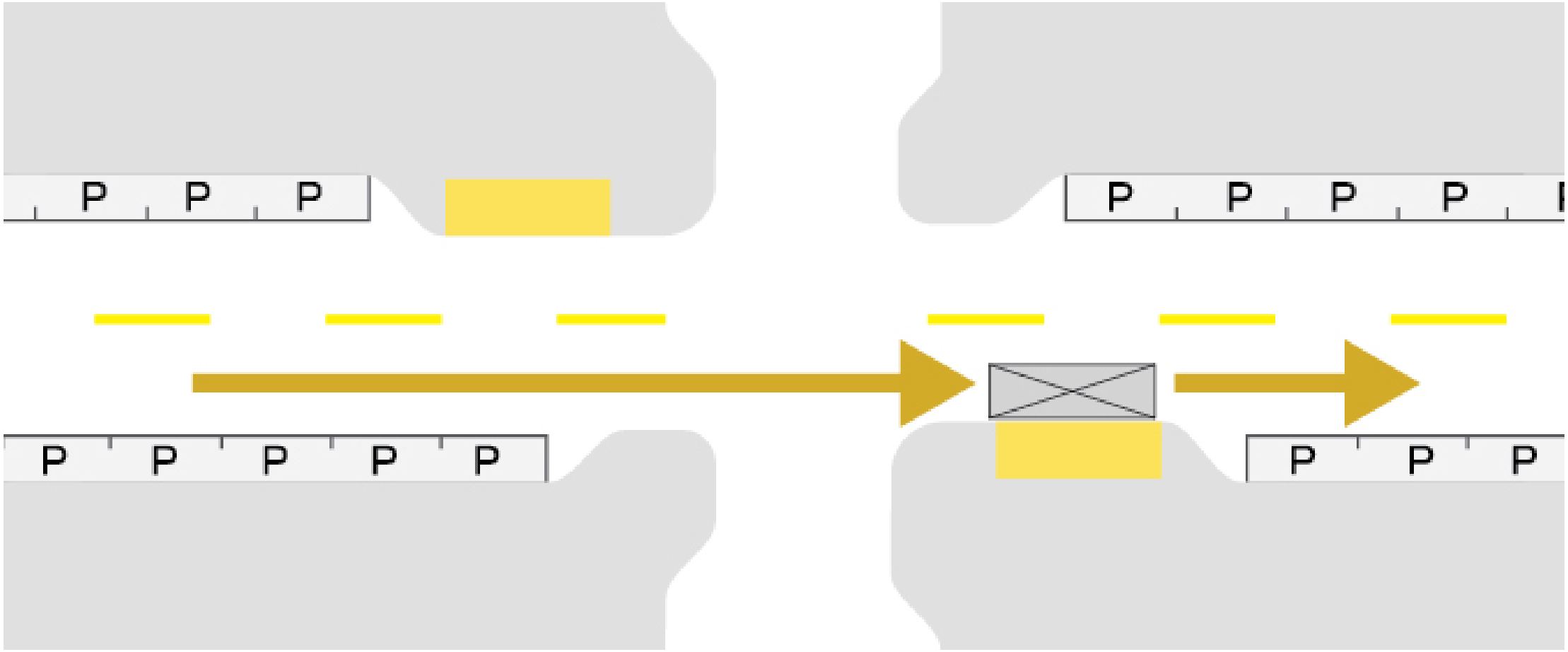
Stop Location – Near Side



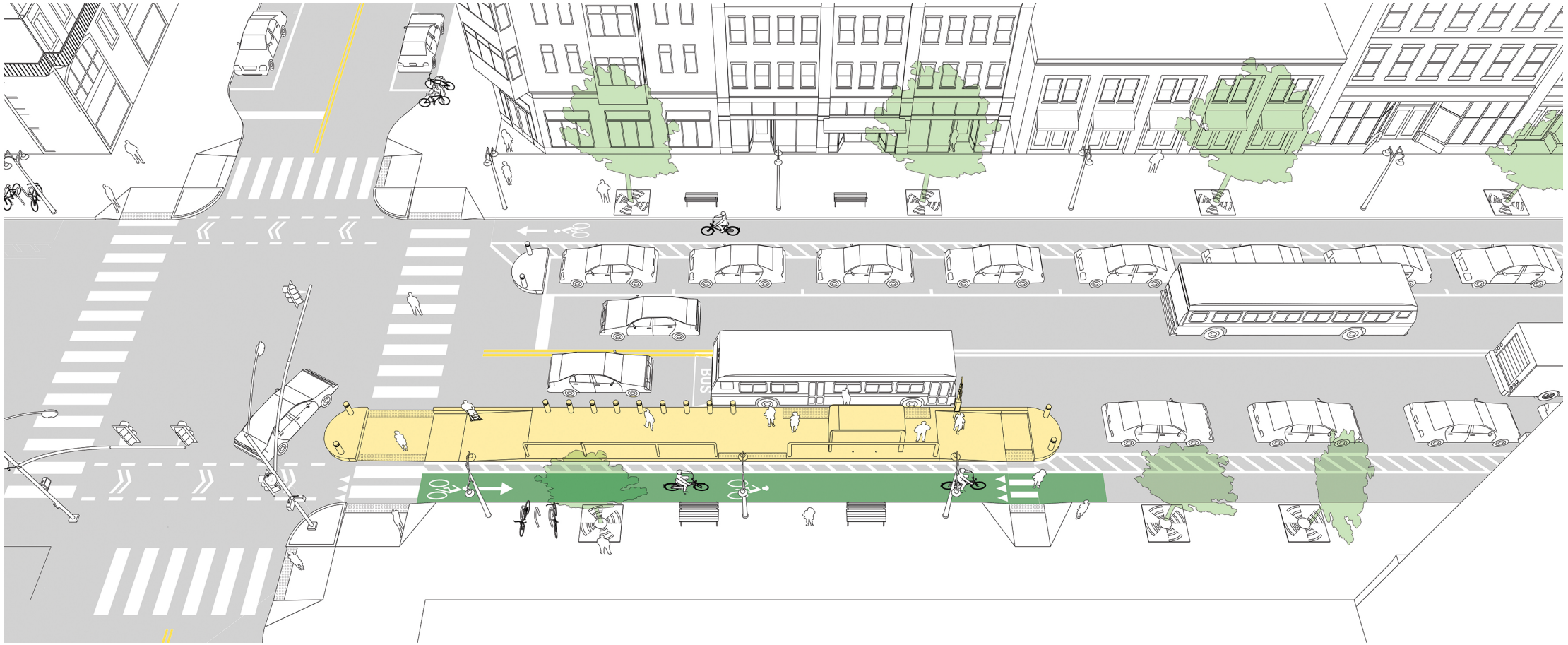
Near-Side, Pull-Out Stop



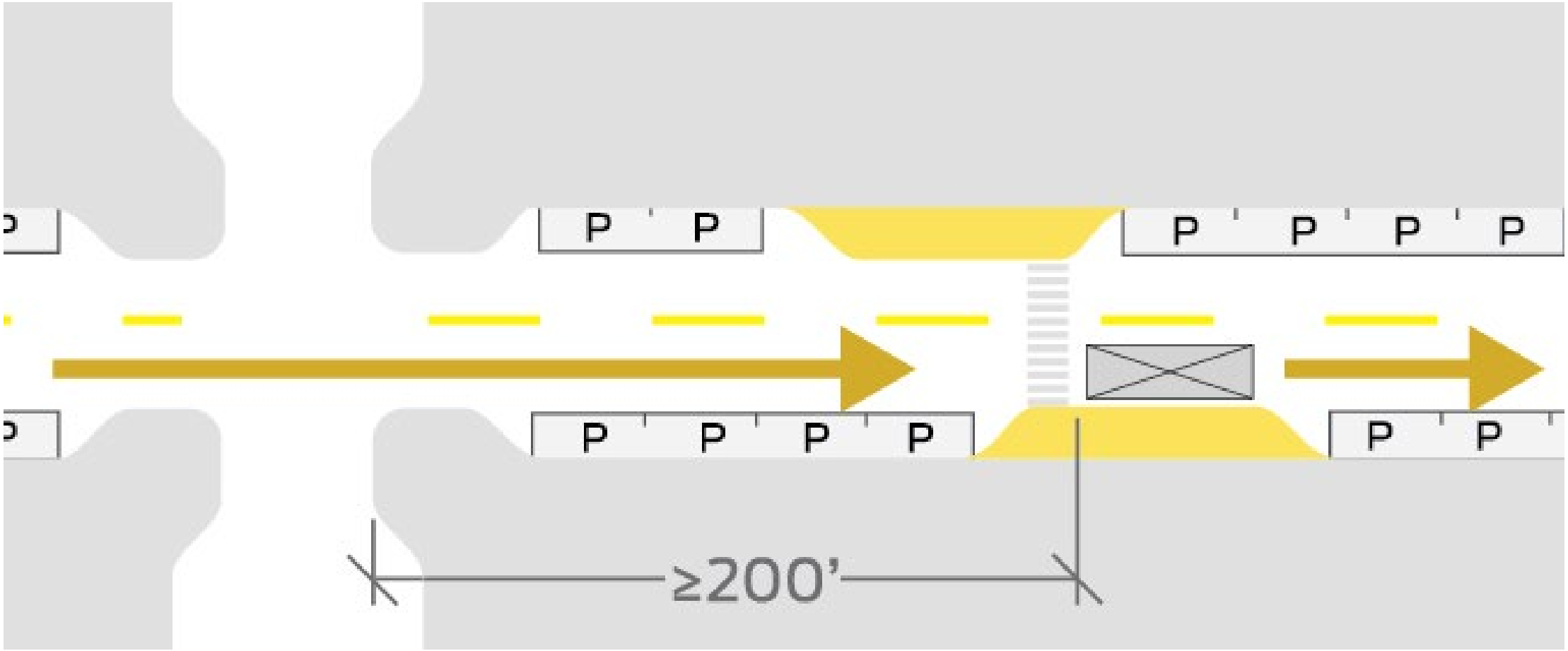
Stop Location – Far Side



Far-Side, In-Lane Stop



Stop Location – Mid-Block

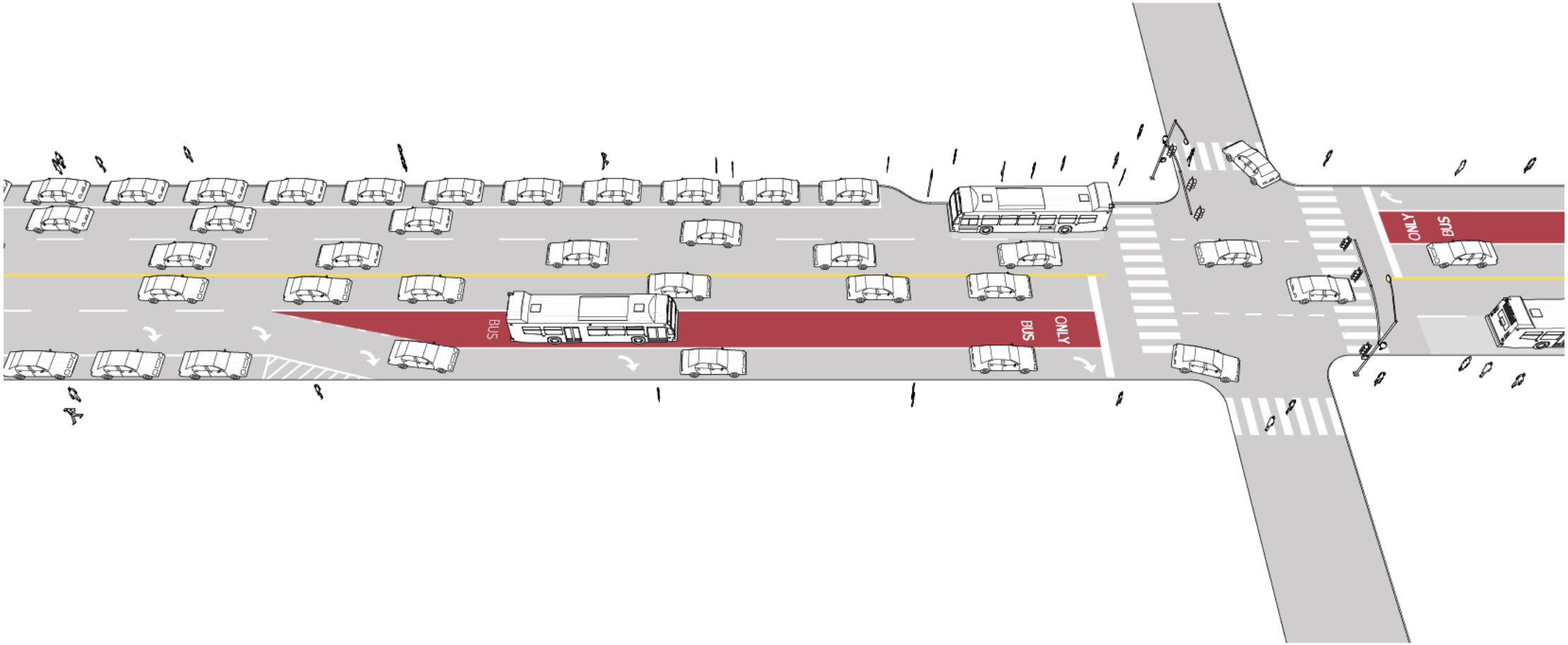


Transit Lane

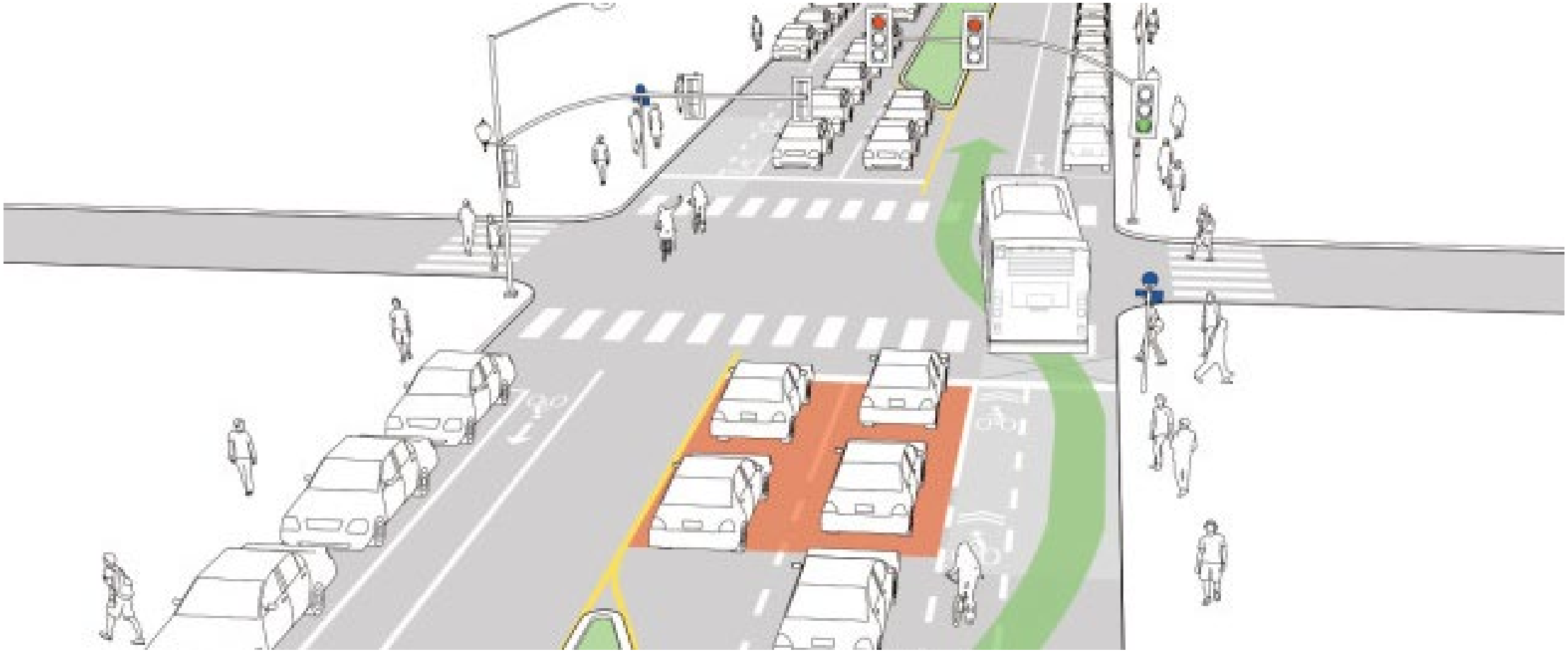
Transitway

SIGNAL
BUS
E HOWELL AVE
SIGNAL
AUTHORIZED VEHICLES ONLY
AUTHORIZED VEHICLES ONLY
SIGNAL
metroway
BETTY MALLON

Transit Approach Lane / Queue Bypass



Queue Jump



Transit Signals

Louvered signal

Transit Signal Head

Active Transit Signal Priority

Toolbox

NACTO

Using Signals to Give Transit Priority

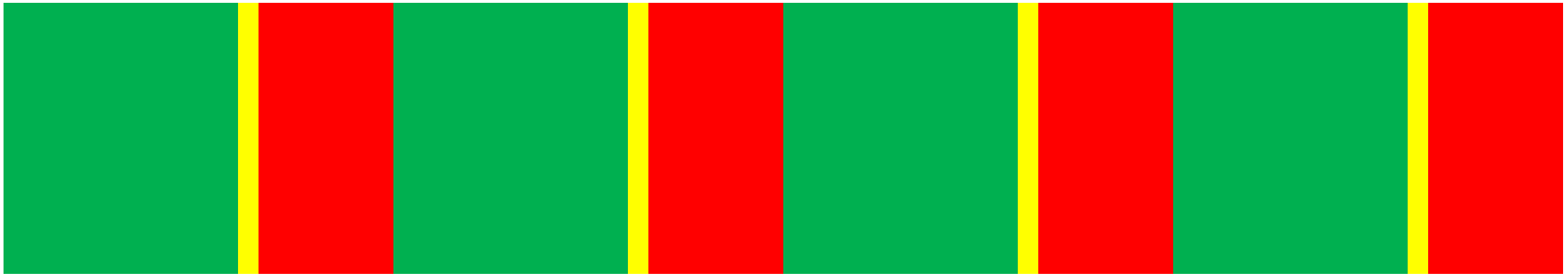
- Use TSP to support project goals
- Combine TSP with geometric treatments
- Avoid penalizing pedestrians
- Consider predictability for all users

When do I give active priority?

(Rules of thumb!)

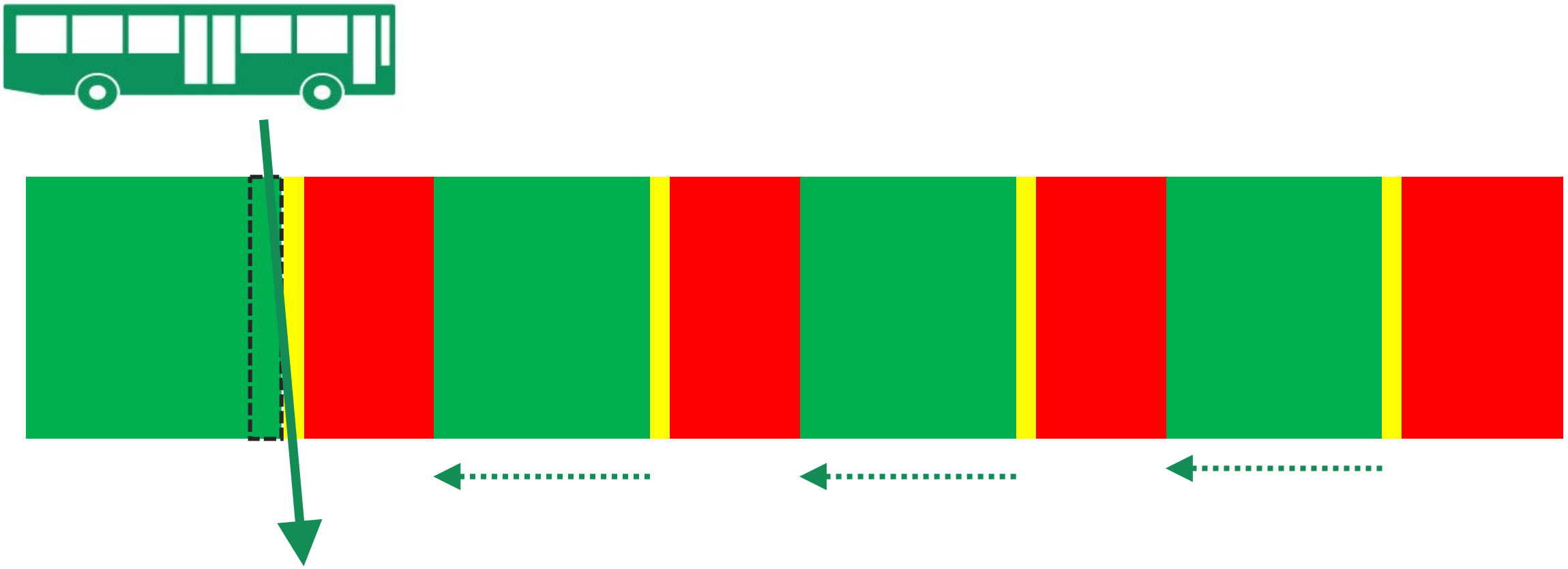
- Buses per hour: (*typically fewer than 15 per hour)*
- v/c ratio? *(0.5 – 0.7, may work up to 0.9)*
- Behind the schedule, or always? *(policy decision)*

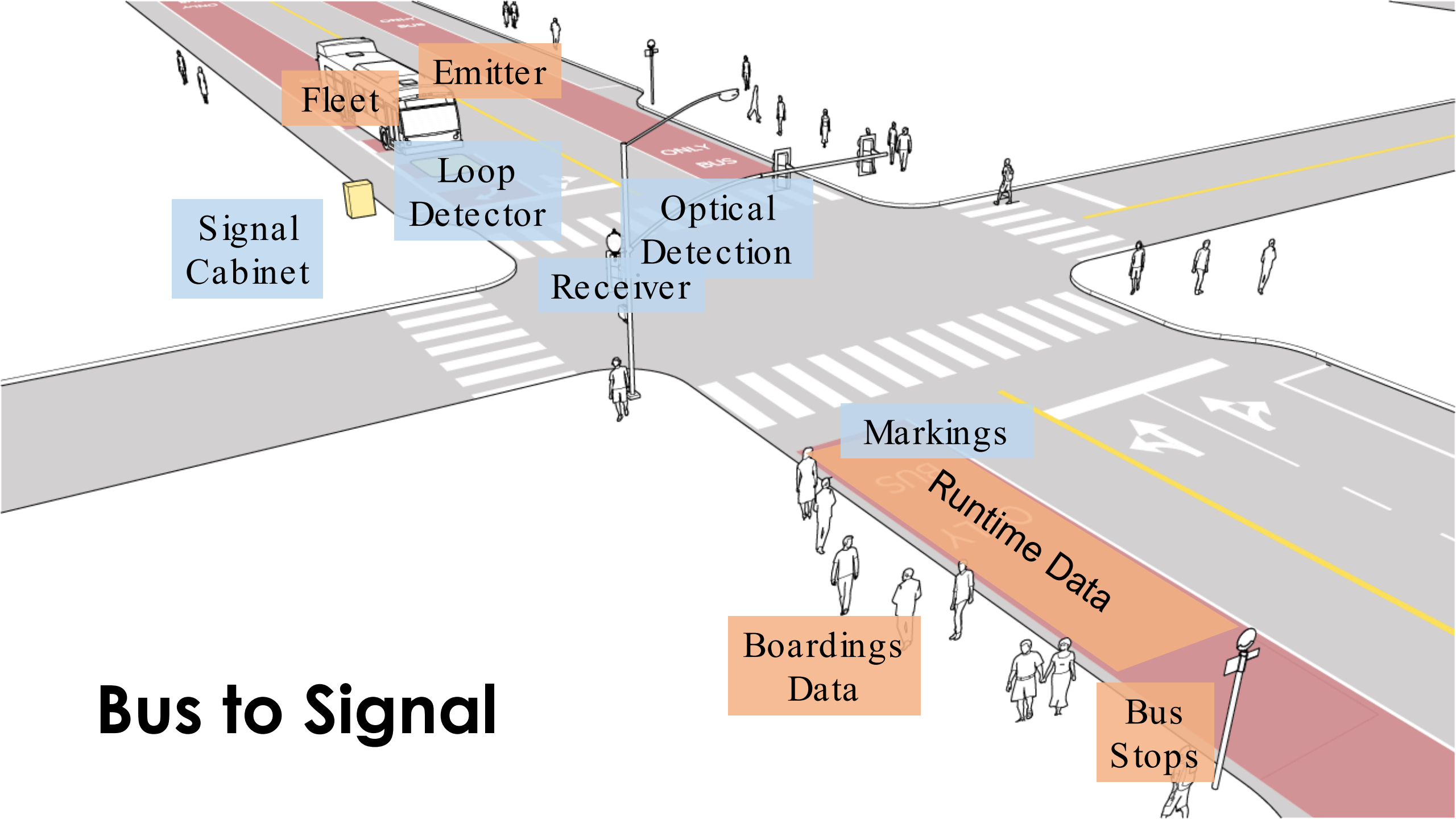
Typical Active TSP



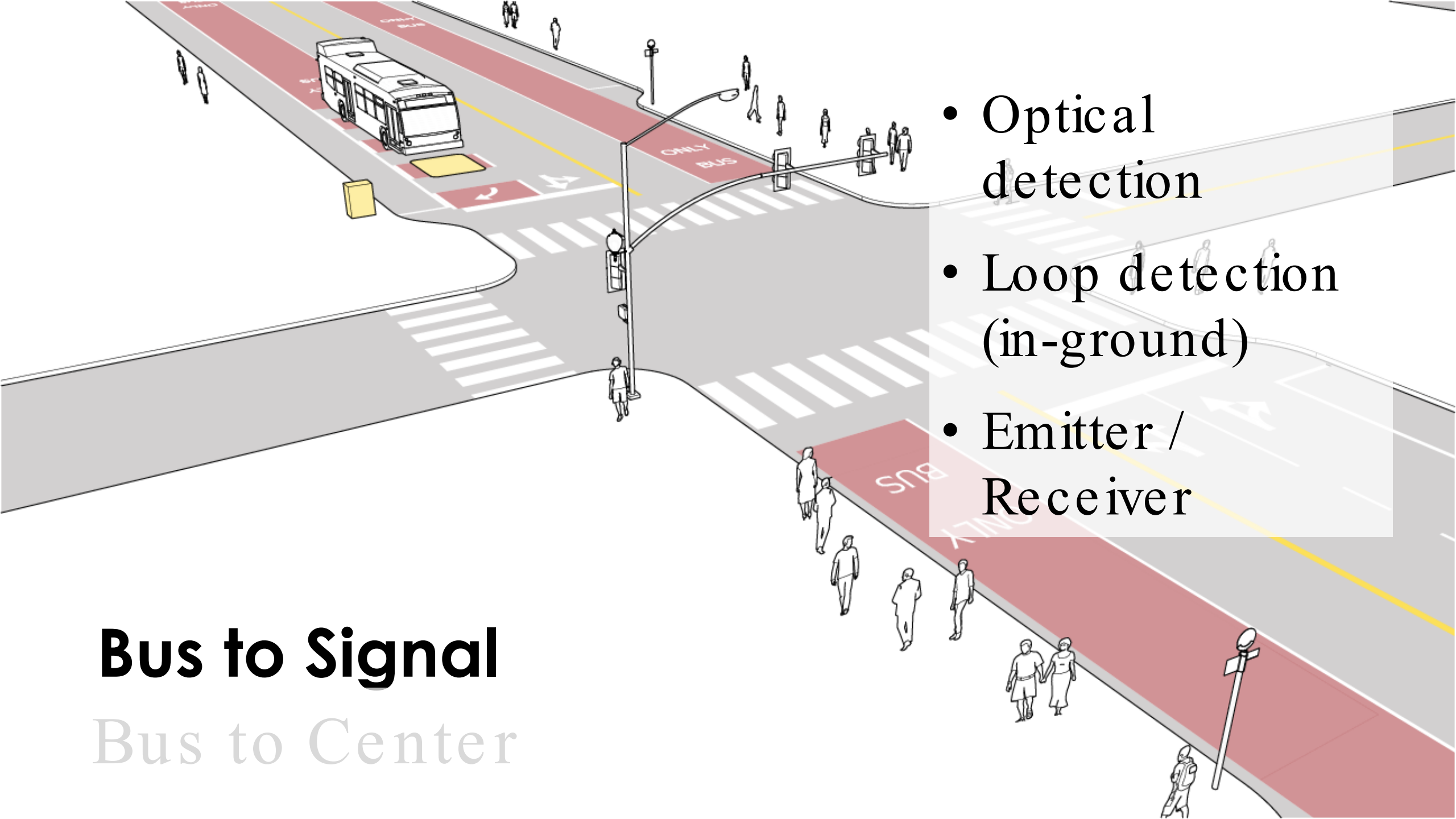
Typical Active TSP

Typical Active TSP





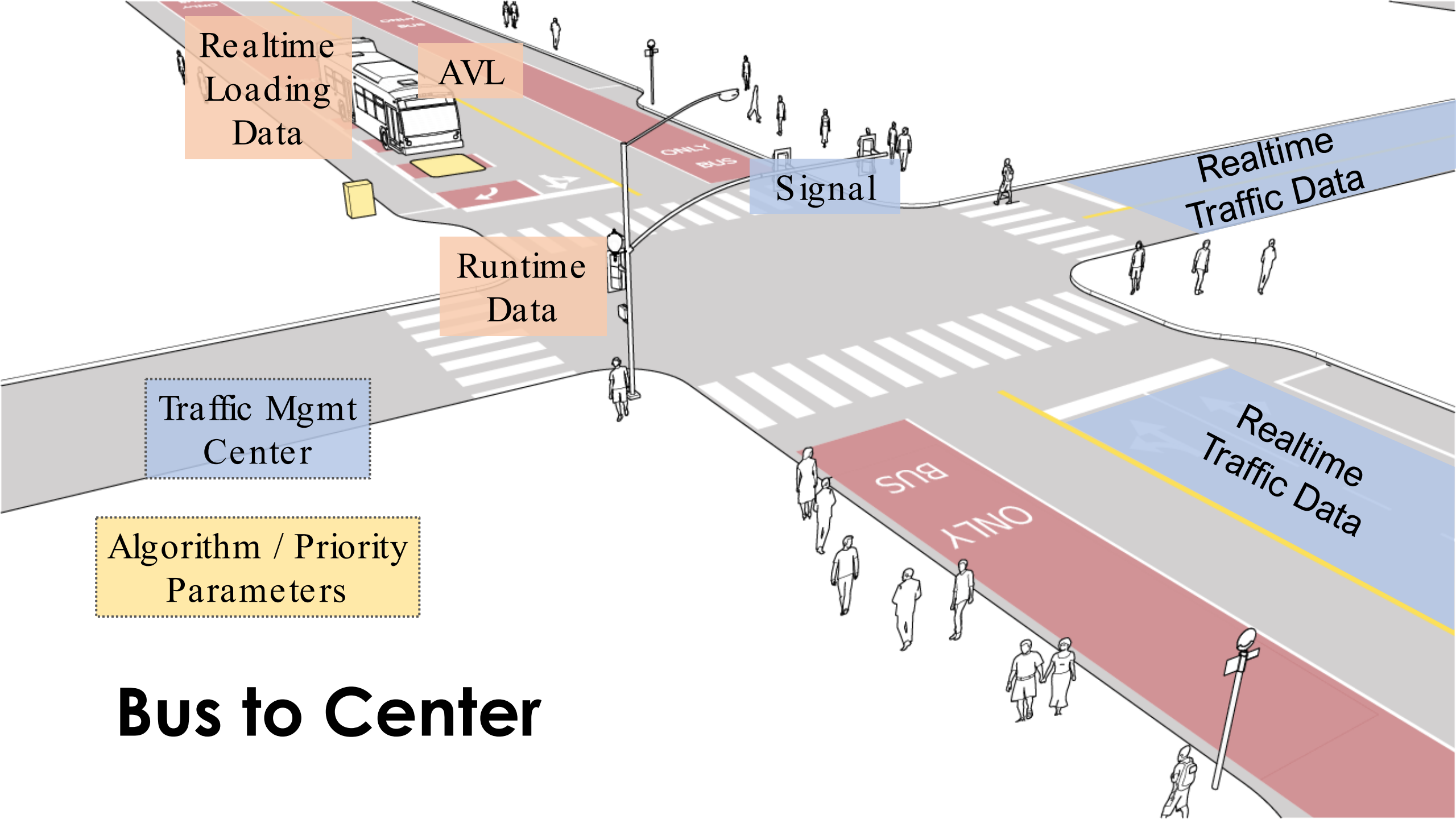
Bus to Signal



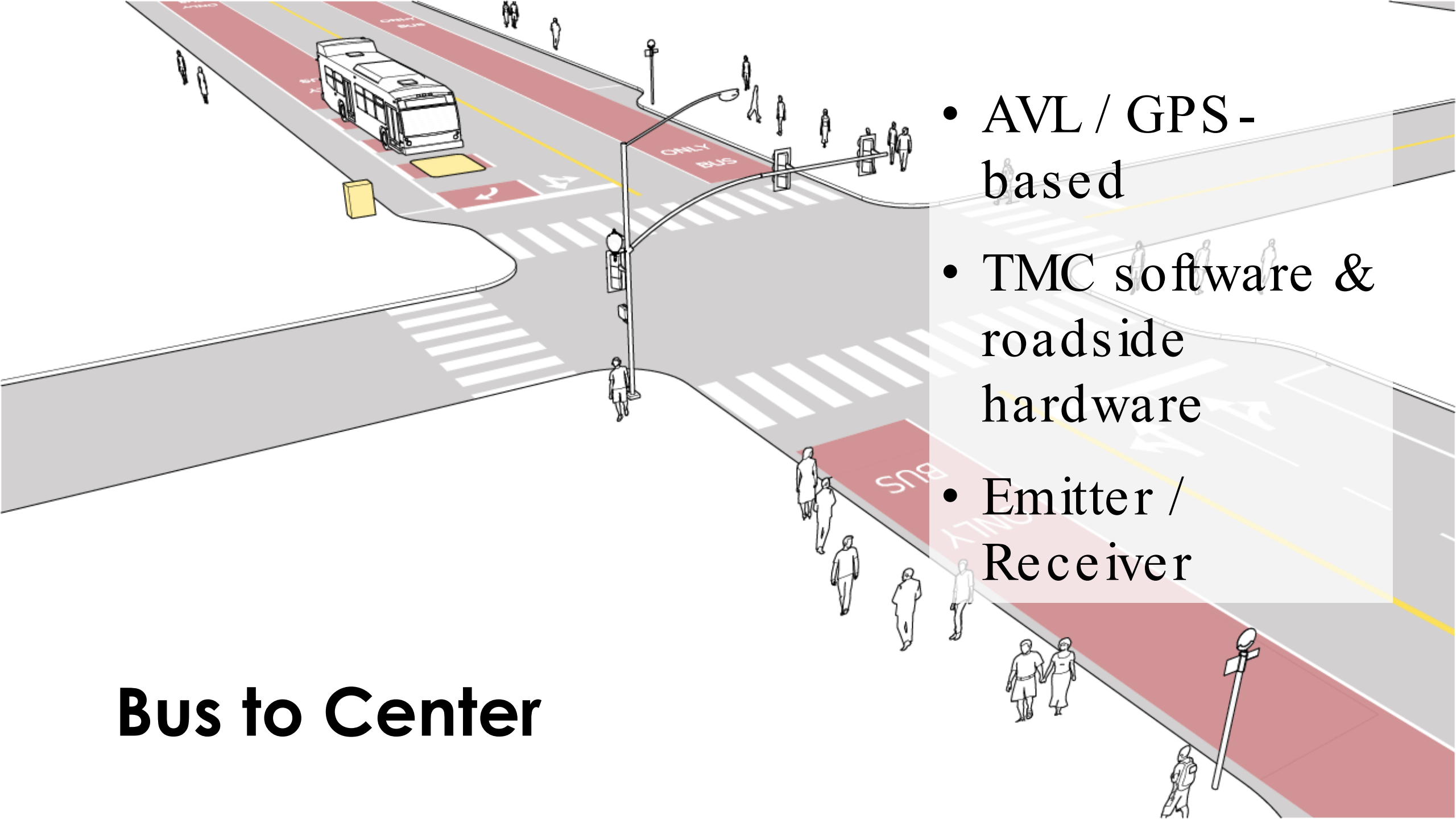
- Optical detection
- Loop detection (in-ground)
- Emitter / Receiver

Bus to Signal

Bus to Center



Bus to Center

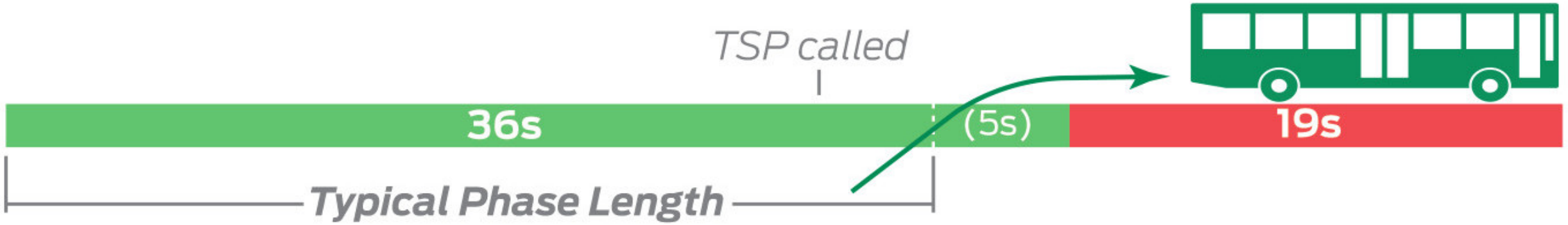


- AVL / GPS-based
- TMC software & roadside hardware
- Emitter / Receiver

Bus to Center

Active TSP Tools

Green Extension



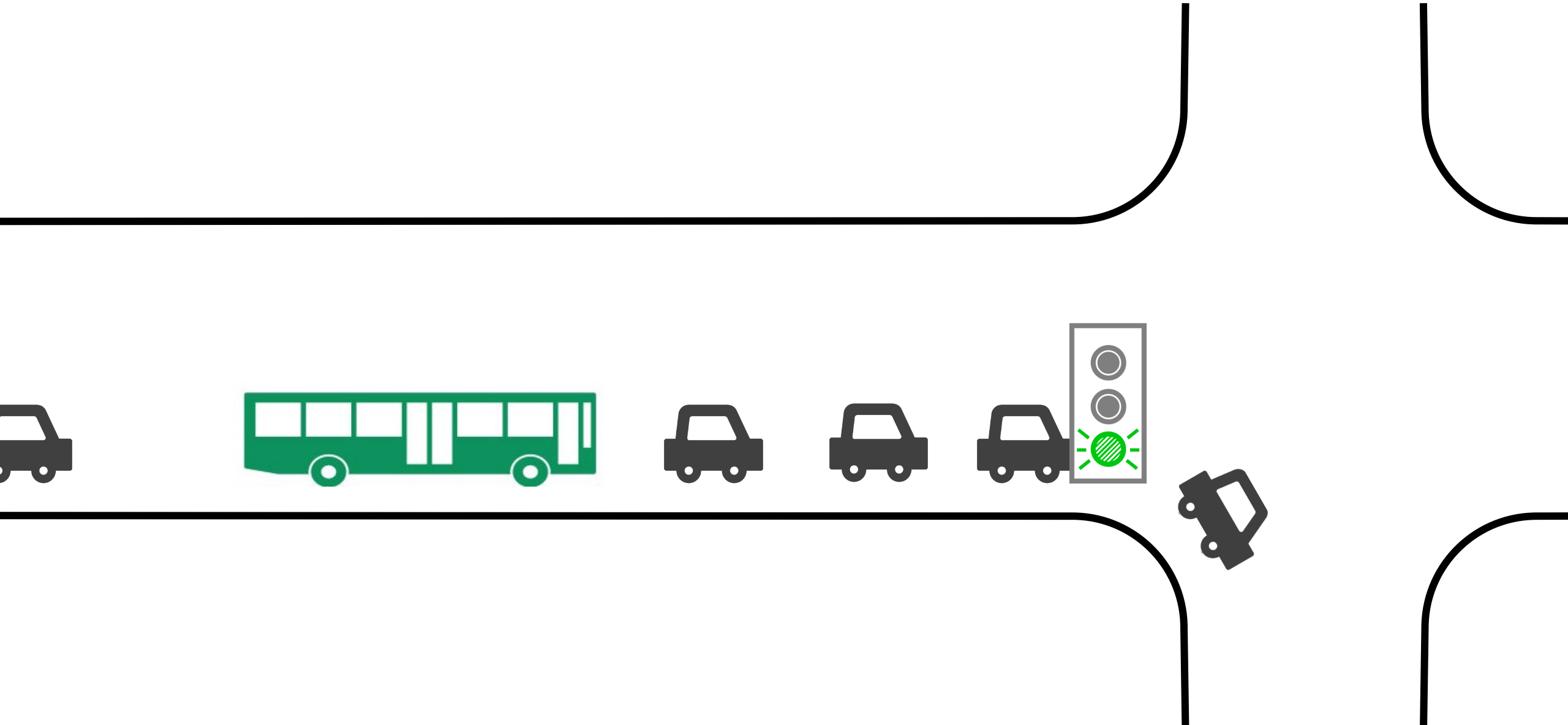
Applications

- Typically far-side or no stop location
- Mixed travel, transit lane, or transitway
- May use advance detection

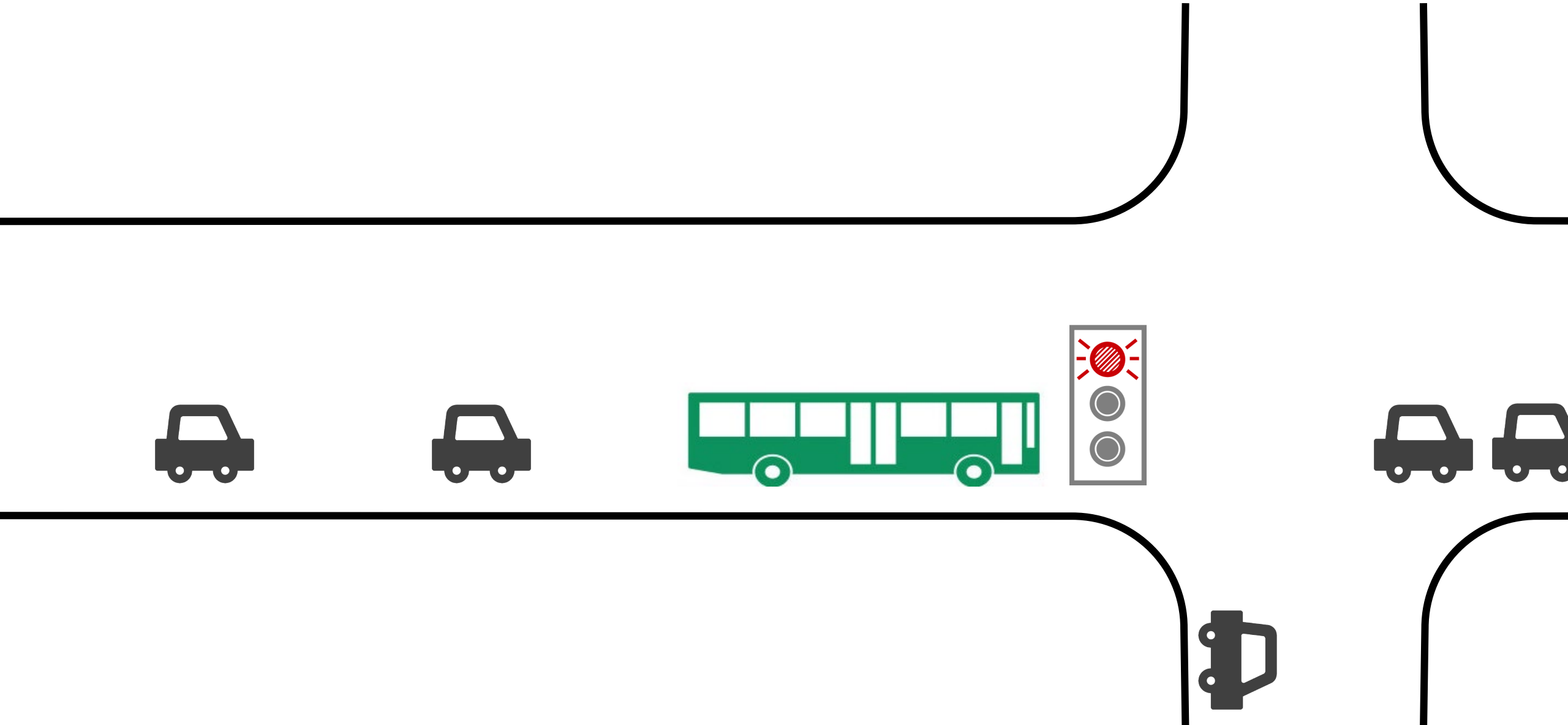
Benefits & Challenges

- Relatively simple to implement
- Doesn't affect pedestrian crossing time (on thru street)

Before

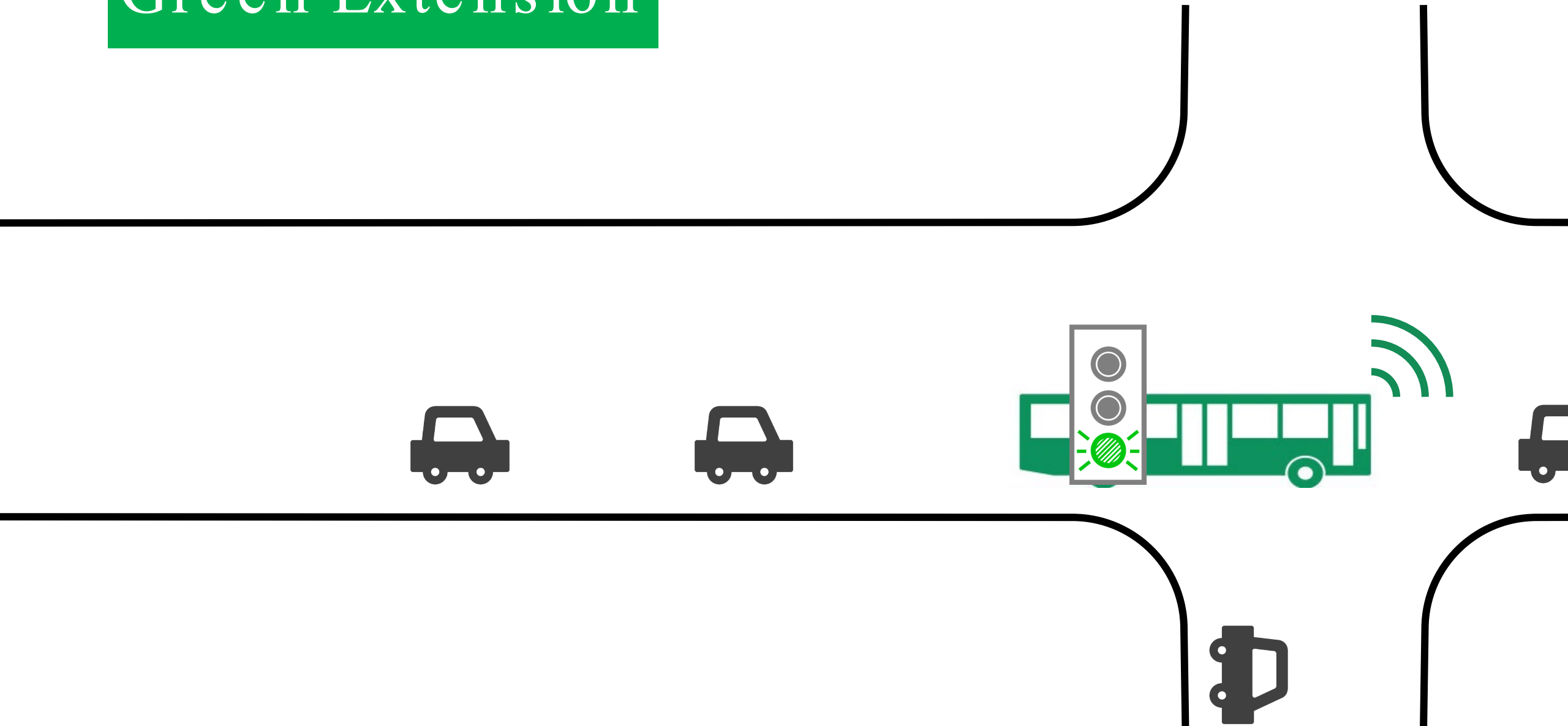


Before

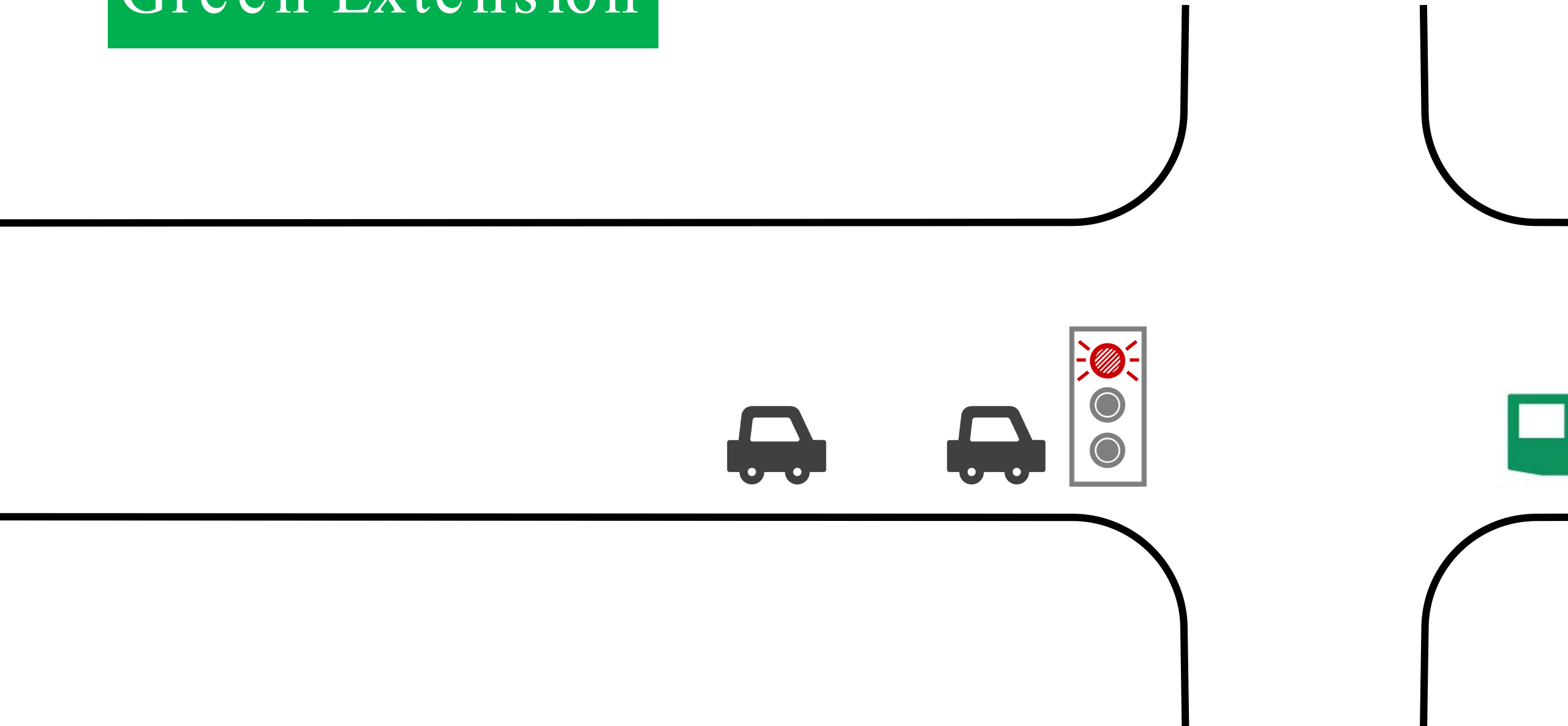


Green Extension

Green Extension



Green Extension



Green Reallocation

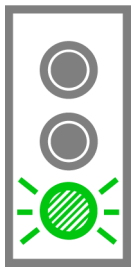
Applications

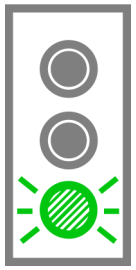
- Near-side, far-side, or no stop location;
- Mixed travel, transit lane, or transitway
- Requires advance detection

Benefits & Challenges

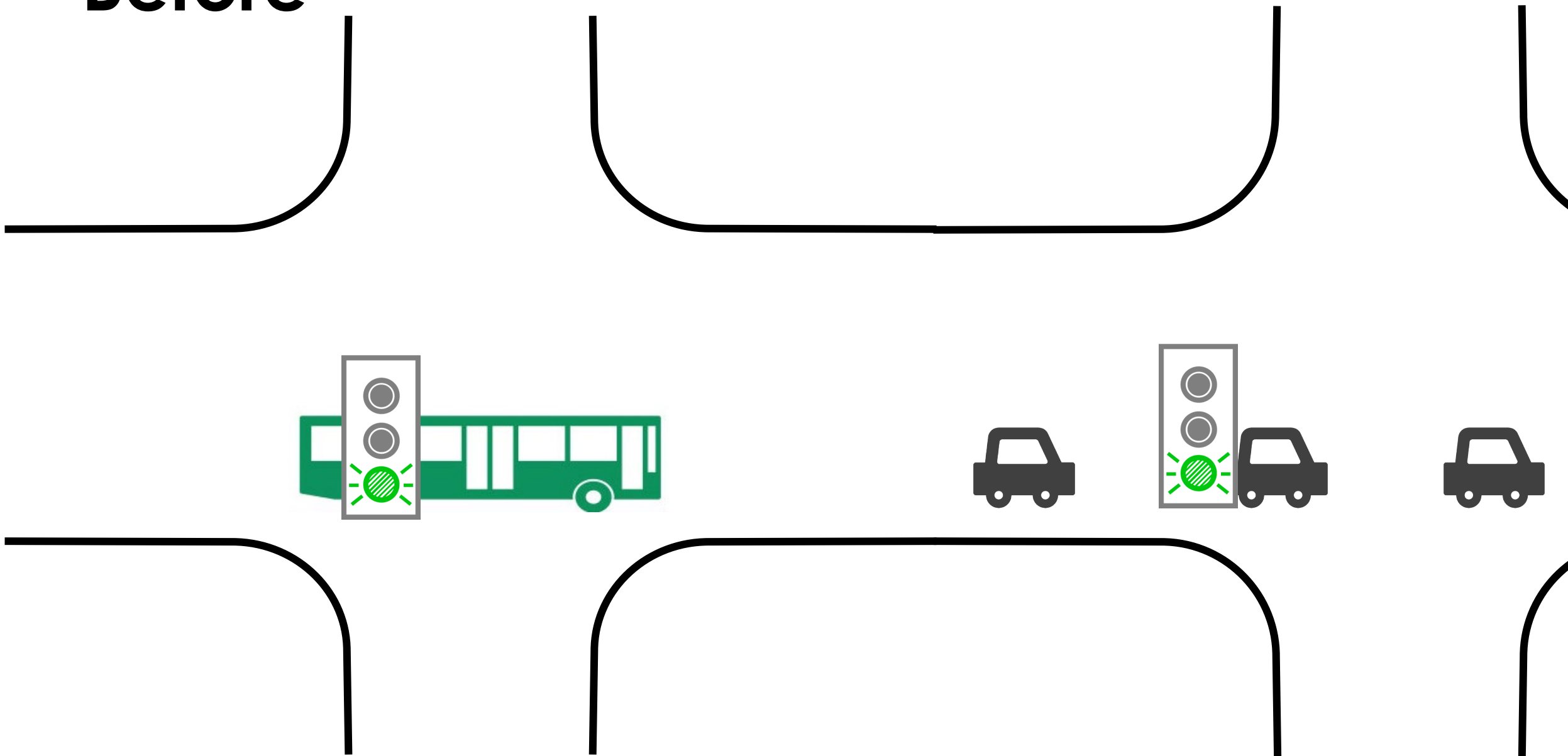
- Doesn't change red / green allocation
- Shortens cross-street pedestrian crossing time

Before

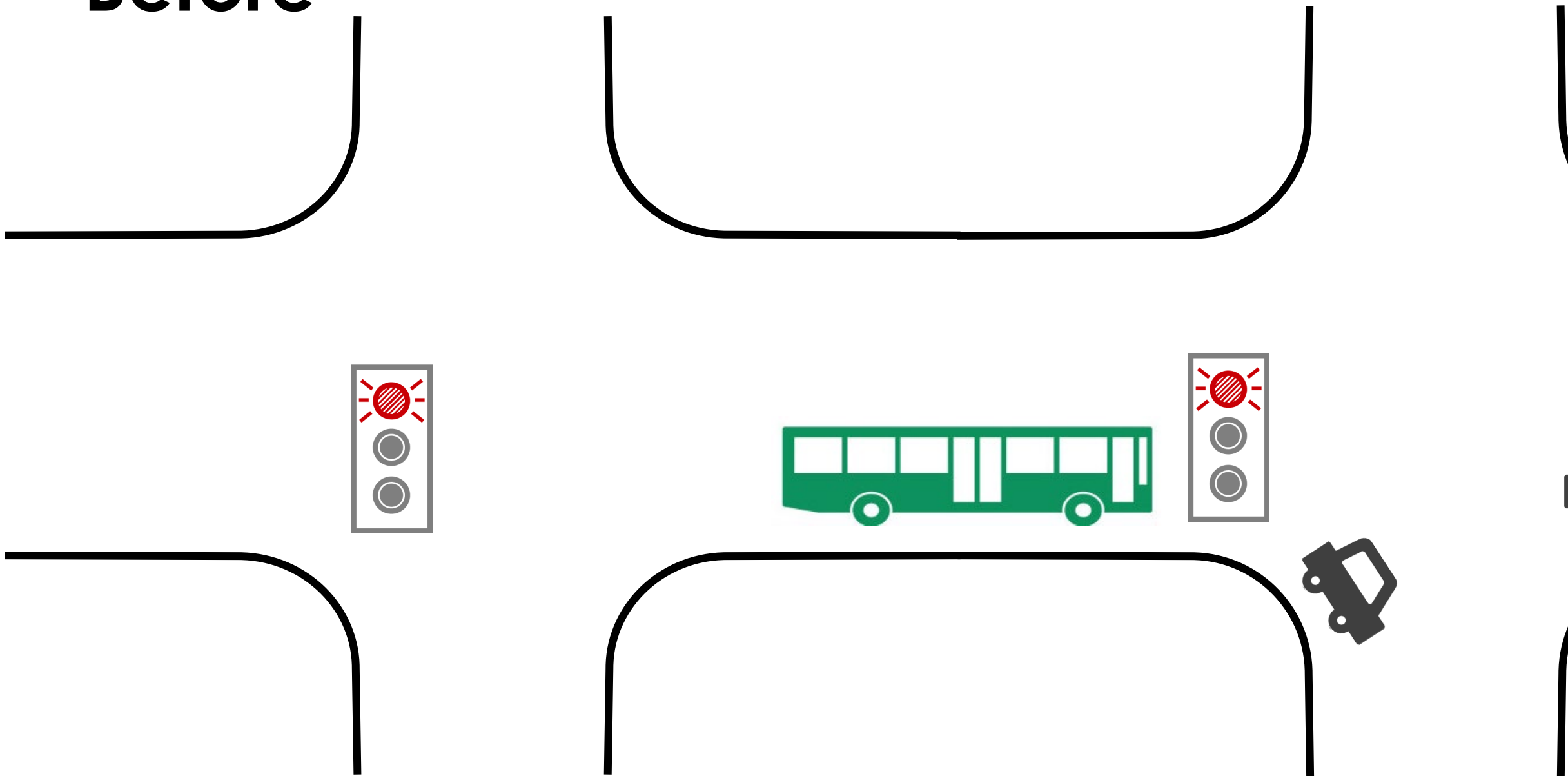




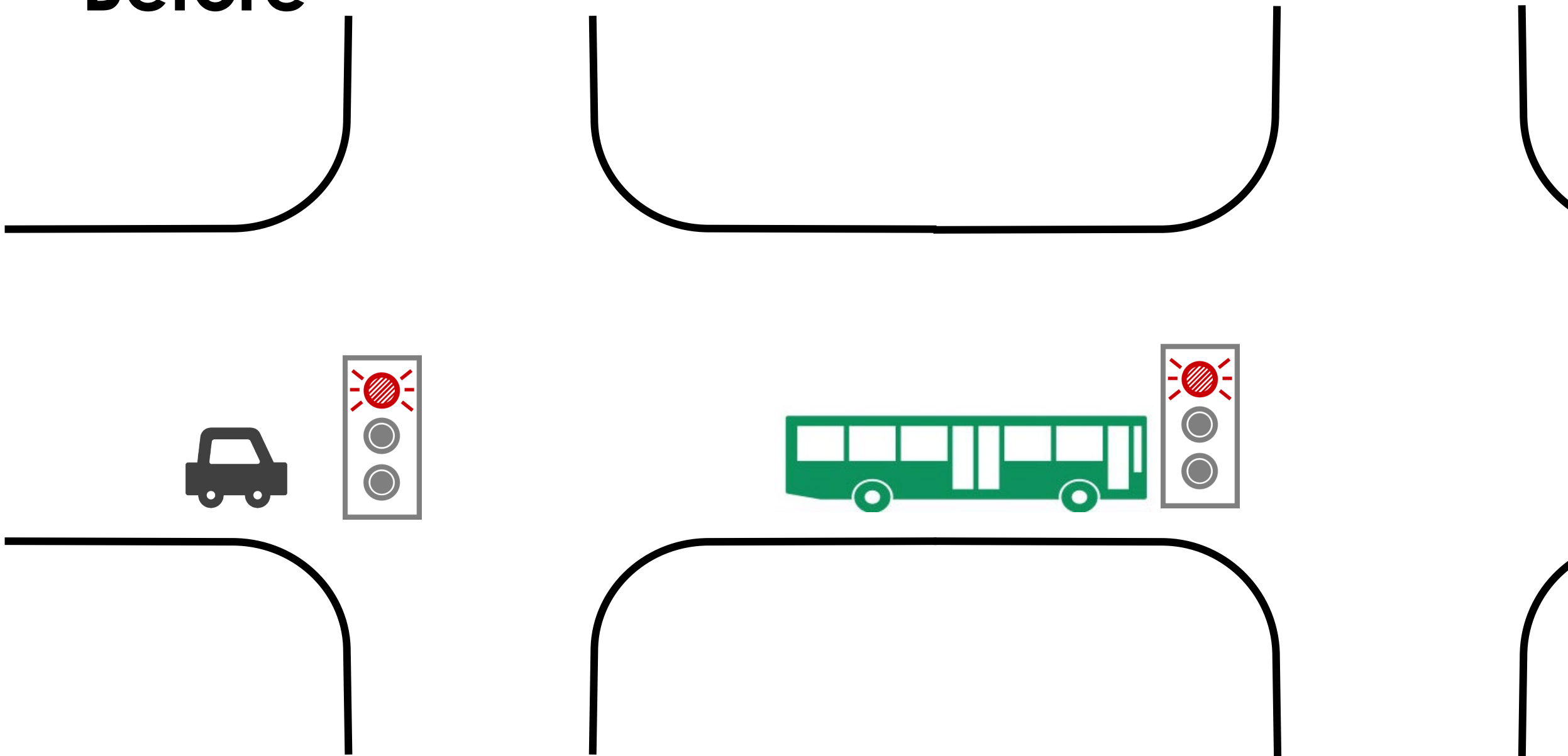
Before



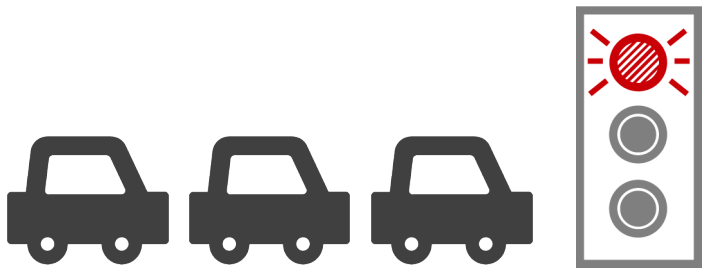
Before



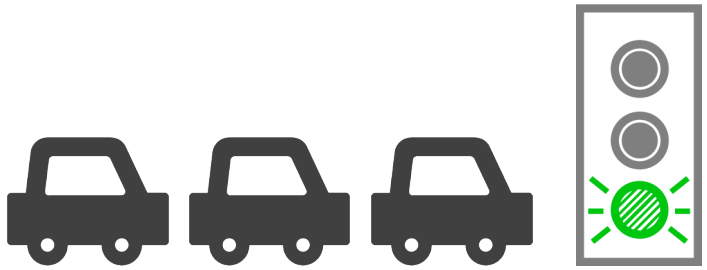
Before



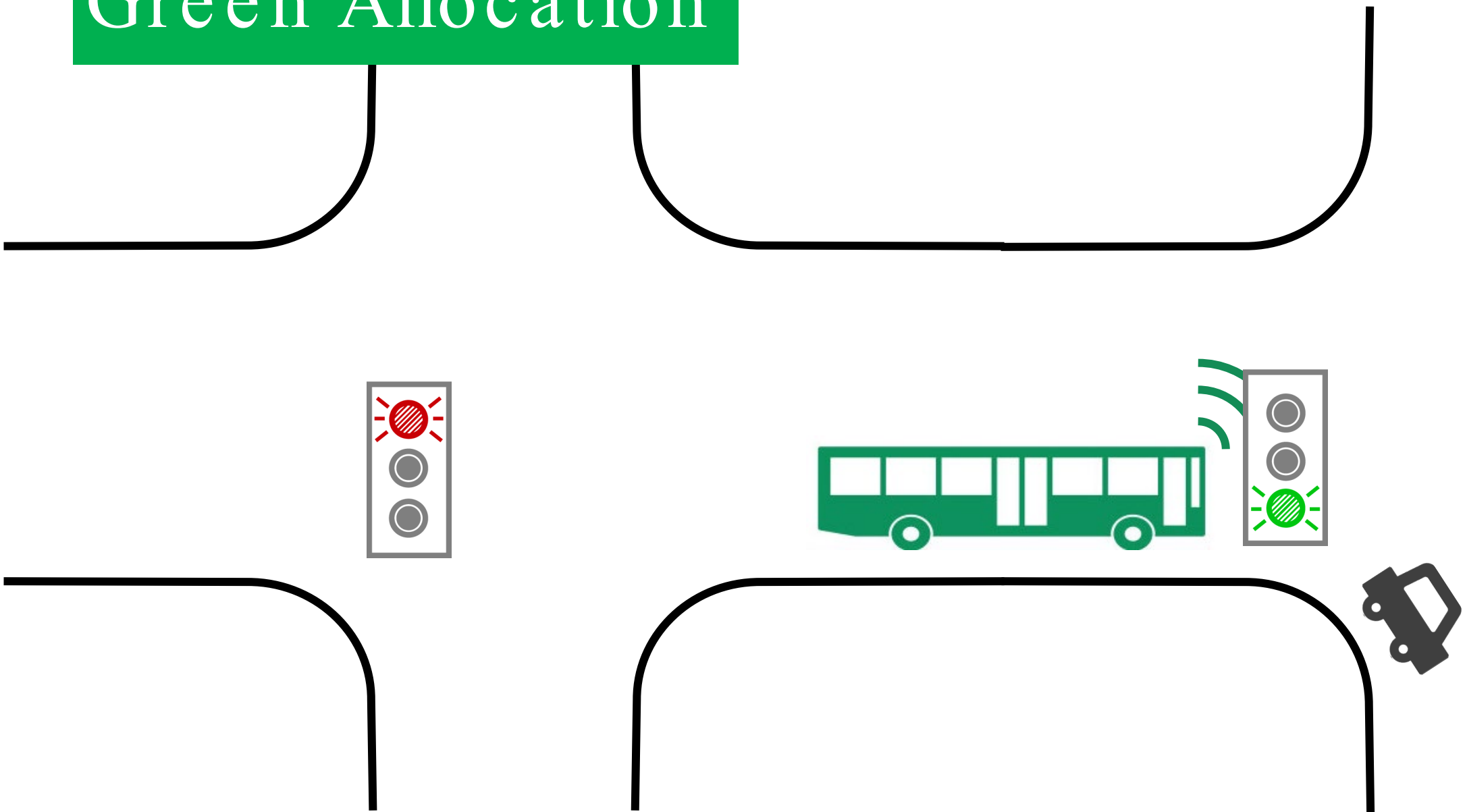
Green Allocation



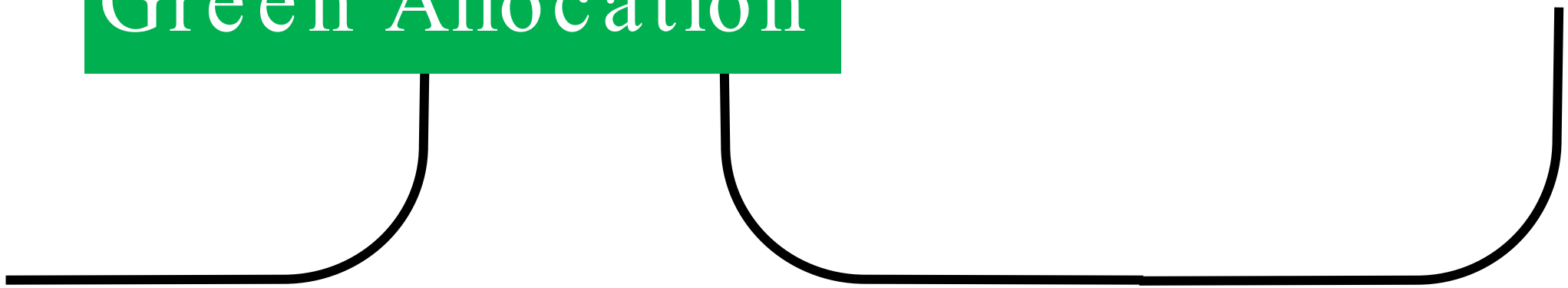
Green Allocation

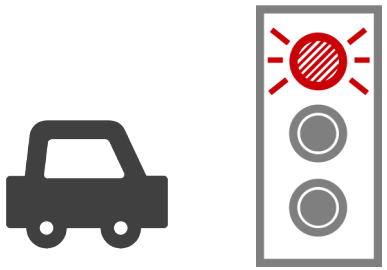


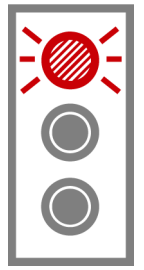
Green Allocation

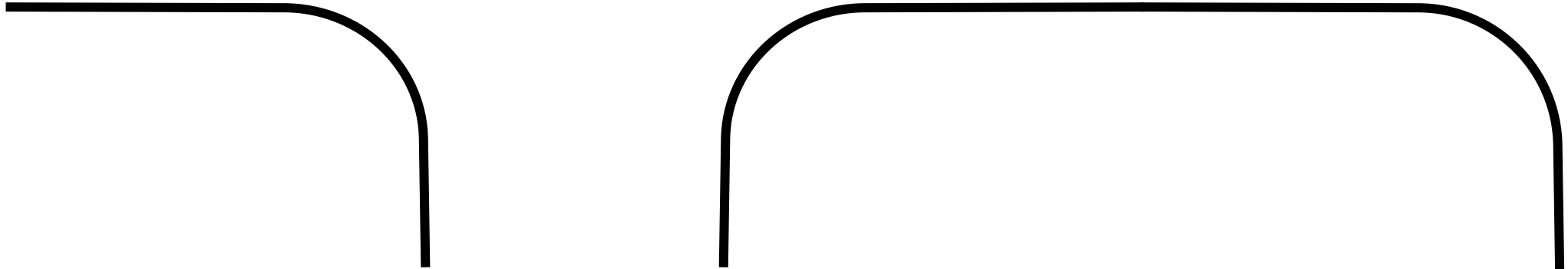


Green Allocation

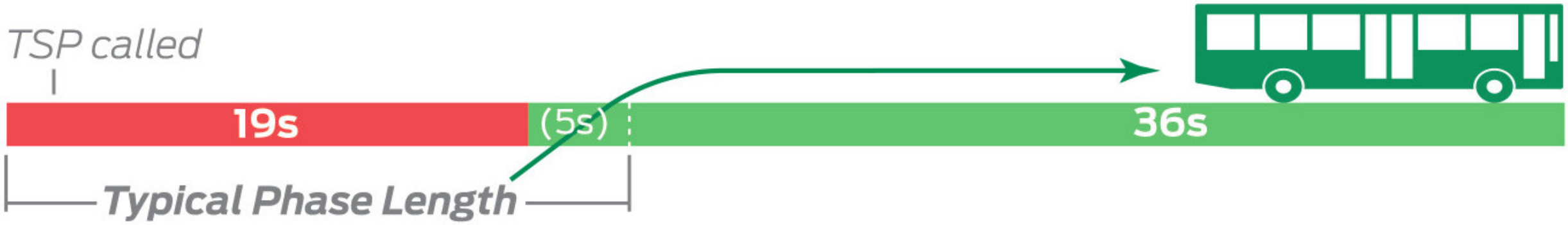








Red Truncation



Applications

- Far-side stop / no stop
- Congested locations / long queues
- High-turning movement counts

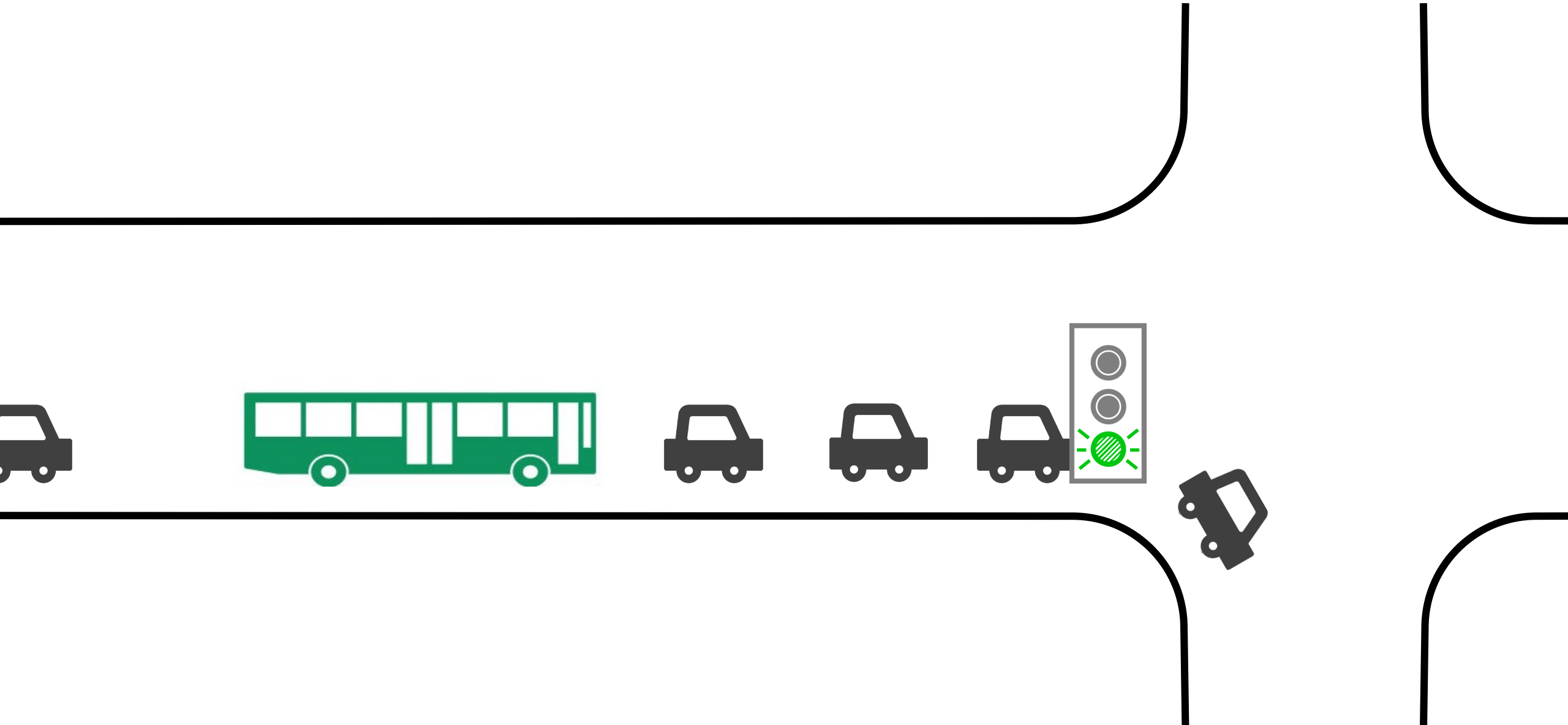
Benefits & Challenges

- Metering queue length in front of transit
- Difficult to model and implement
- Pedestrian crossing time on cross-street shortened

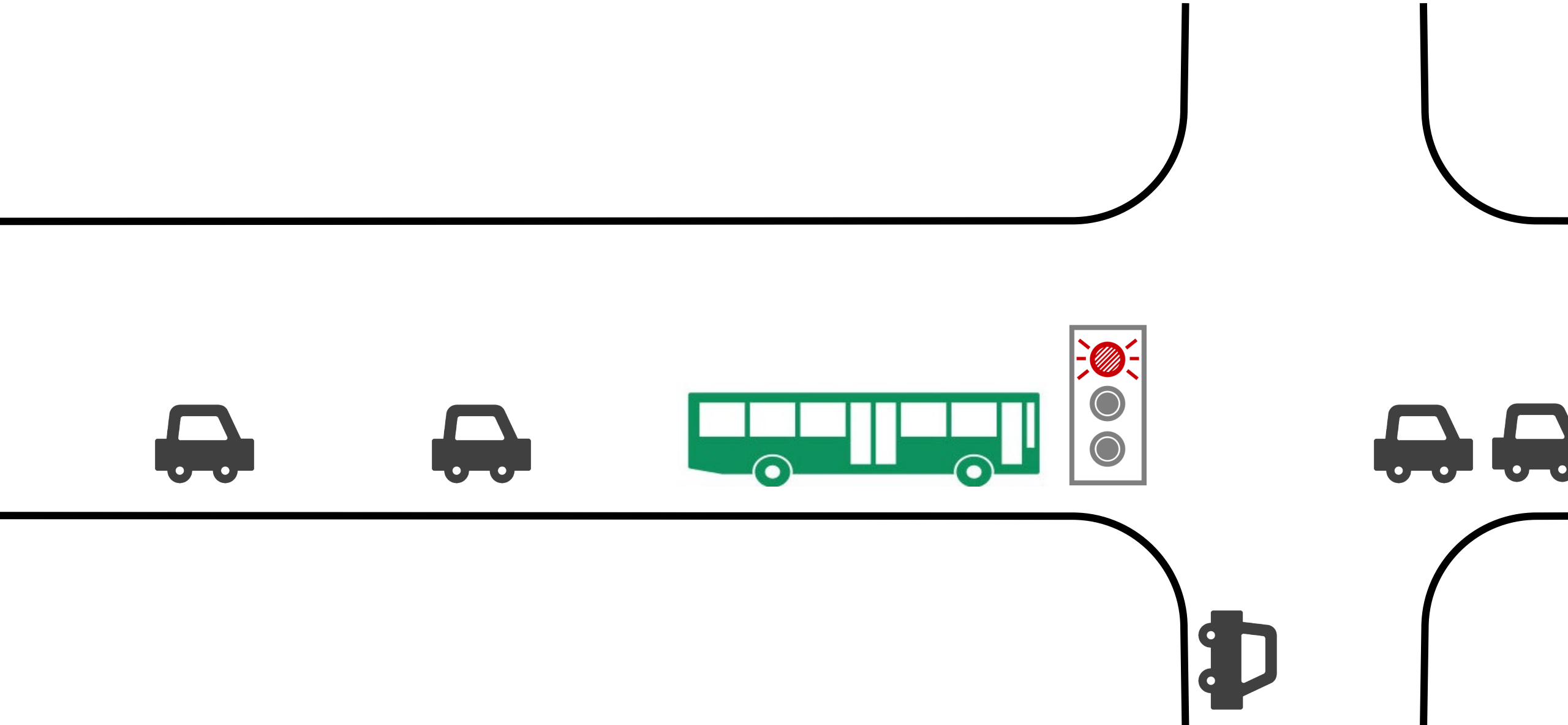
Before

Before

Before



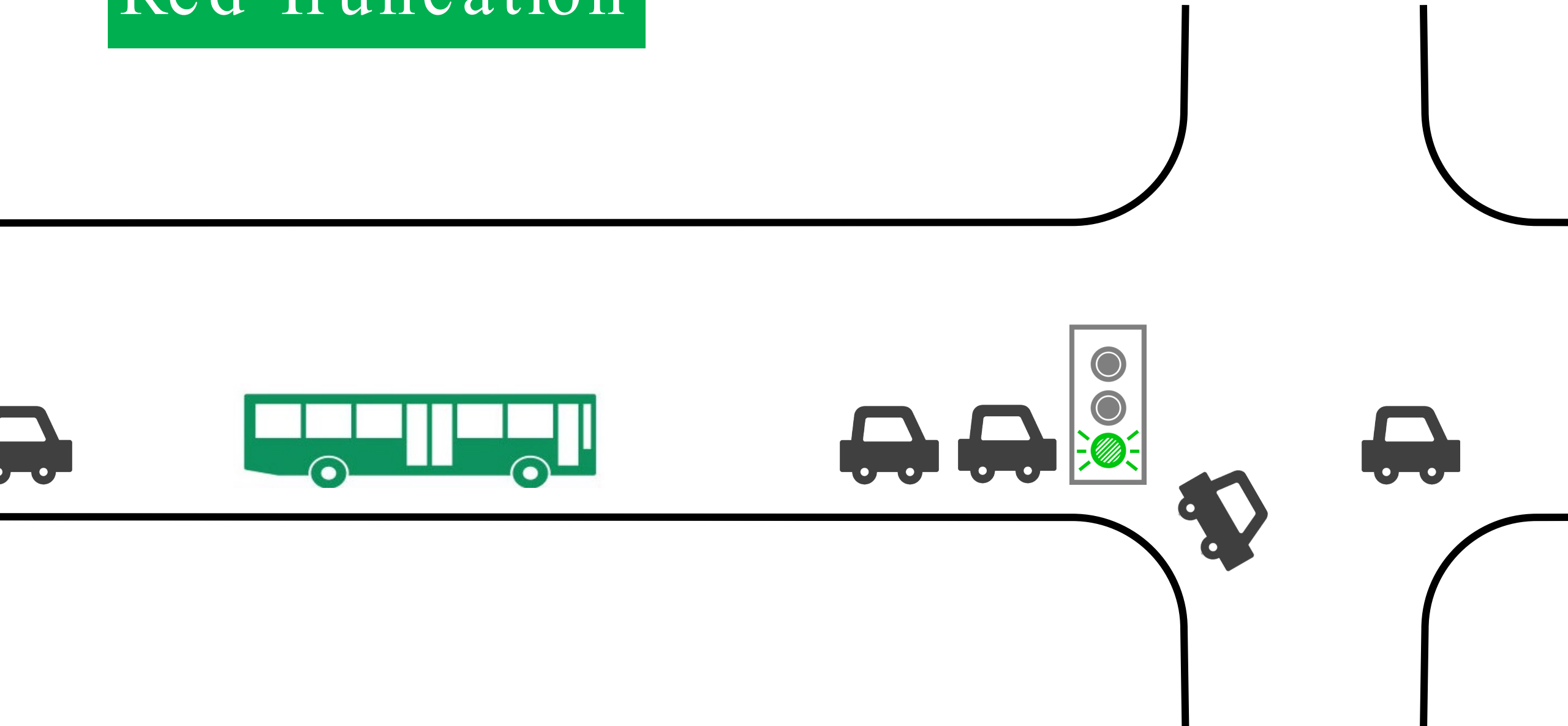
Before



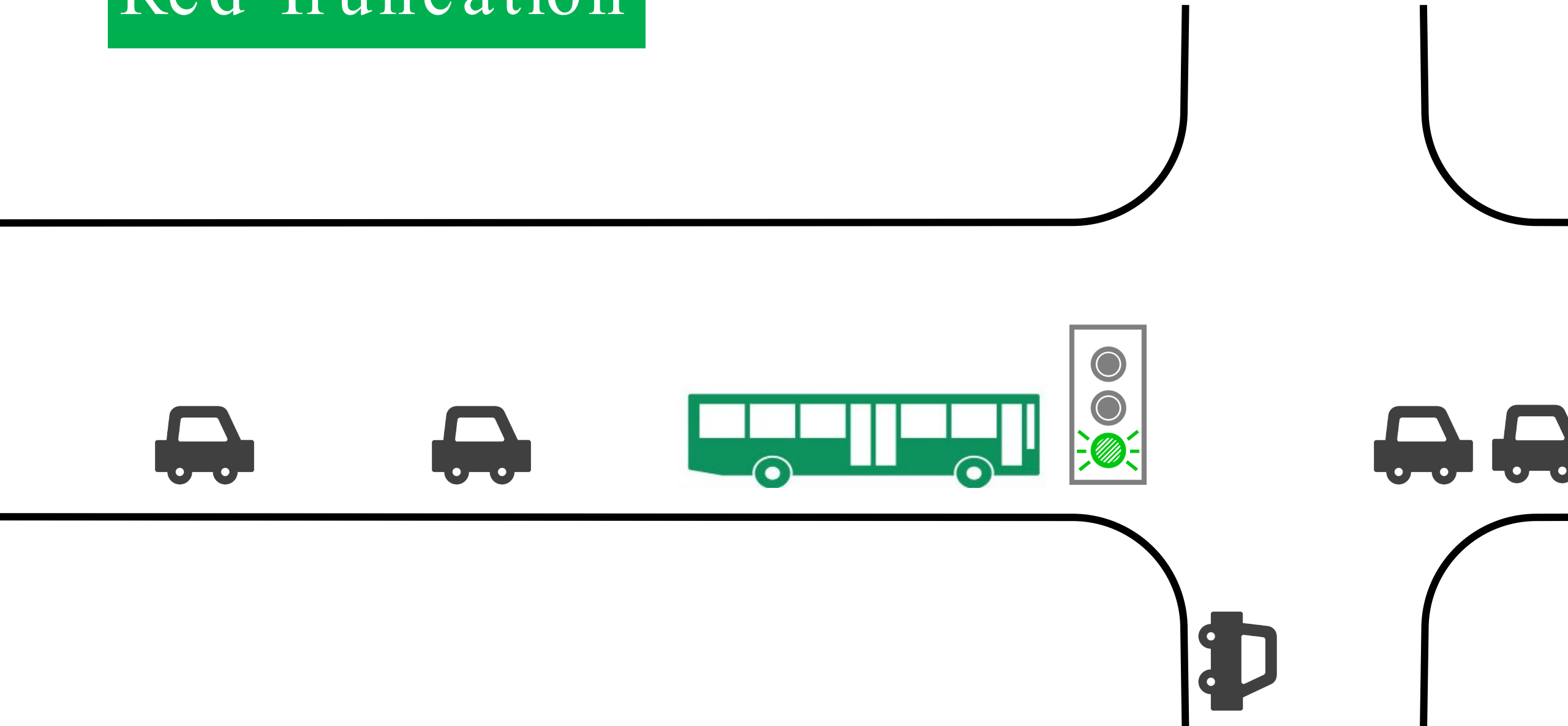
Red Truncation

Red Truncation

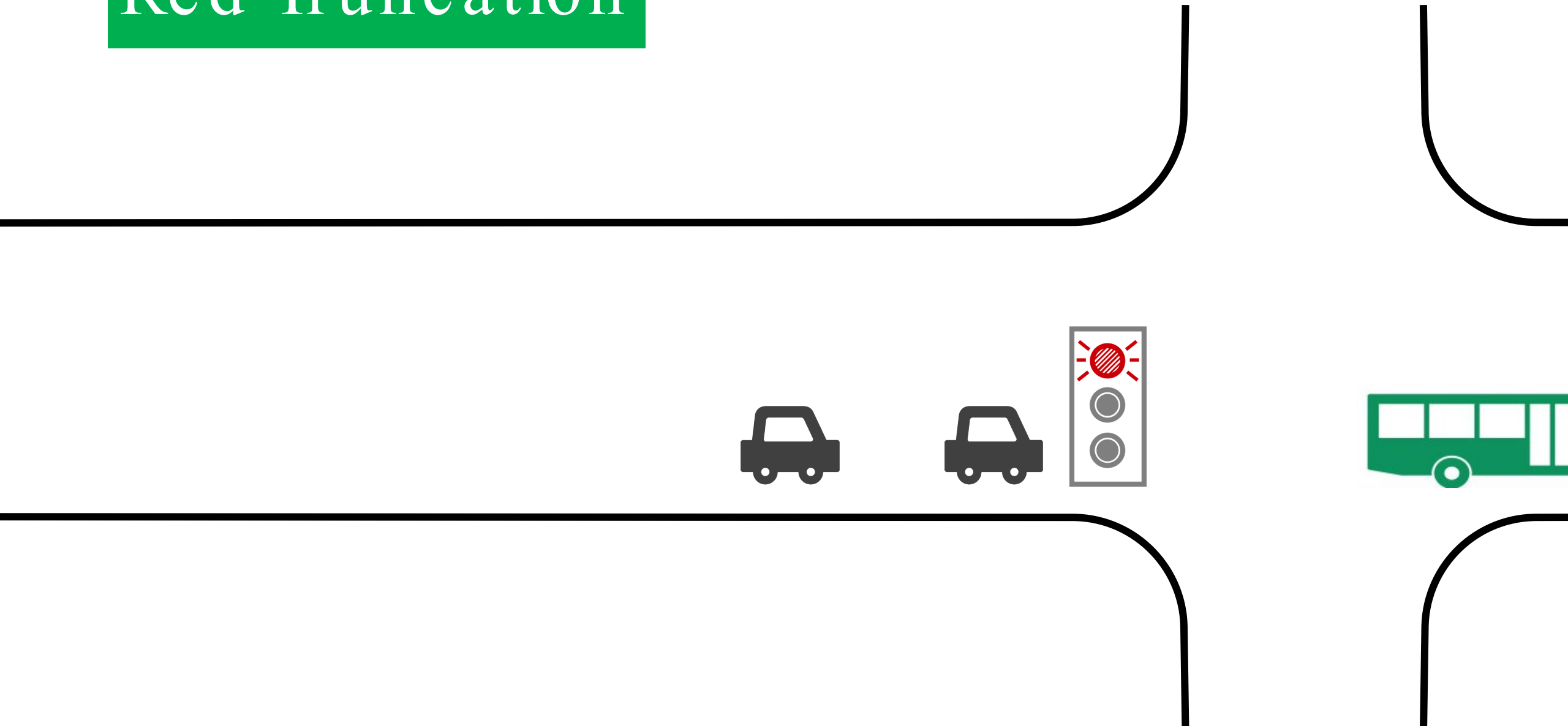
Red Truncation



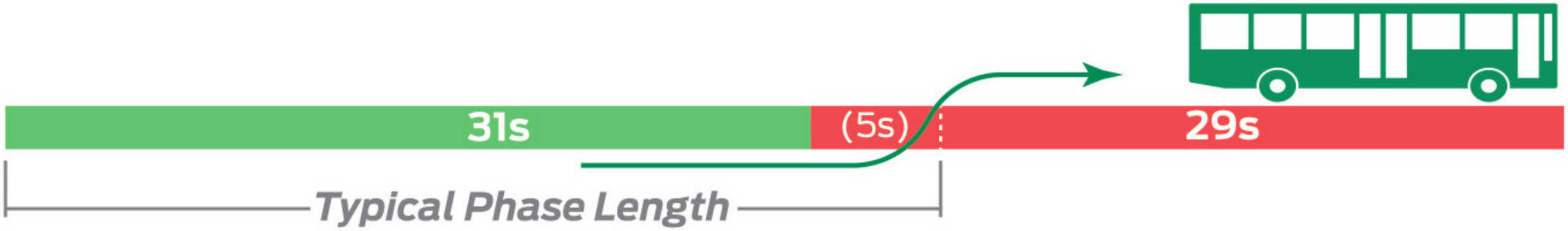
Red Truncation



Red Truncation



Upstream Green Truncation



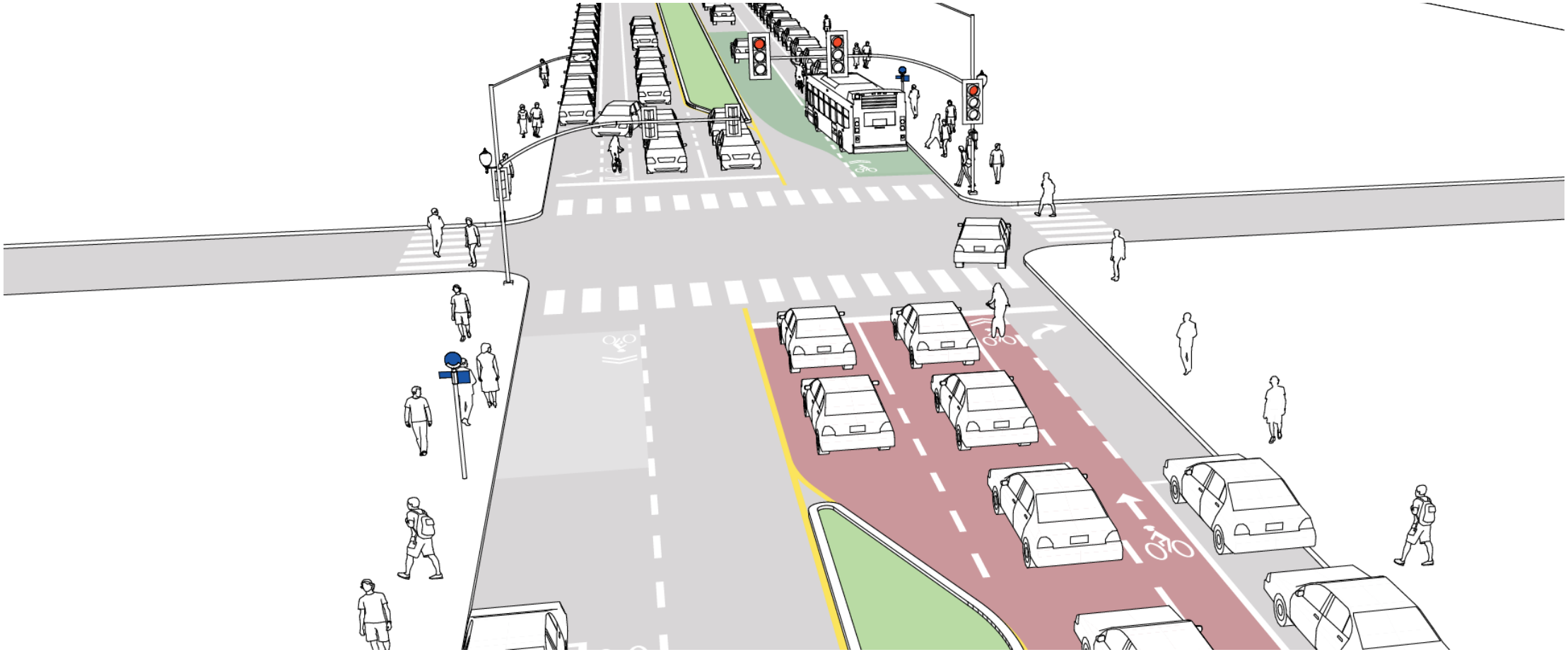
Applications

- Near- or Far-side Pull-Out stops
- Bus Turns or Merges
- Generally mixed travel conditions

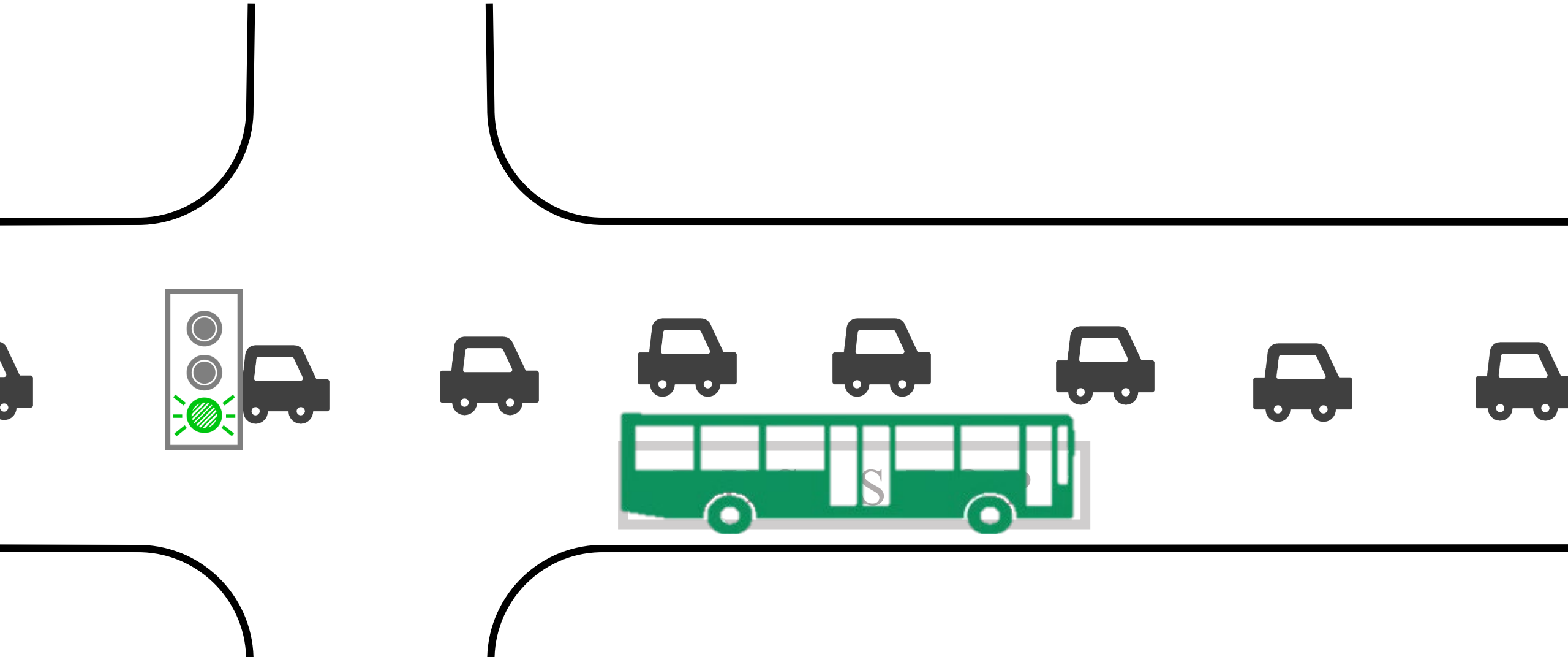
Benefits & Challenges

- Where remerge from stop is a common delay culprit
- No impact to people walking; may impact unprotected bike facilities

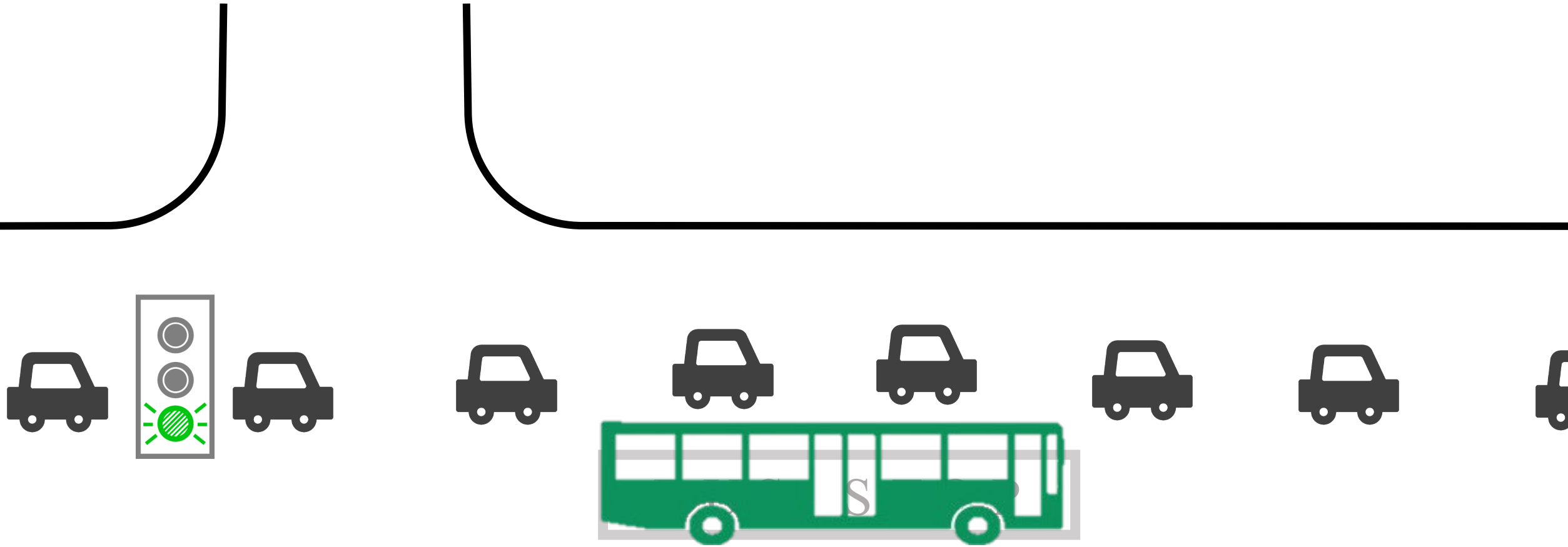
Reverse Queue Jump



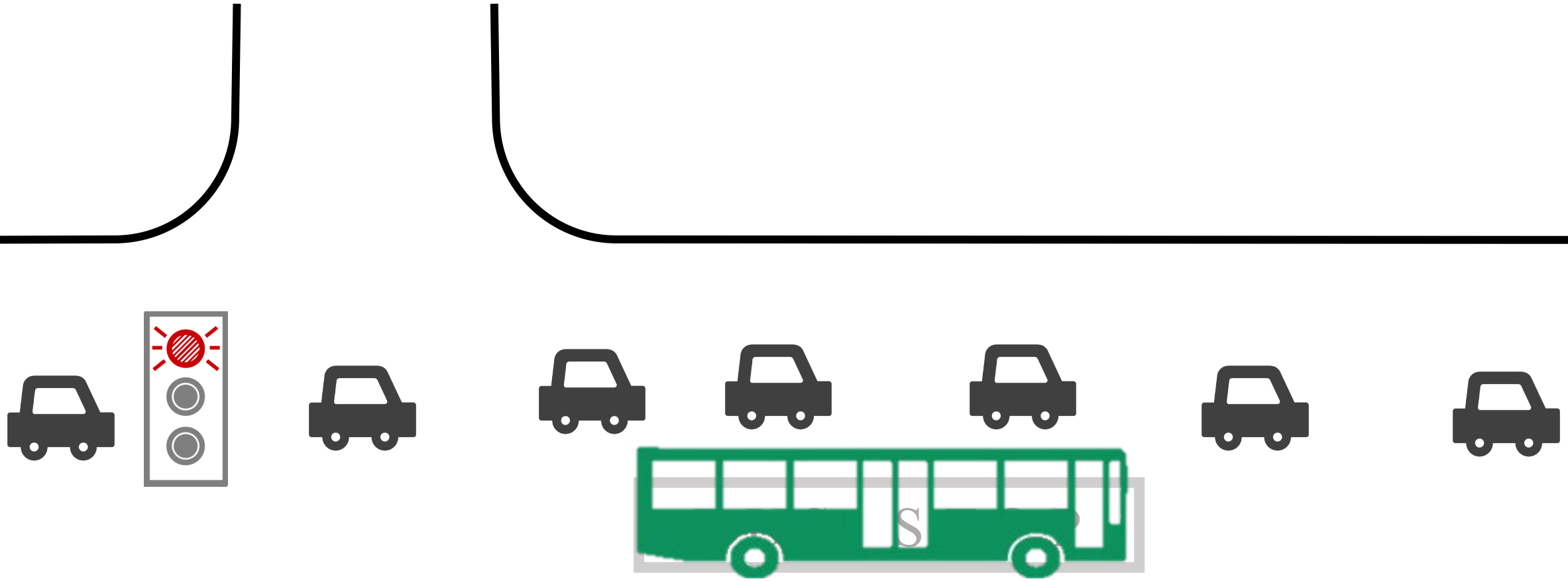
Before



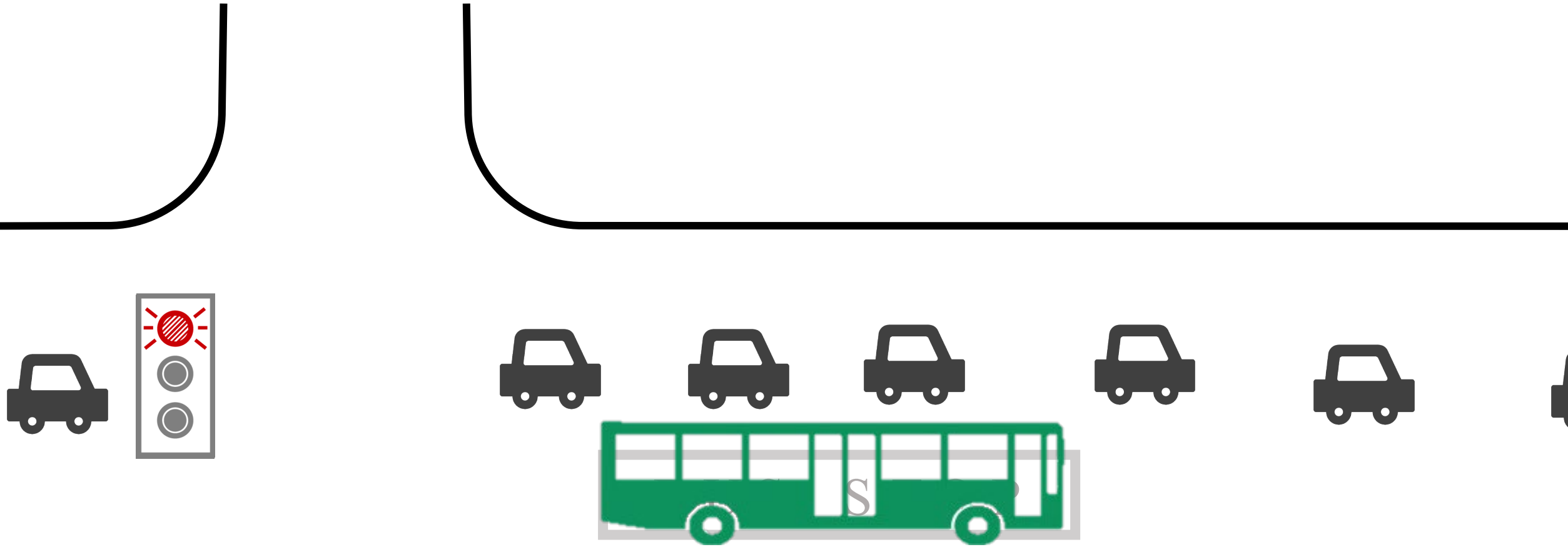
Before



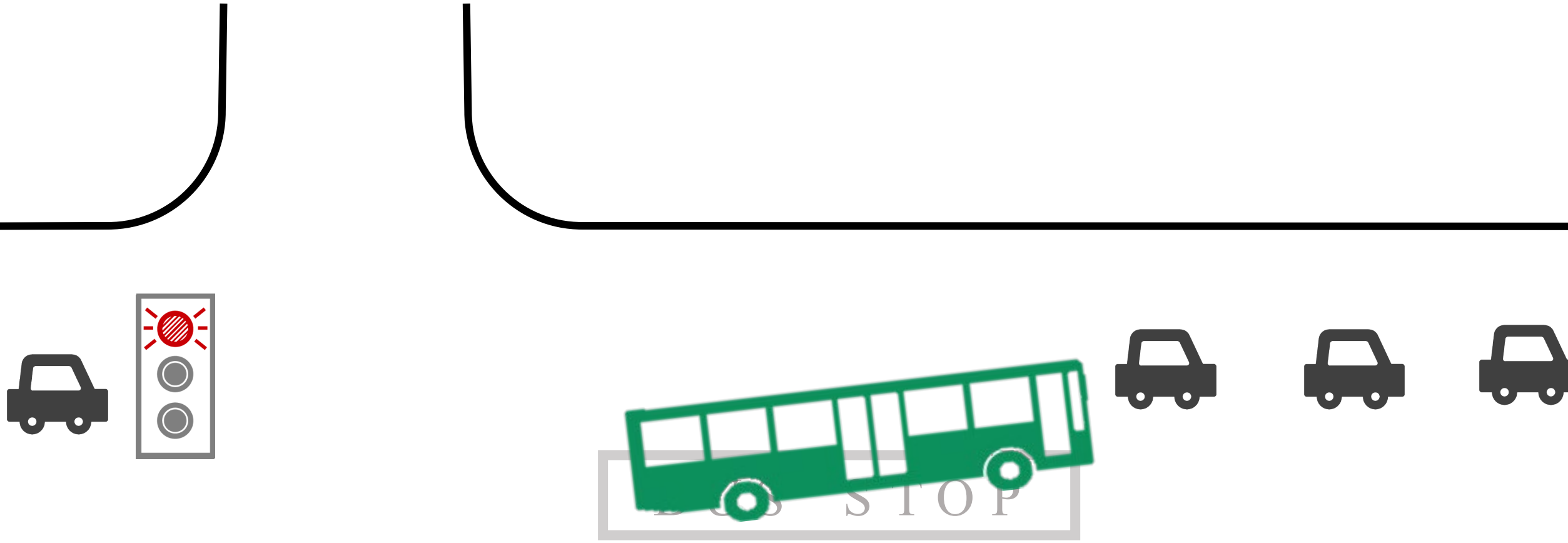
Upstream Green Truncation



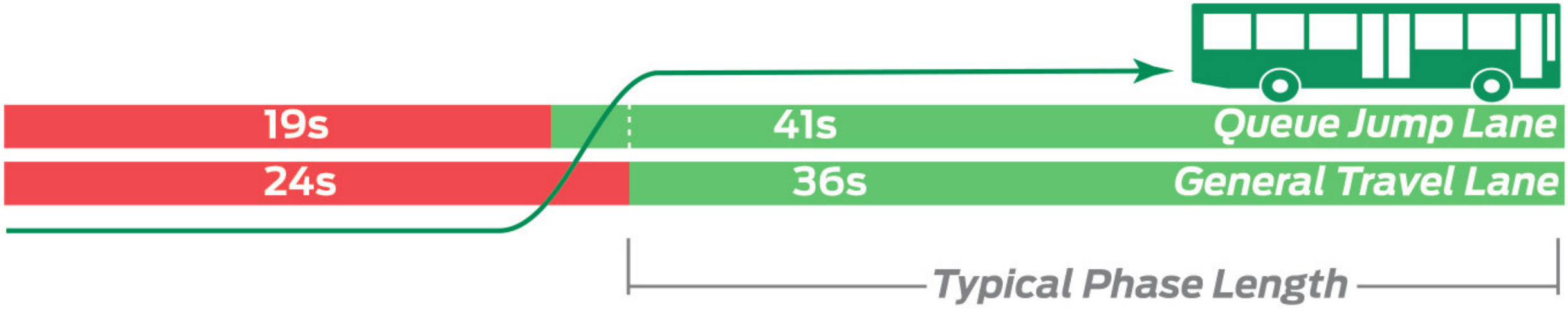
Upstream Green Truncation



Upstream Green Truncation



Phase Insertion



Applications

- Near-side pull-out stops
- Transit Approach Lanes / Queue Jumps, Transit Lanes

Benefits & Challenges

- Flexible actuation / detection
- Can co-implement with LPI / LBI.

Westlake Ave, Seattle

Westlake Ave, Seattle

Westlake Ave, Seattle

Phase Reservice

Applications

- Any stop location type
- Bus turns & Queue Jumps
- Transit Lanes, Transitways, or Mixed Travel

Benefits & Challenges

- Addresses known problems, and requires minimal change to existing phasing
- May impact pedestrian crossing time with conflicting movements

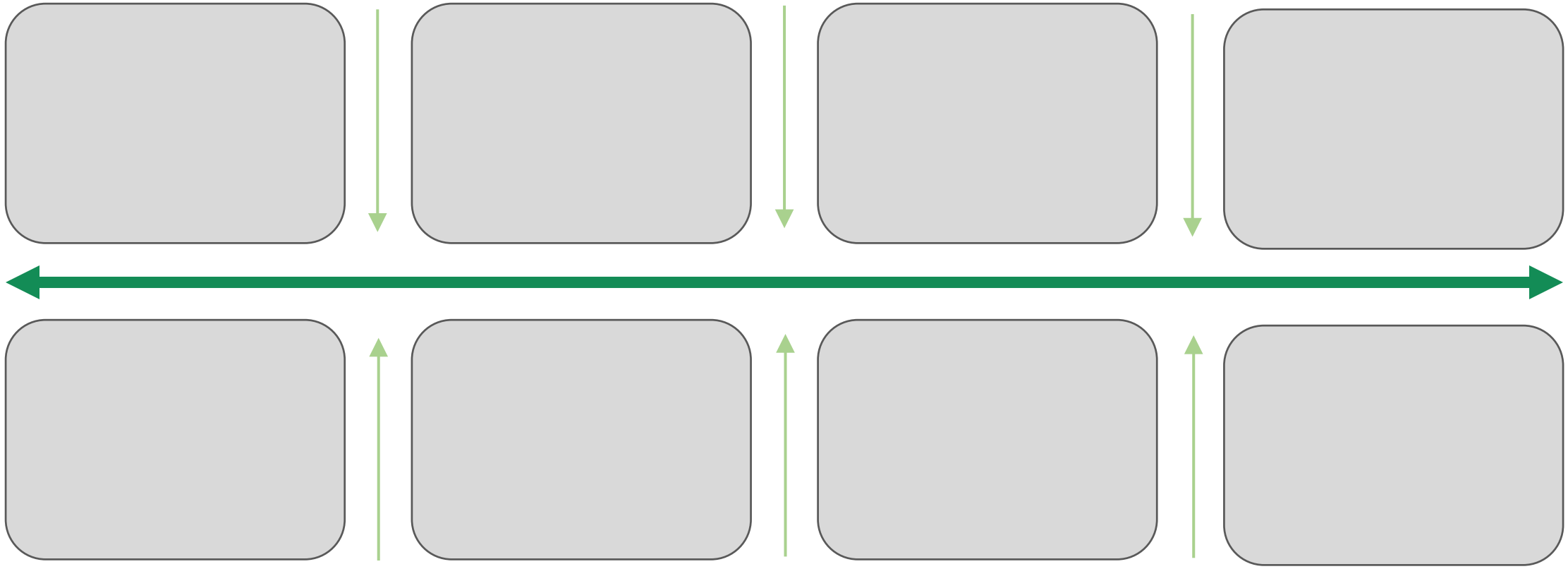
Transit-Friendly Signal Progression

Passive / Fixed Timing Strategies

Timing Corridors for Transit

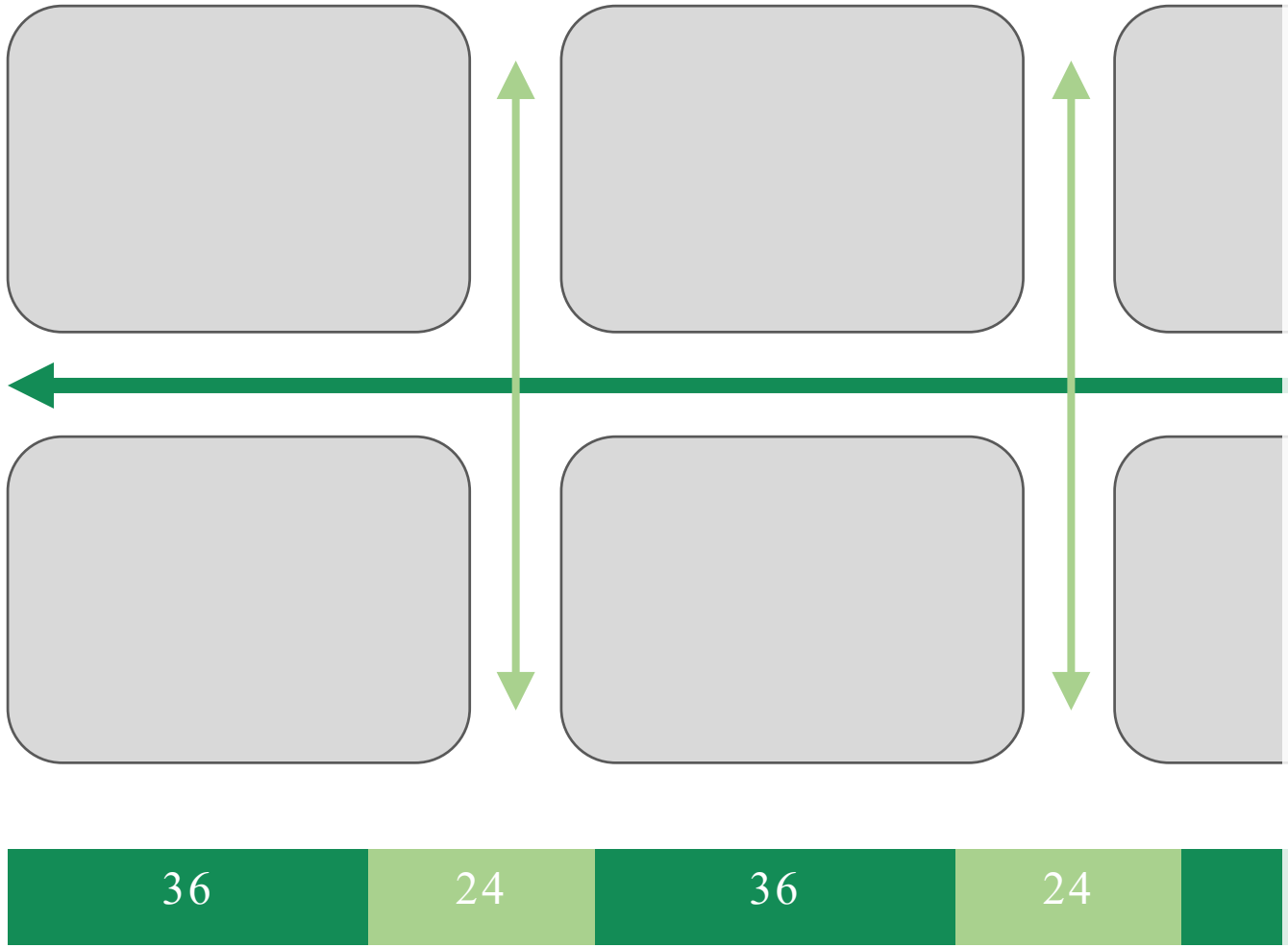
- Reduce Signal Cycle Length
- Increase Transit Green Time
- Time Progressions to Transit Green Wave / Safe Speeds
- Let the bus go straight!

Corridor-Based Timing



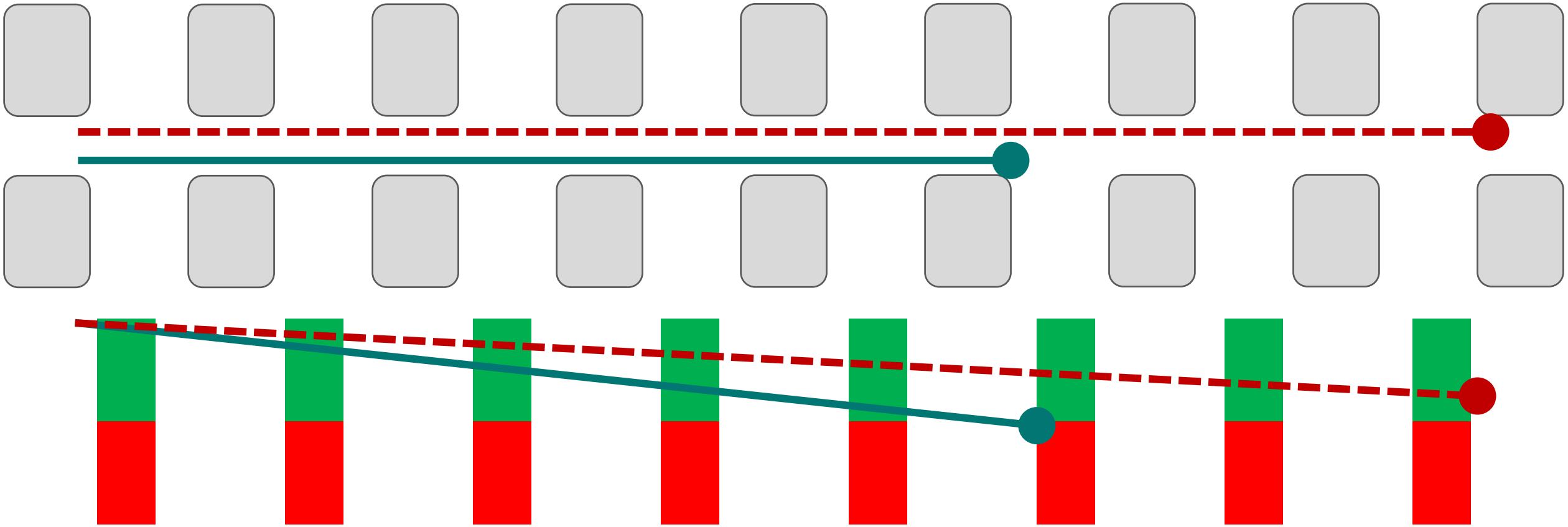
96	24	96	24

Balanced Signal Timing



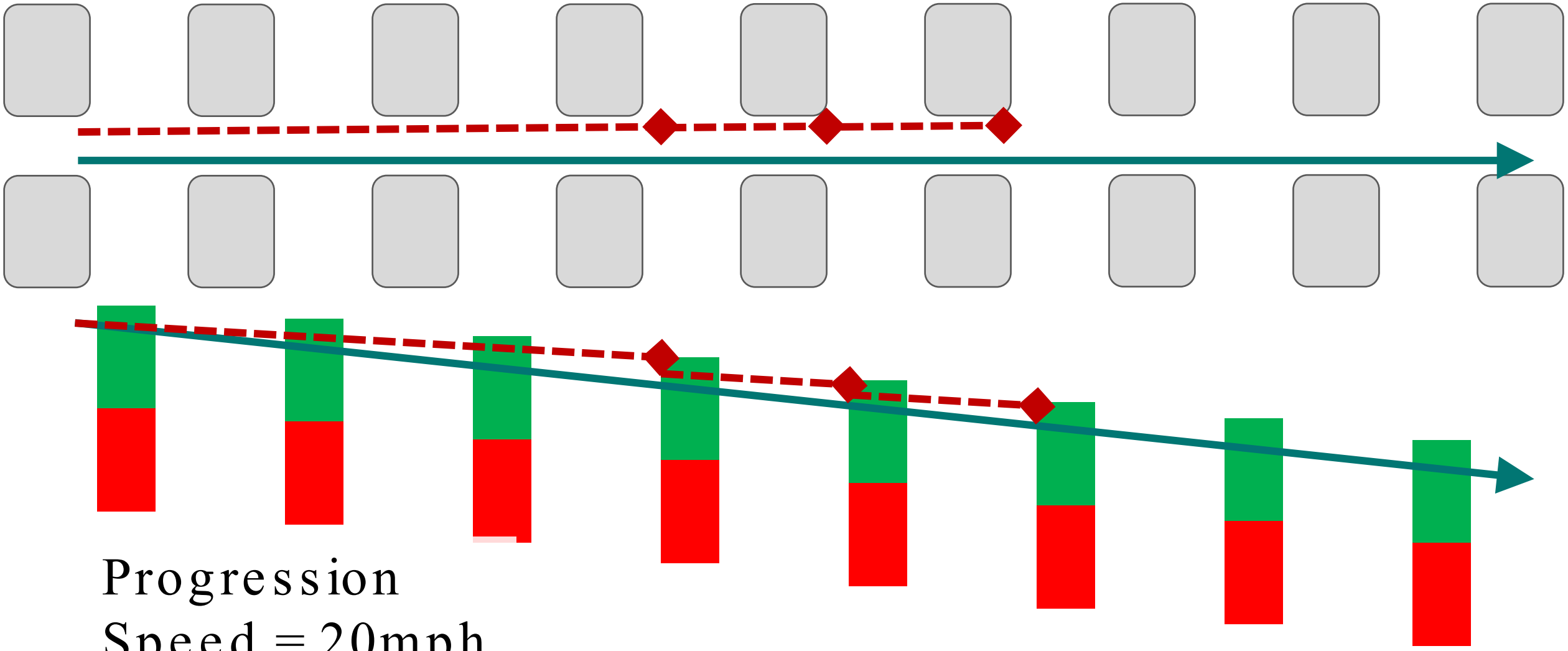
- Reduce average delay to people walking & biking
- Opportunity for speed management / safety benefit
- Opportunity for transit-friendly progression

One-way progression



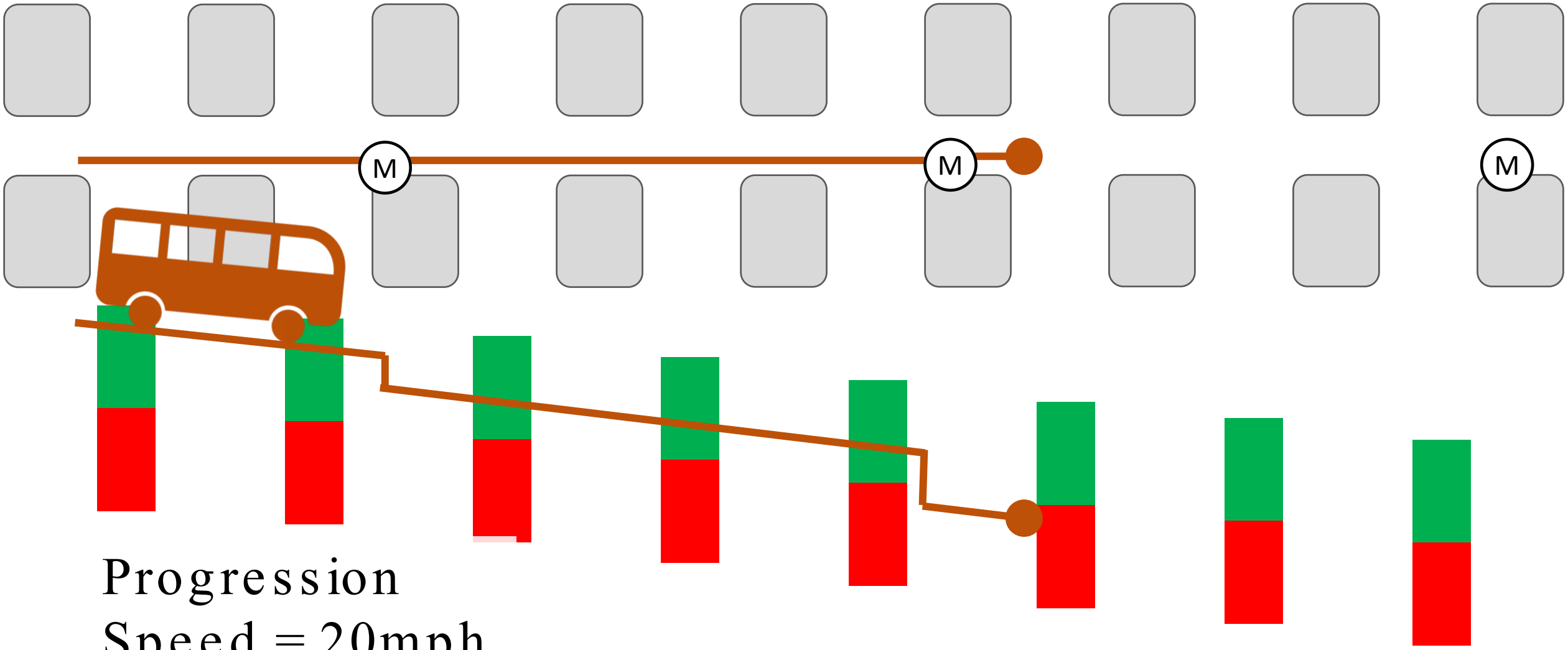
Signal
Blocks

One-way progression

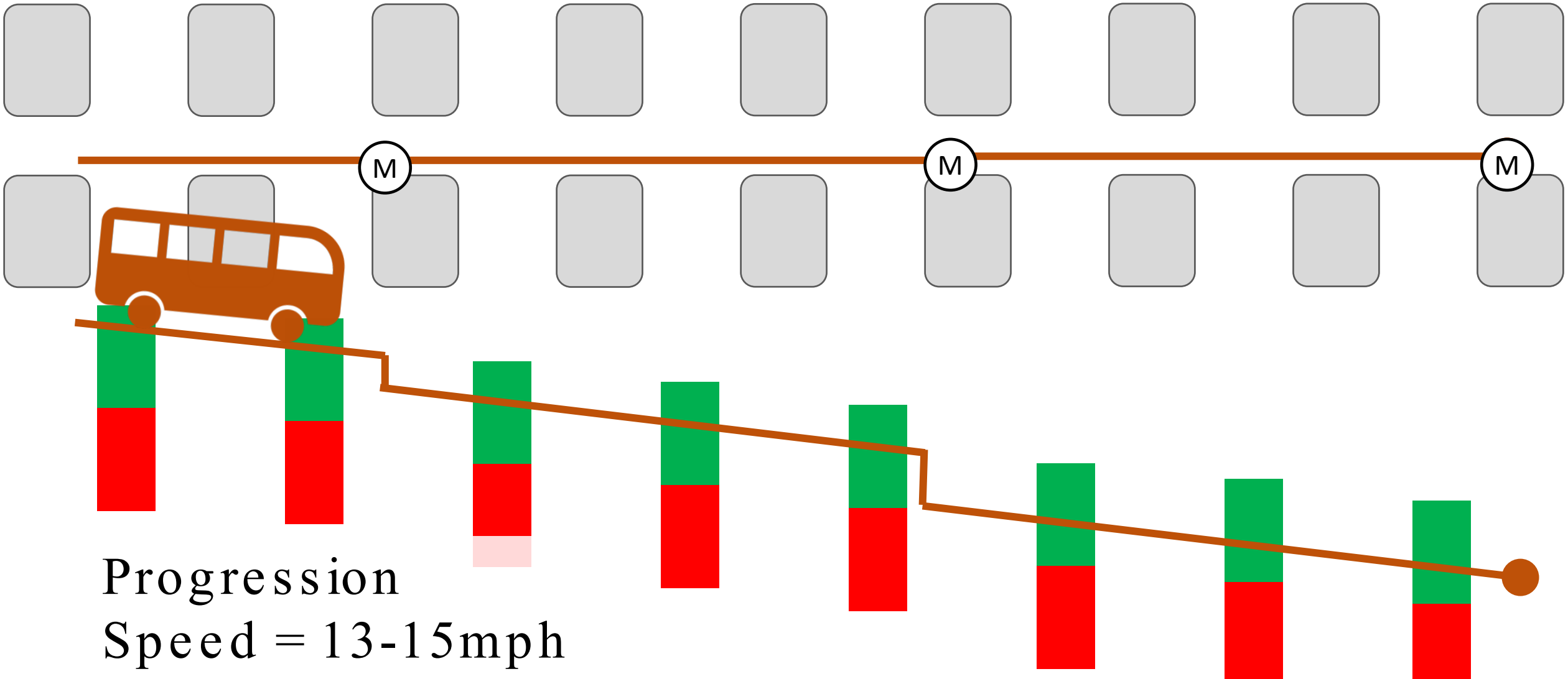


Progression
Speed = 20mph

One-way progression – Before

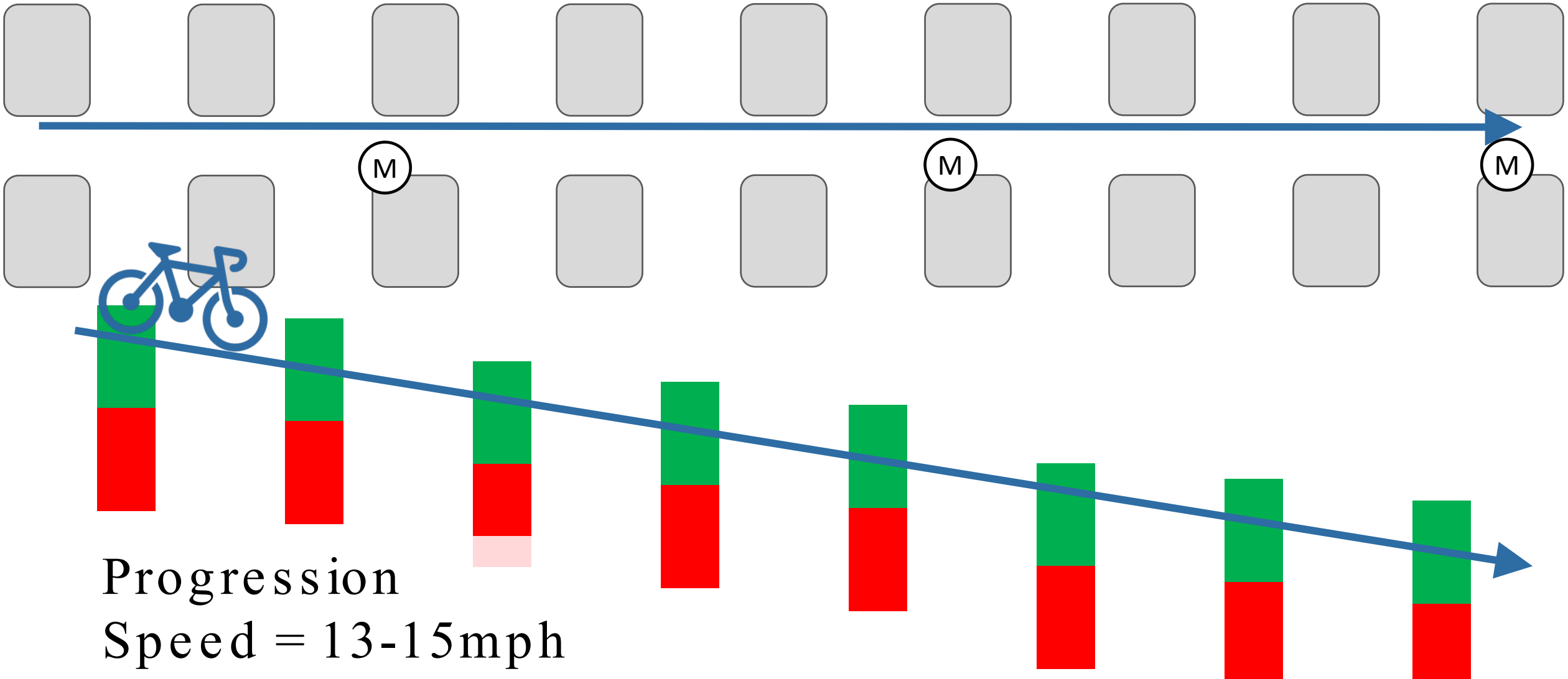


One-way progression – After

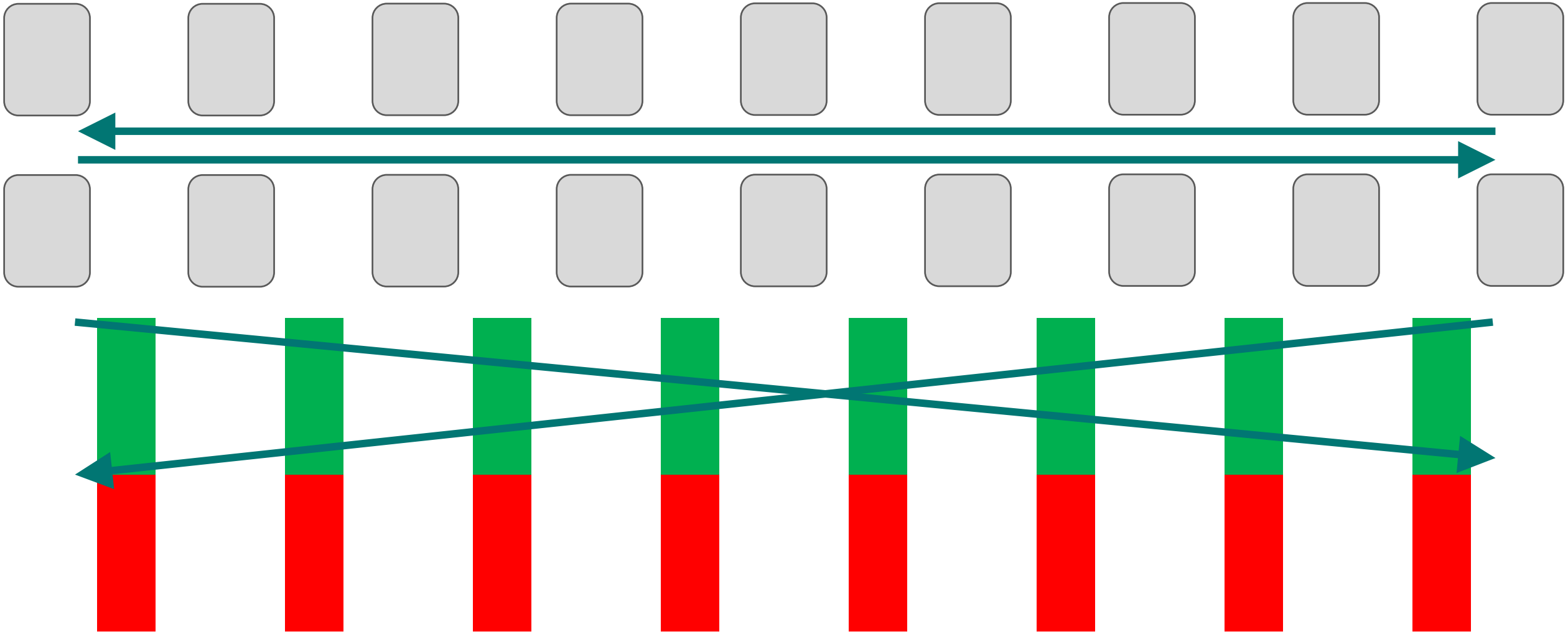


Progression
Speed = 13-15mph

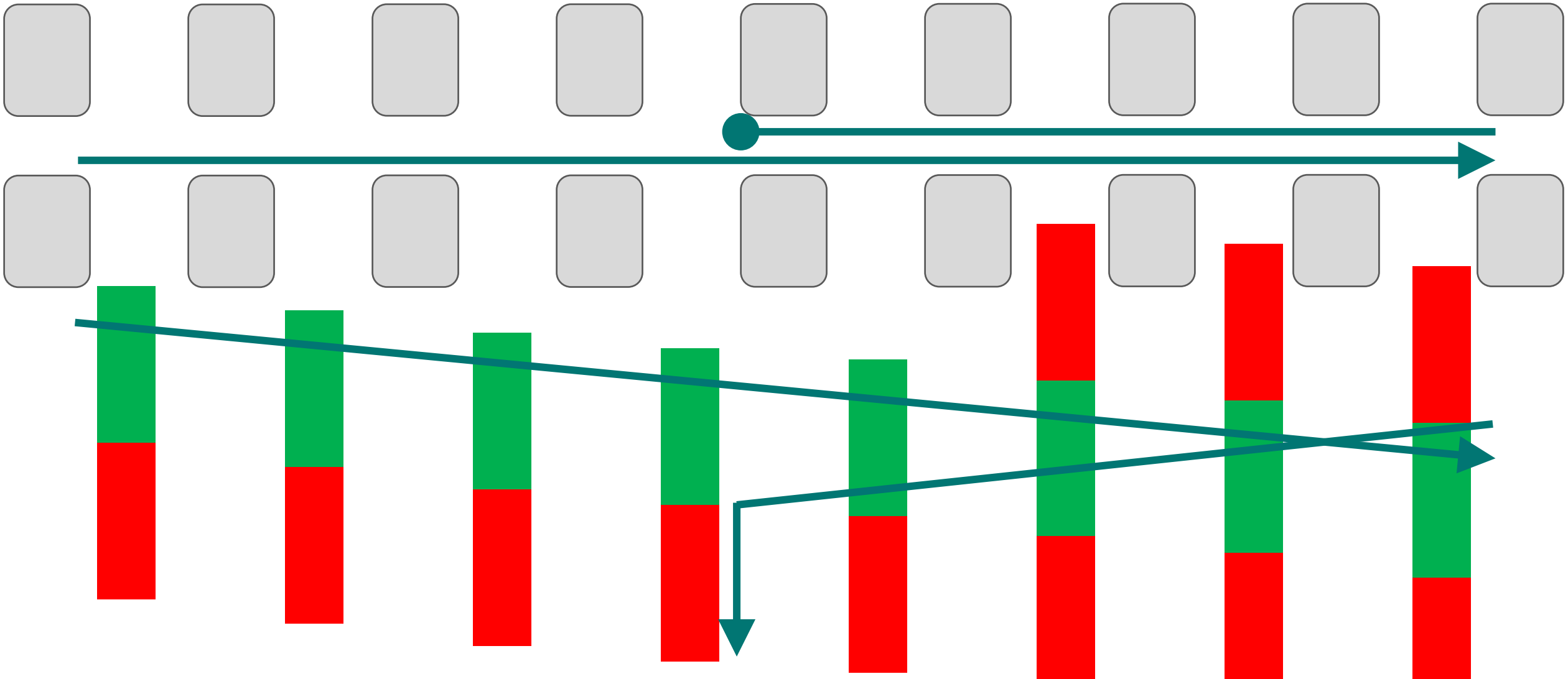
One-way progression



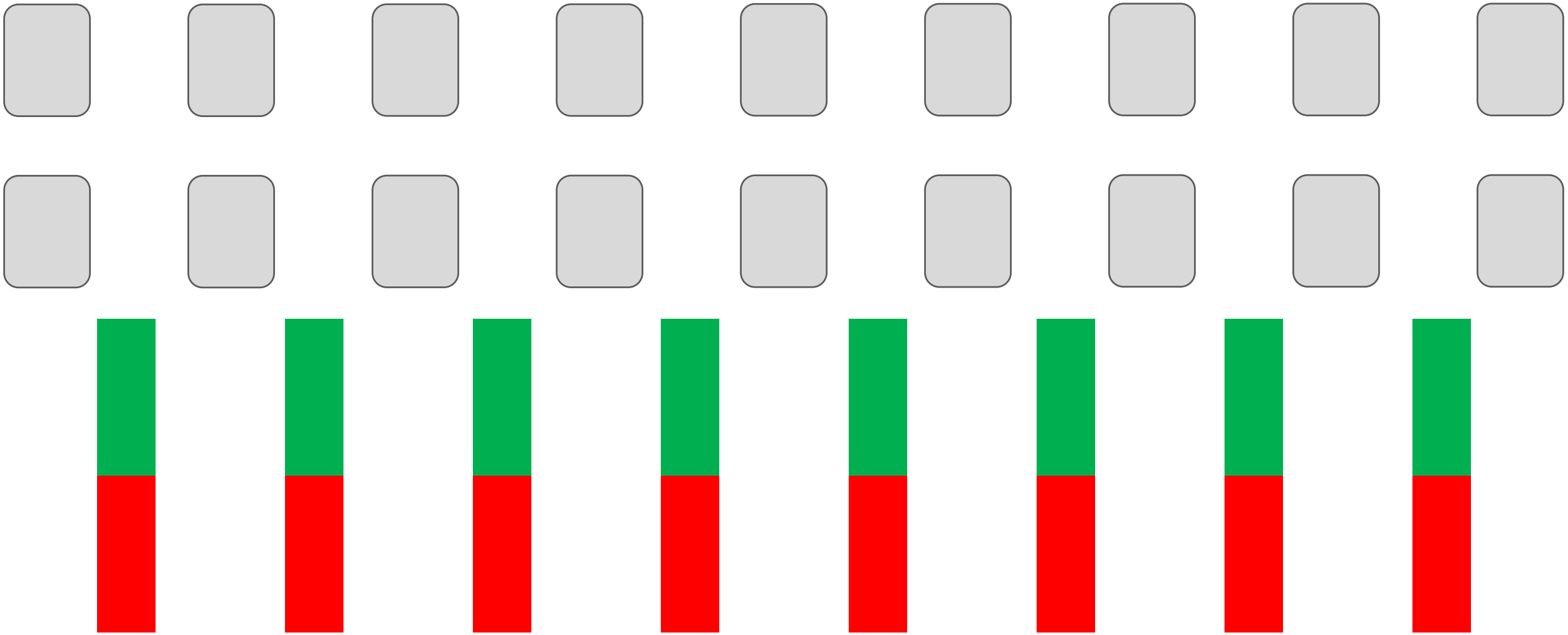
Two-Way Progression



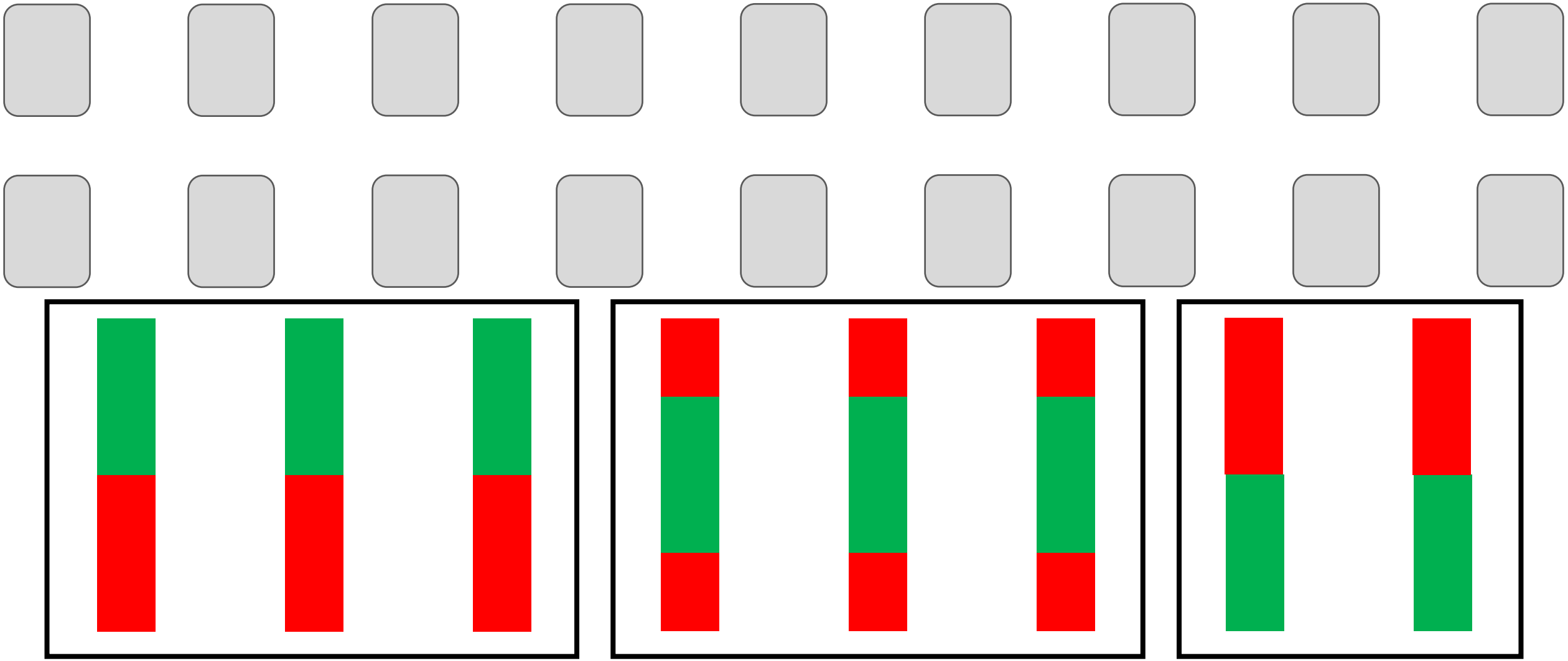
Two-Way Progression



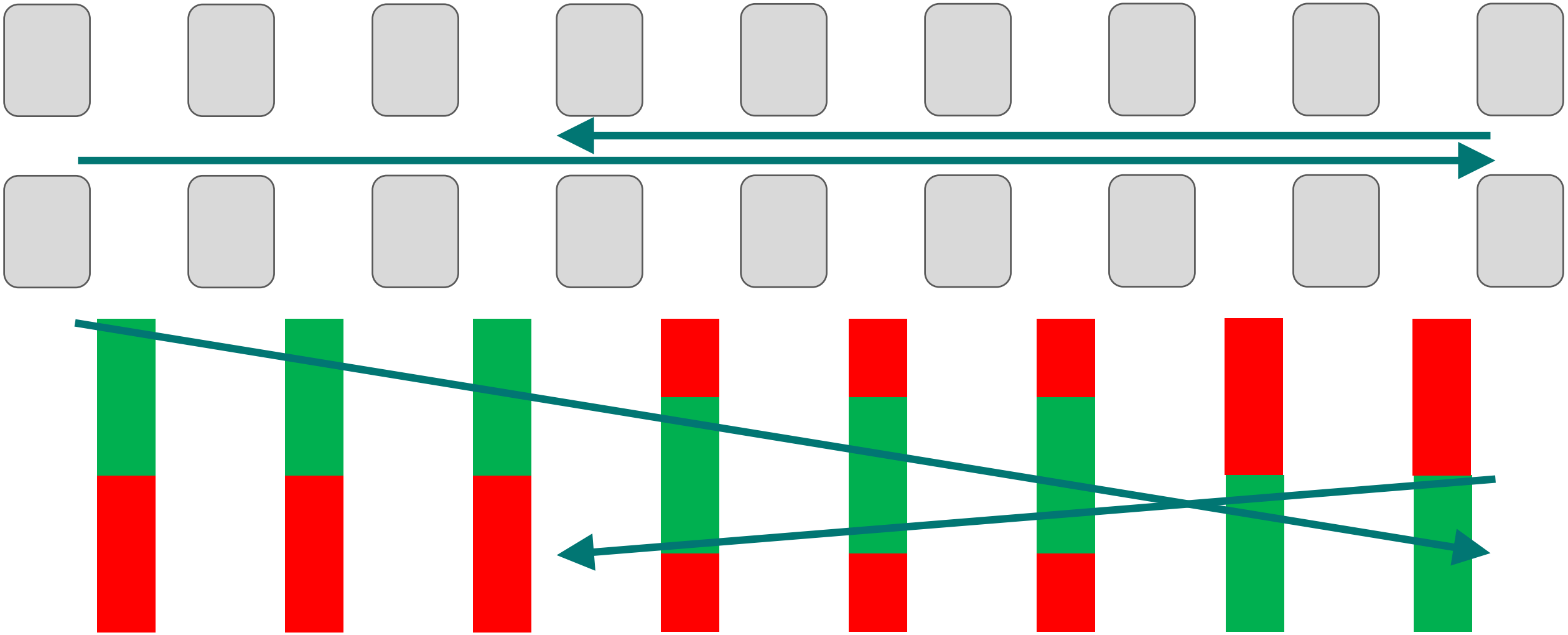
Two-Way Progression



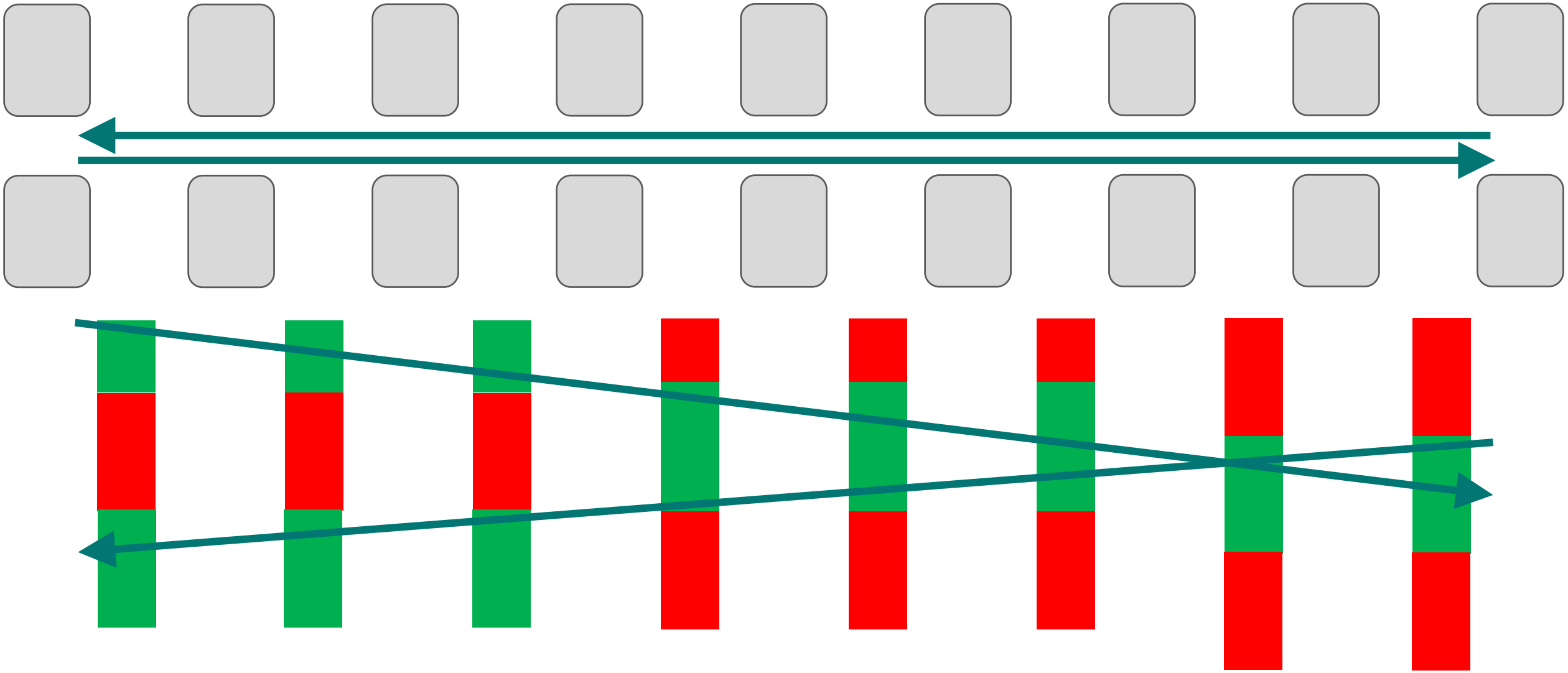
Two-Way Progression



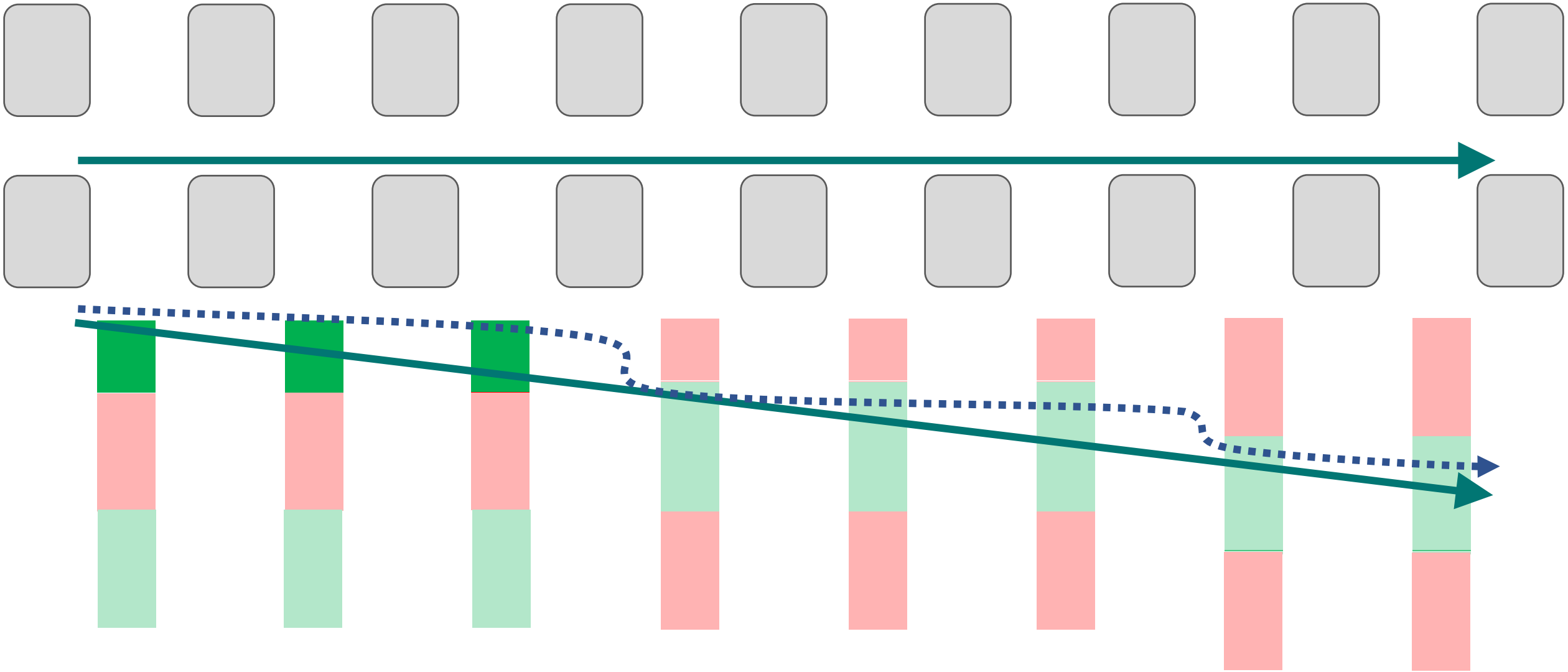
Two-Way Progression



Two-Way Progression



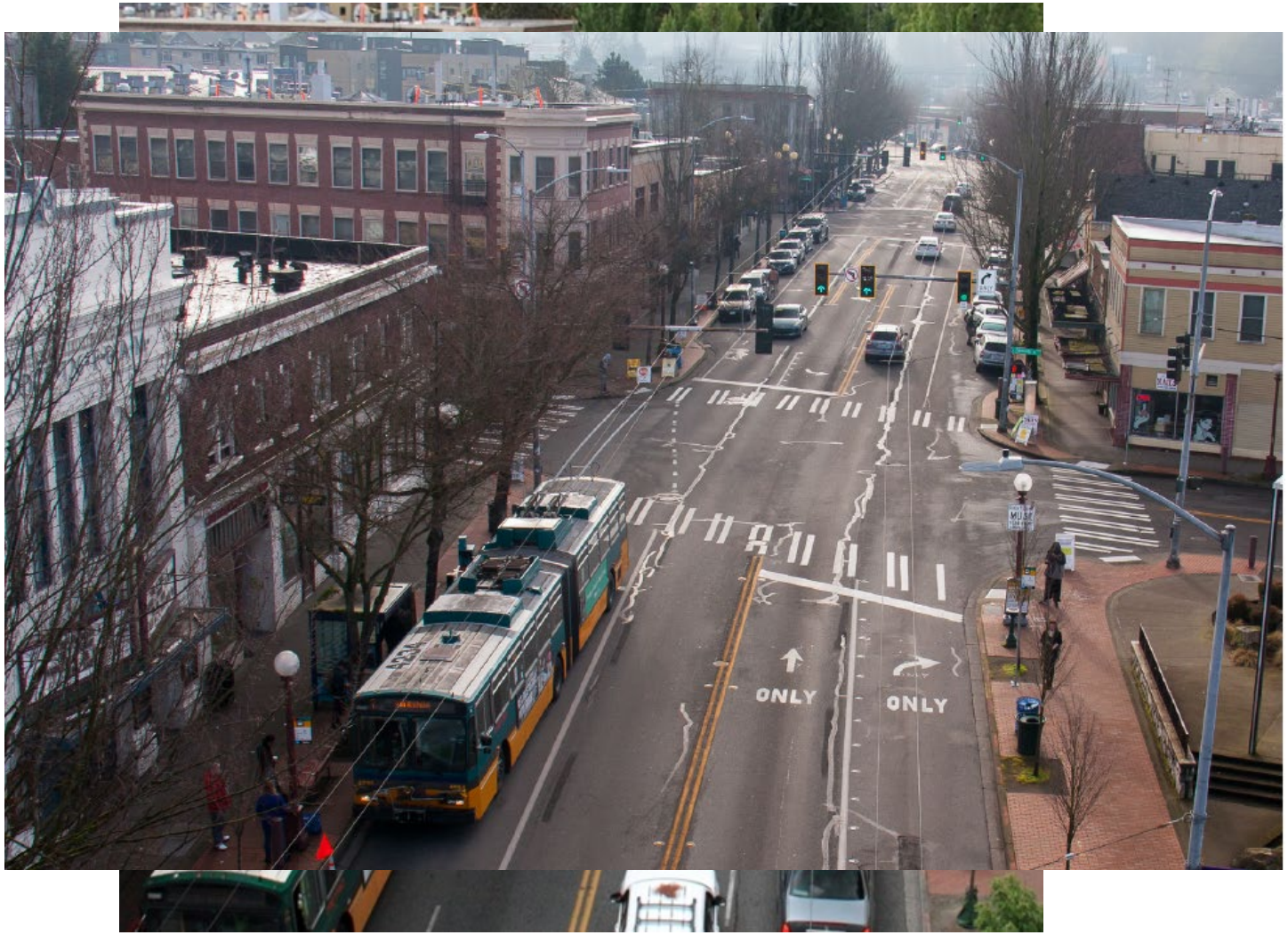
Two-Way Progression – Speed Mgmt



Shorter Cycle Lengths can help control speeding, reduce delay penalty

- Fill “gaps” in the platoon with slower progression speed
- Use small clusters / signal blocks to disincentivize speeding (decrease “unconstrained arrivals”)
- Shorter Cycle Length reduces network delay

Longer Cycle Lengths can offset delay during peak hours



AM Peak	
Street	Before
S Edmunds St	60
S Ferdinand St	60
S Hudson St	60
39th Ave S	60
Brandon St	60
S Orcas St	60
S Kenny St	60

Longer Cycle Lengths can offset delay during peak hours

AM Peak		
Street	Before	After
S Edmunds St	60	120
S Ferdinand St	60	120
S Hudson St	60	120
39th Ave S	60	60
Brandon St	60	60
S Orcas St	60	120
S Kenny St	60	60

Longer Cycle Lengths can offset delay during peak hours

Off-Peak		
Street	Before	After
S Edmunds St	60	60
S Ferdinand St	60	60
S Hudson St	60	60
39th Ave S	60	60
Brandon St	60	60
S Orcas St	60	60
S Kenny St	60	60

Rainier Ave S, Seattle

Motor Vehicle Travel Times

Direction	Before	After	Change
NB	07:52	08:47	+ :55
SB	09:39	10:59	+ 1:20

Transit Travel Times

Direction	Before	After	Change
NB	19:32	16:31	- 3:01
SB	15:34	15:36	+ :02

Motor Vehicle Speeding ↓ 40%

High-End Speeding (over 40mph) ↓ 75%

Identify Sources of Delay

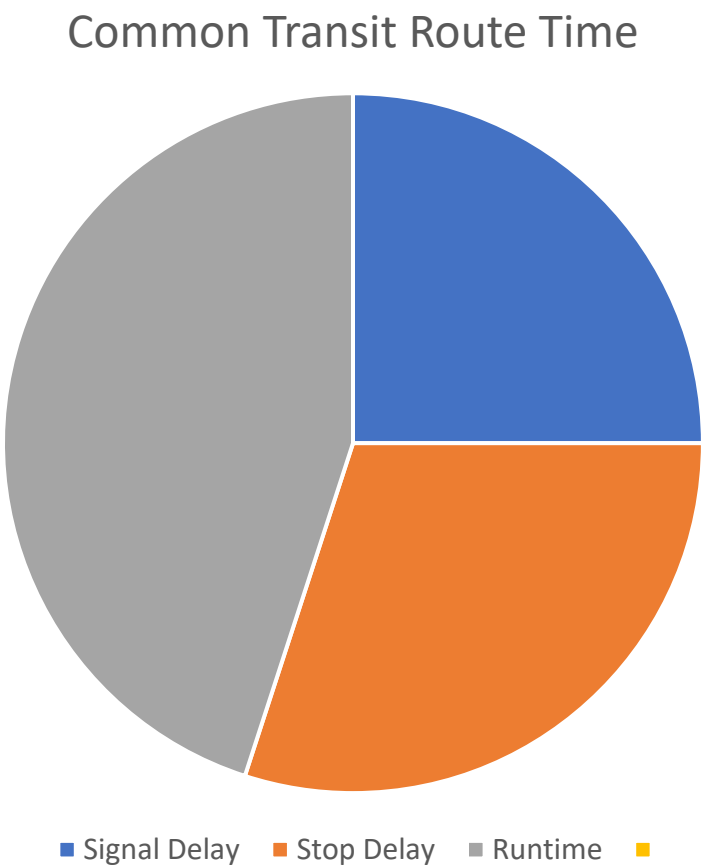
"What's the problem I want to solve?"

Identifying Sources of Delay

- Dwell-time Delay at Stops
- Intersections: Turn Delay
- Intersections: Queue Length Delay
- Remerge Delay

Identifying Sources of Delay

- Stop / Dwell Delay
  - "Doors open to Doors Close"
  - 25th / 50th / 75th percentile dwell
  - May not capture remerge delay
- Intersection / Signal Delay
  - Setting AVL waypoints / frequency
- Runtime
  - May include Queue Delay



Delay by Segment

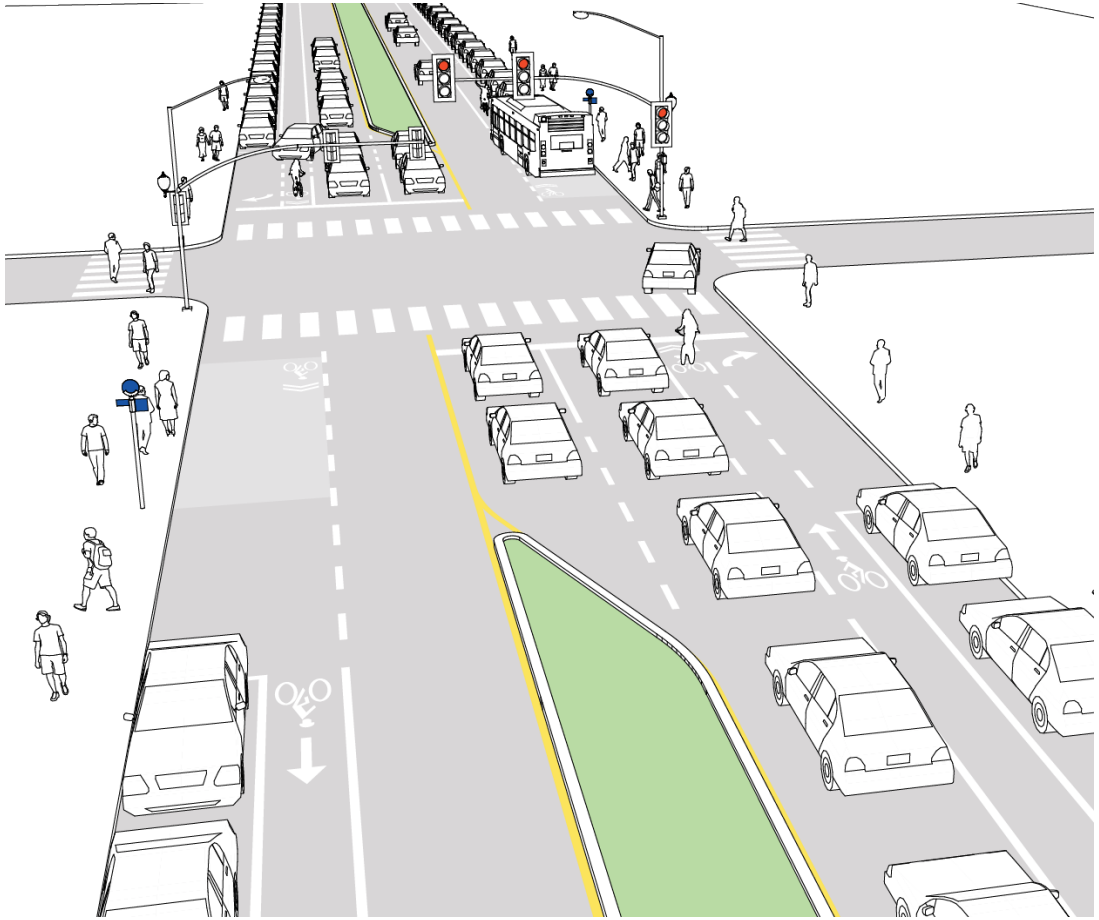
Intersection Delay: Time-Lapse

Intersection Delay: Time-Lapse

Quantifying delay at a single stop

Broadway / 14th St SB	**Weekday 7:30am - 5pm**
Total number of buses (southbound)	315
Number of buses delayed	110 (35%)
Maximum delay per bus	77s
Cumulative delay of southbound buses	26m 30s
Avg delay per delayed bus	14.5s
Avg delay across all buses	5.0s
Total daily southbound ridership	3,470
Total customer delay per day	**4.9 hours**

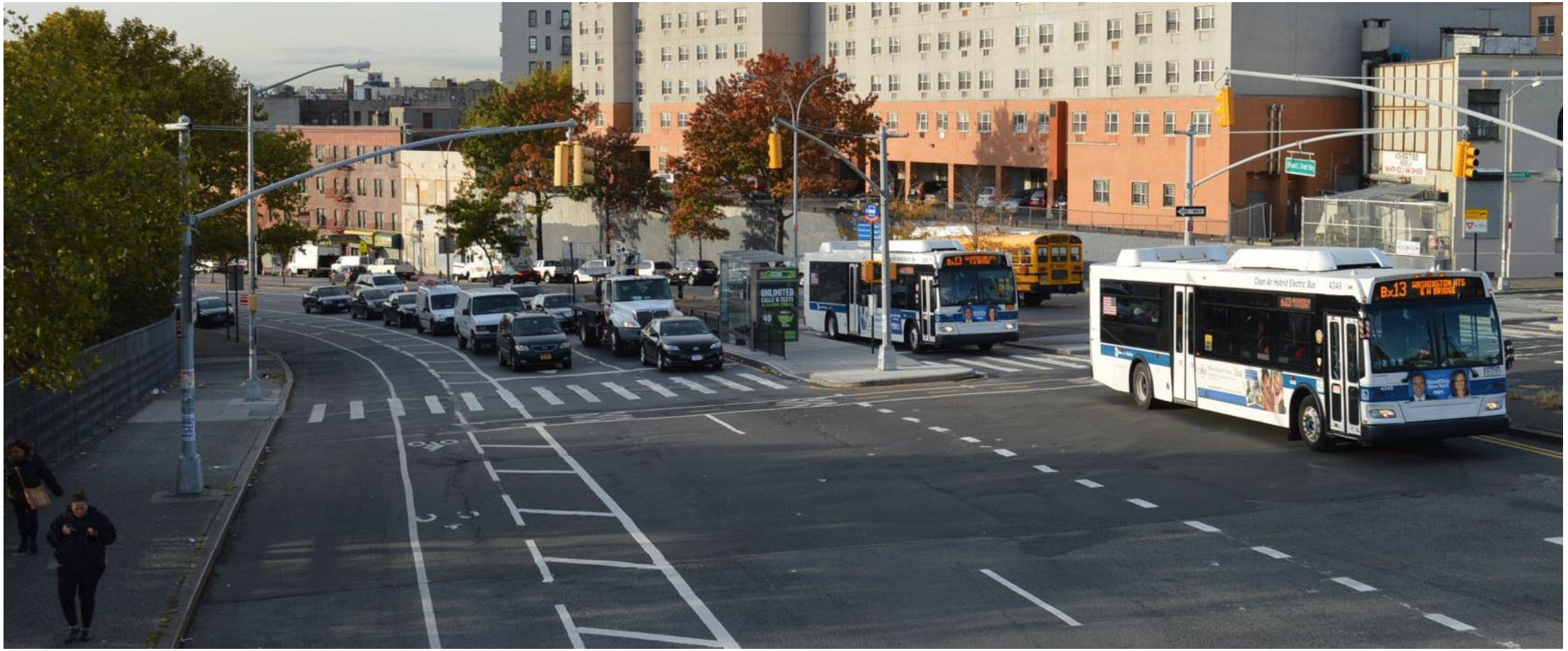
Stop / Dwell Delay



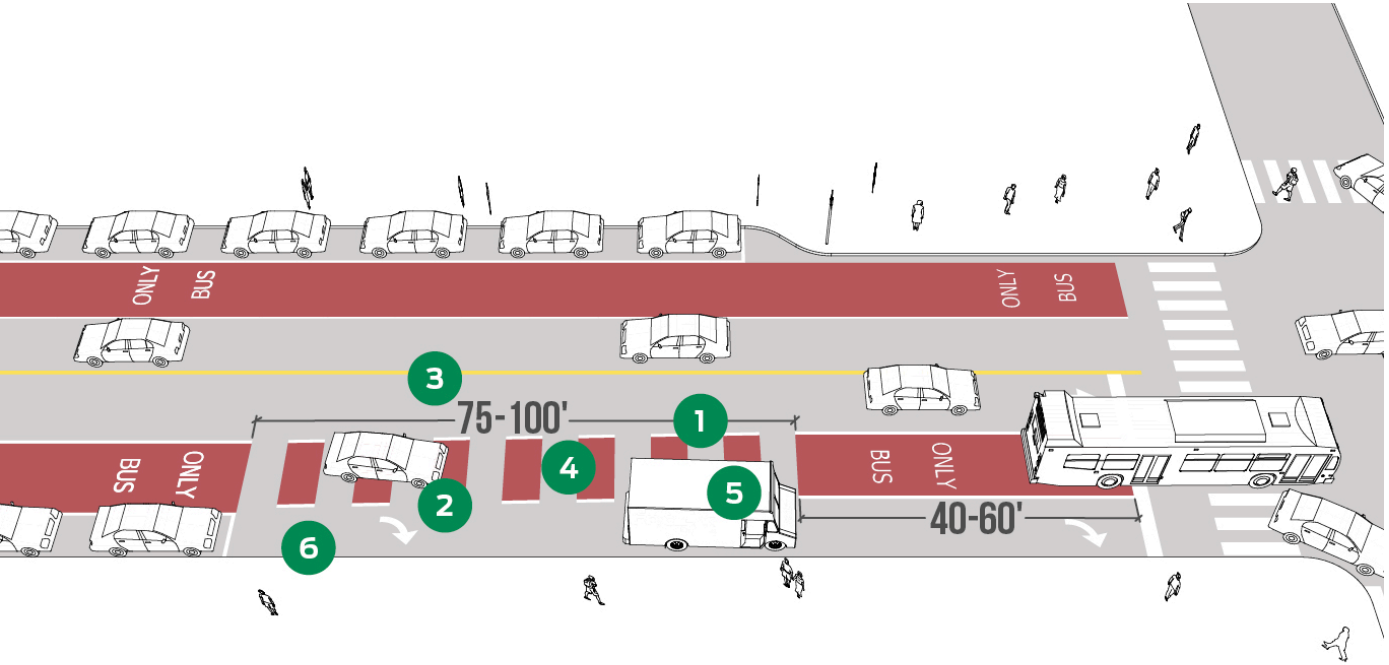
- ✓From Pull-Out to In-Lane Stops + Passive TSP
- ✓Increase Signal Offsets
- ✓Active TSP (far-side)
- ✓Queue Jump (near- or far-side)

Stop / Dwell Delay

Stop / Dwell Delay



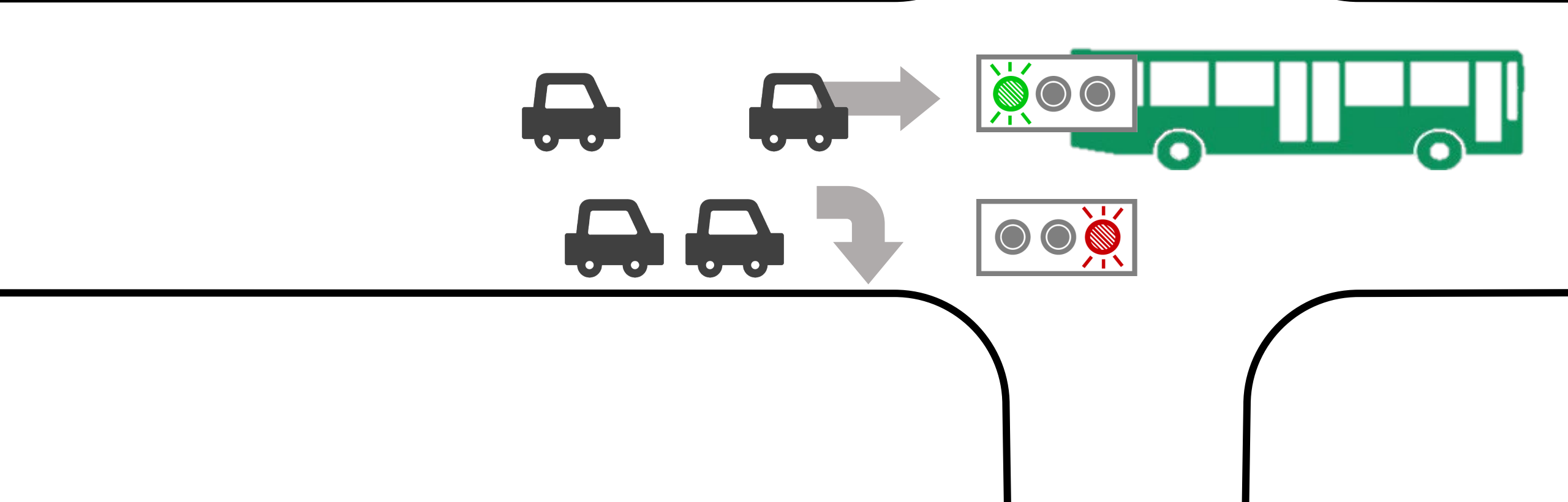
Turning Vehicle Delay



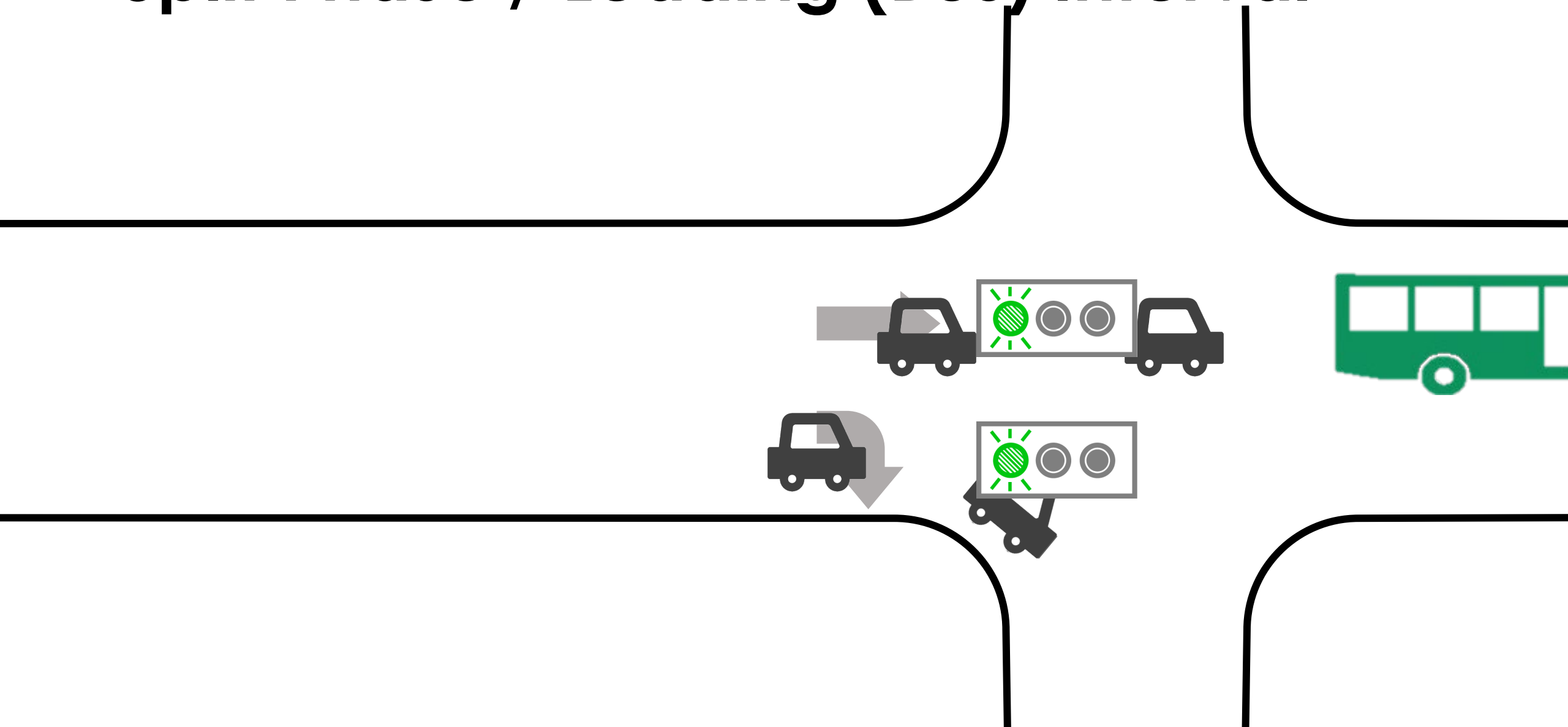
- ✓Transit Approach Lane + Active / Passive TSP
- ✓Right Turn Pocket + Split Phase
- ✓Dropped Transit Lane
- ✓Turn Prohibitions

Split Phase / Leading (Bus) Interval

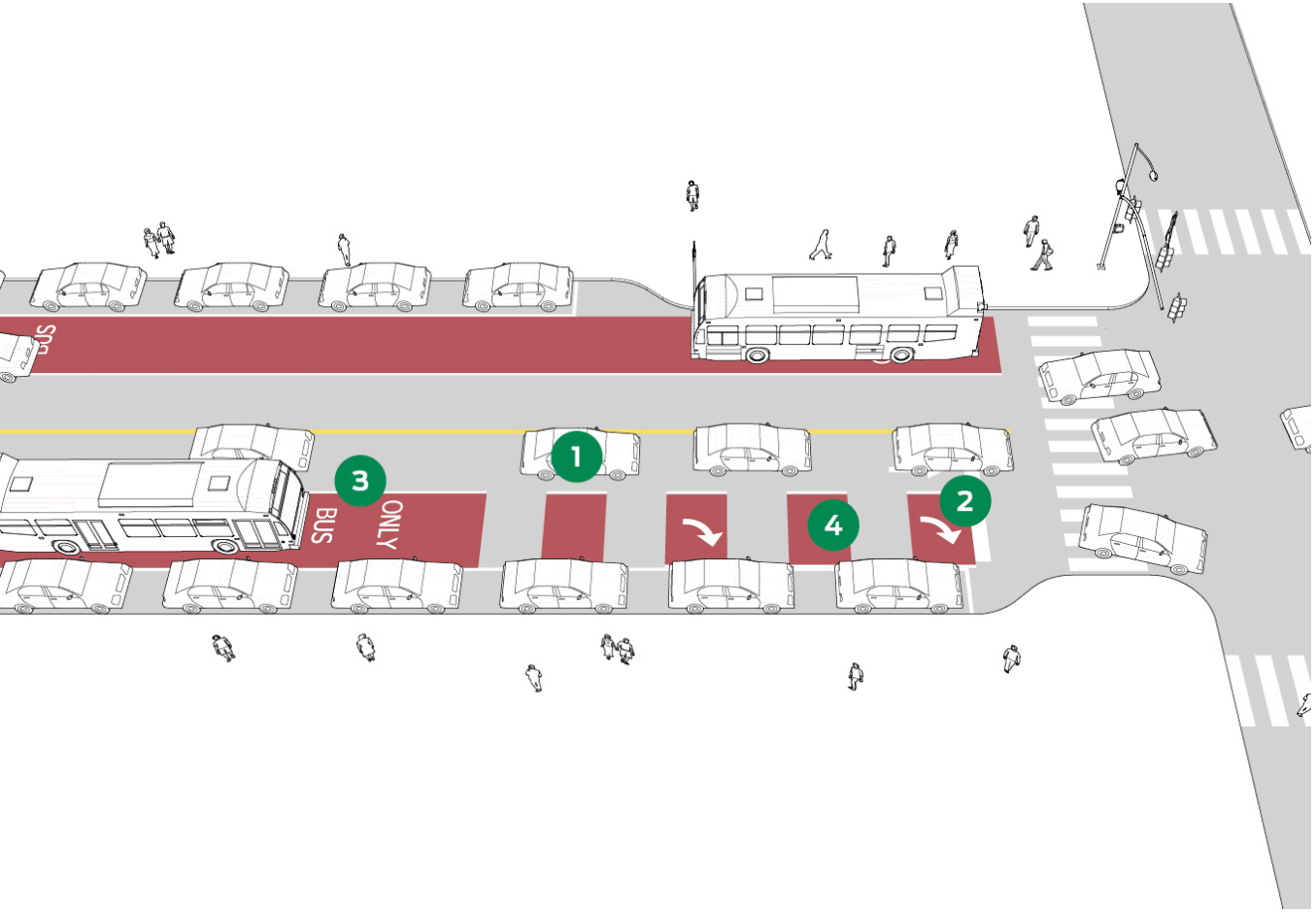
Split Phase / Leading (Bus) Interval



Split Phase / Leading (Bus) Interval

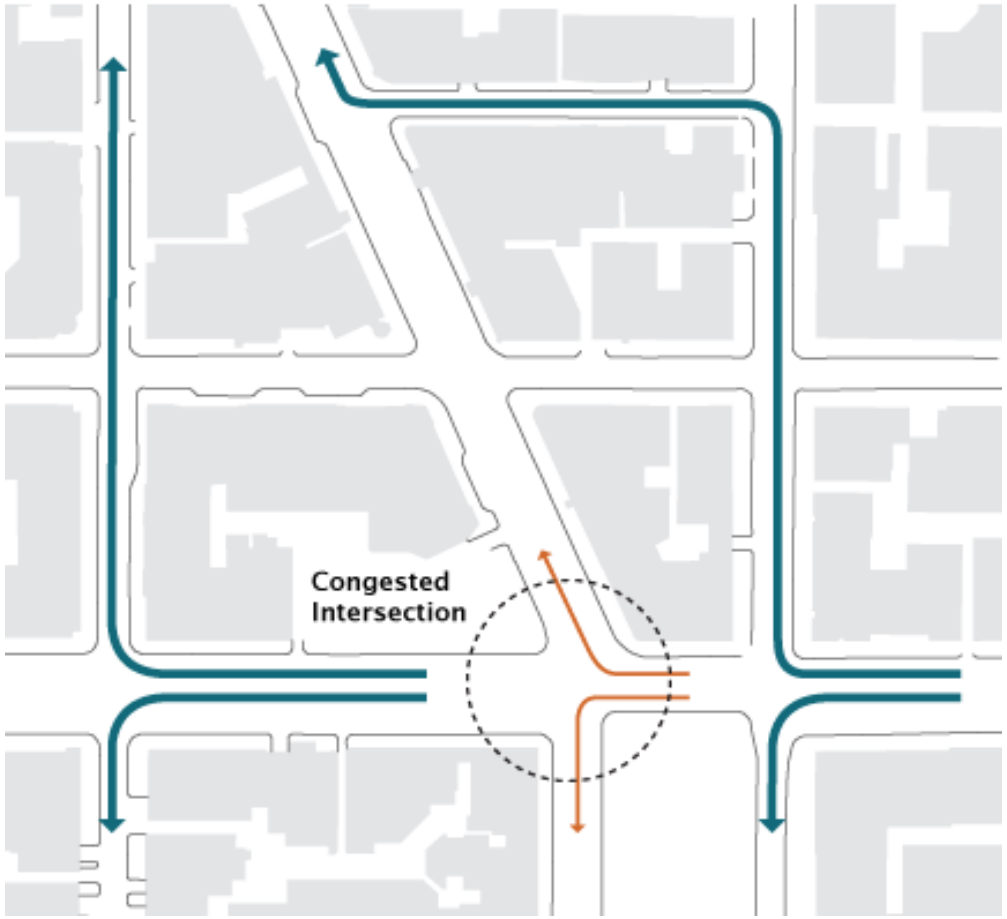


Queue Length Delay



- ✓Transit Lane + Active / Passive TSP
- ✓Shared Right Turn / Transit Lane
- ✓Traffic Metering (Forced Turns, Green Truncation)

Turn Prohibitions



- Reroute Before
- Reroute After
- Right-Left-Left
- Three Rights