Novel Transit Management Strategies: Driver Advisory Systems with Cooperative Space and Time Priorities

Kareem Othman
Amer Shalaby
Baher Abdulhai

TAL TRANSIT ANALYTICS LAB
CATTS | CENTRE FOR AUTOMATED AND TRANSFORMATIVE TRANSPORTATION SYSTEMS
UNIVERSITY OF TORONTO
Mobility Network

Agenda

- Background
- Objectives
- Driver Advisory System (DAS)
- DAS algorithms (4 algorithms)
- Supporting Strategies (space and time priority)
- Simulation Results
- Conclusions

Background/Motivation

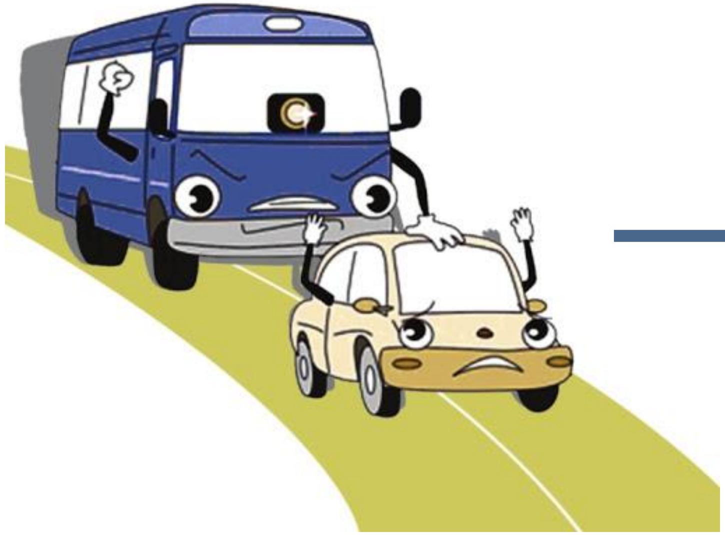
Minimize bus energy consumption

Improve ride quality/comfort

Speed

Reliability

+



Traditional

Win-Win

Mitigating the impact on the general traffic

Objectives

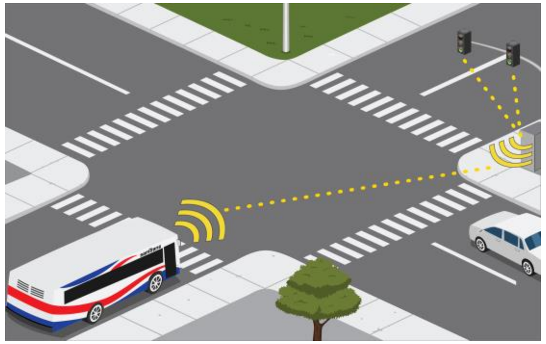
- Propose novel transit management strategies that improve both transit and traffic performance:
  - Improve transit service performance (speed, reliability, comfort, and energy consumption)
  - Give priority to transit
  - Minimize the impact on the general traffic

Proposed Strategies

Choose the bus speed

Driver Advisory system (DAS)

Space Priority (EBLs, DBLs)



Time Priority (TSP)

Supporting Strategies

Driver Advisory System (DAS)

- Allows buses to arrive at the intersections when the signal is green
- Based on CV technology (V2I)
- Reduces the instances of bus stopping (Lower energy consumption, Environmentally friendly, Improve comfort, Achieve max travel speed)

Driver Advisory System (DAS) Components

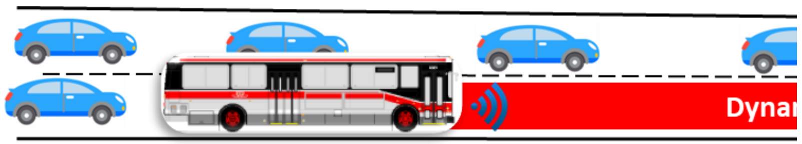
Driver Advisory system (DAS)

Green Light Optimal Speed Advisory (GLOSA)

Green Light Optimal Dwell Time Advisory (GLODTA)

Space Priority (su

- To allow the bus to
  Two strategies are
  - EBLs
  - Dynamic Bus lane
    - These lanes are ac
      present
    - Connected vehicle



Transportation Research Record: Journal of the Transportation Research Board

NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

Impact Factor: **2.019** / 5-Year Impact Factor: **2.005**

Open access | Research article | First published online June 14, 2022

Dynamic Bus Lanes Versus Exclusive Bus Lanes: Comprehensive Comparative Analysis of Urban Corrido Performance

Kareem Othman, Amer Shalaby, and Baher Abdulhai View all authors and affiliations

Volume 2677, Issue 1 | https://doi.org/10.1177/03611981221099517

Contents | PDF / ePub | Cite article | Share options | Information, rights and permissions | Metrics and citati

Abstract

Exclusive bus lane (EBL) is one of the most common transit prioritization strategies implemented to improve transit speed. However, one major drawback of implementing EBLs is the associated reduction in road capacity left for other road users. In corridors with EBLs and infrequent bus service, the lanes are underutilized for extended periods of time. Dynamic bus lane (DBL), a new priority strategy enabled by vehicle connectivity, can provide buses with priority while allowing the general traffic to access the bus lane when buses are not present. Although the DBL concept is promising, a limited number of studies have explored its effectiveness under various conditions. Thus, this paper investigates the impacts of DBLs through a comparison with EBLs and mixed traffic operation under different levels of traffic demand and transit frequency. As a case study, the Eglinton East corridor in Toronto, Canada, was simulated using Aimsun Next, and different scenarios of behavioral impacts were considered in the analysis. The results reveal that DBL is a promising strategy with potential to improve the overall corridor performance over a wide range of traffic and transit service conditions, especially under intermediate traffic demand levels. On the other hand, EBL can be an efficient prioritization strategy that improves the overall corridor

Relatec

Similar

Free

Peri
to D
Stuc

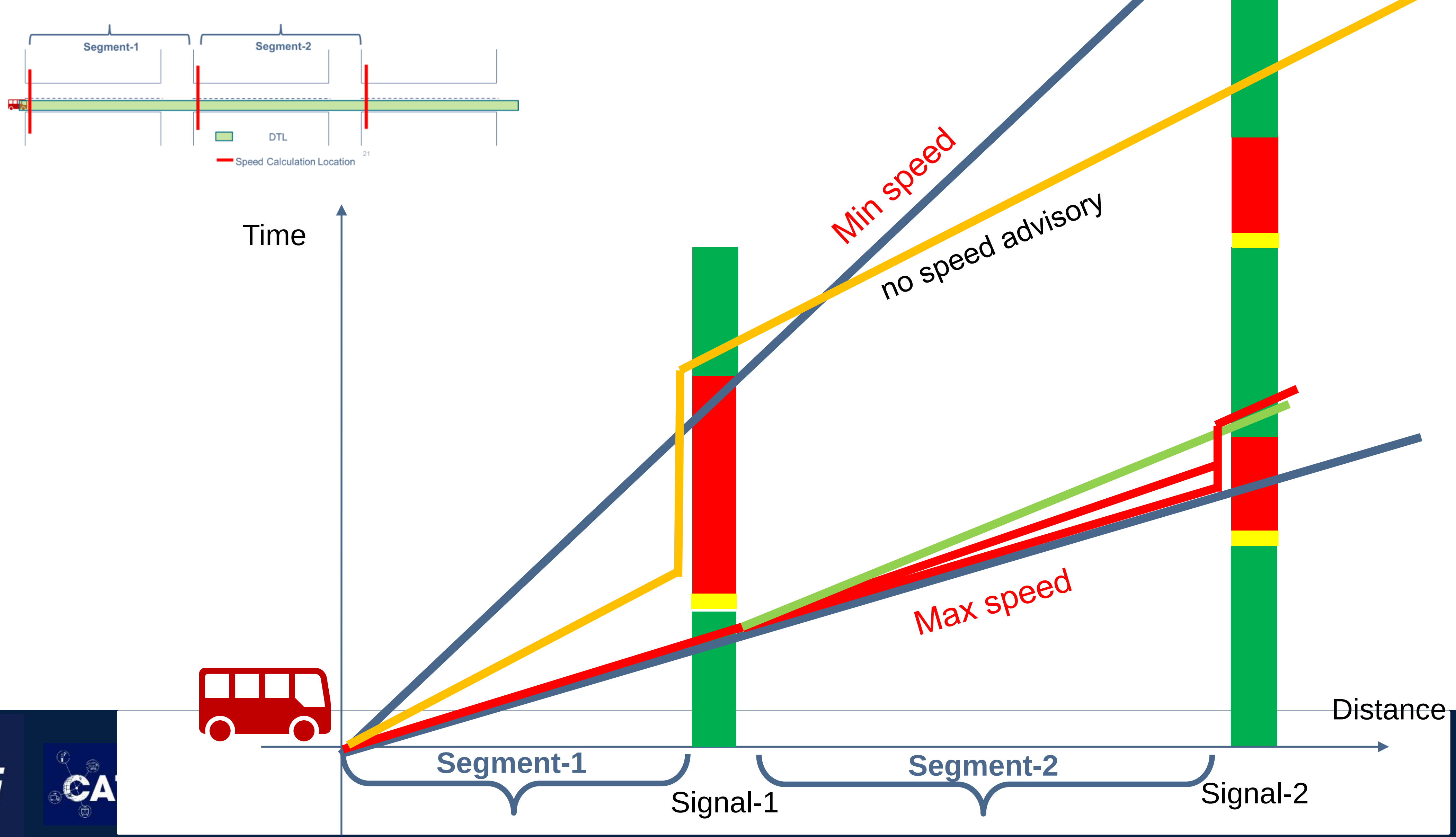
Sho

Free

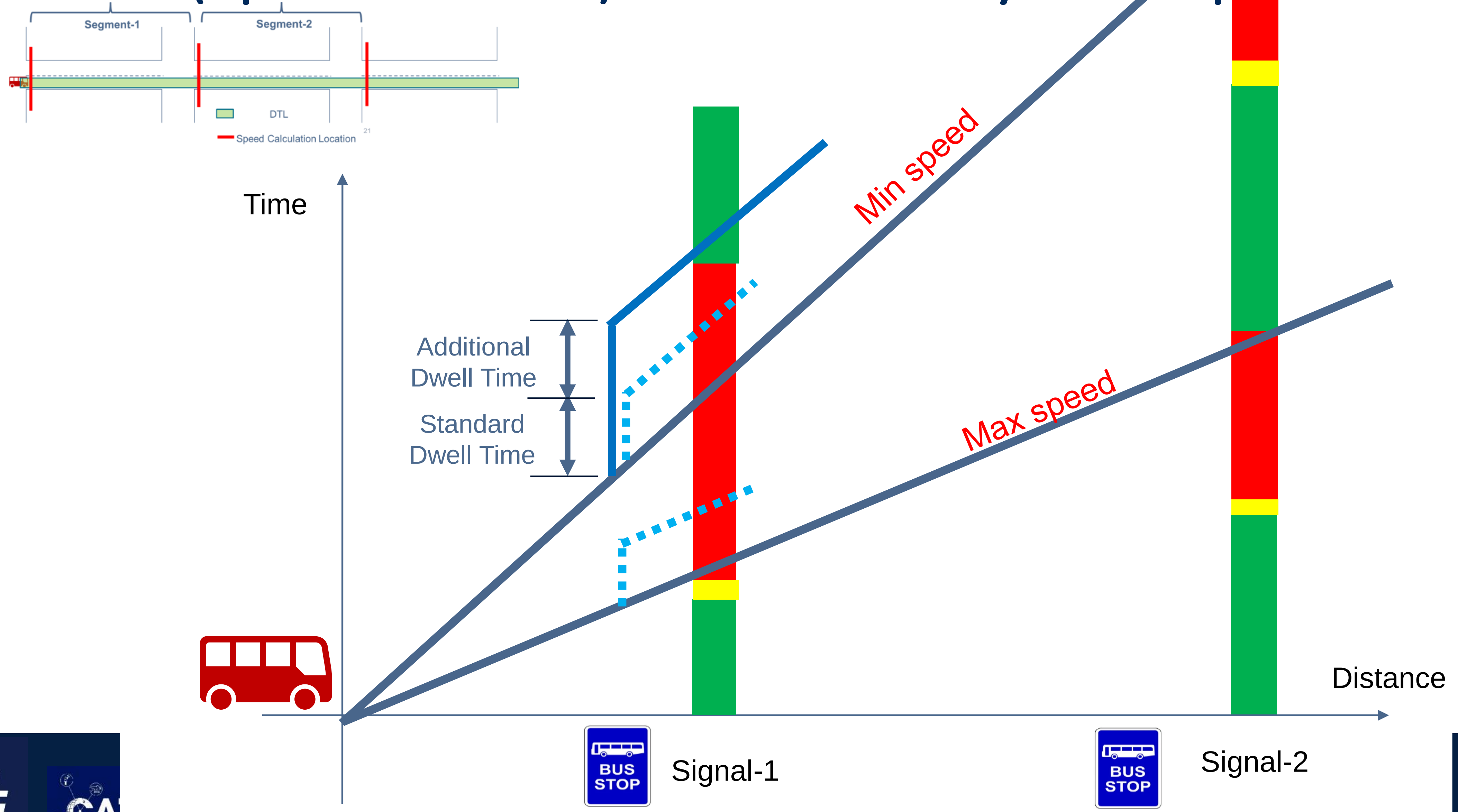
Dev
Usir

Sho

Driver (Speed)Advisory System Concept



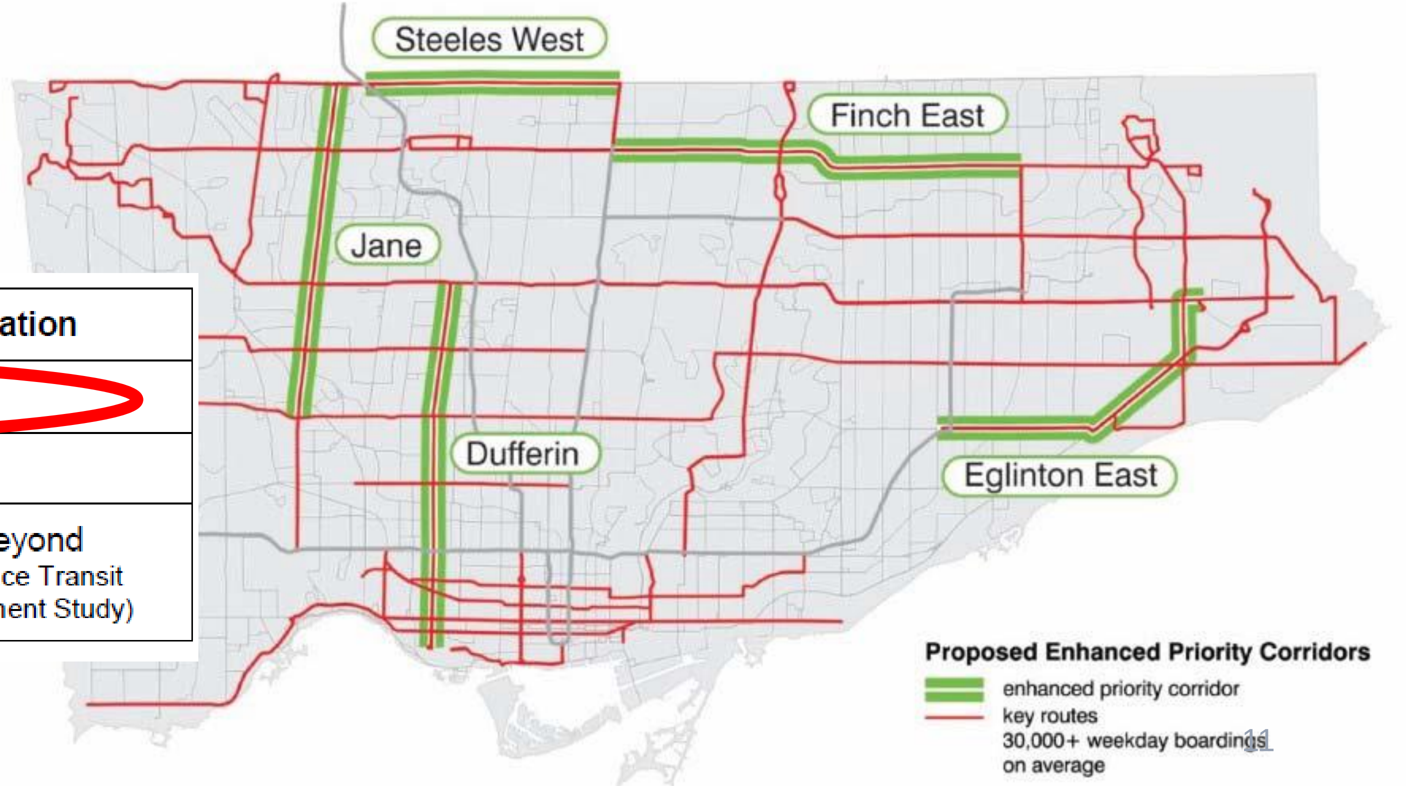
Driver (Speed + Dwell) Time Advisory Concept



Simulation Case study-RapidTO- Eglinton E

- In December 2019, the Toronto Transit Commission (TTC) Board approved the TTC's 5-Year Service Plan
- The TTC identified 5 corridors for the implementation of EBLs; these corridors experience heavy vehicles and carry high volumes of transit passengers

Priority	Corridor	Implementation
A	Eglinton East	2020
B	Jane Street	2021
C	Dufferin Street, Finch East, Steeles West	2022 and beyond (included in Surface Transit Network Improvement Study)

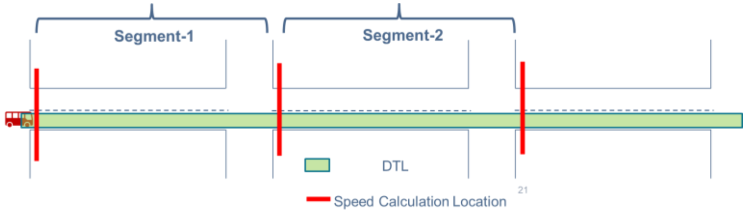


DAS Algorithms

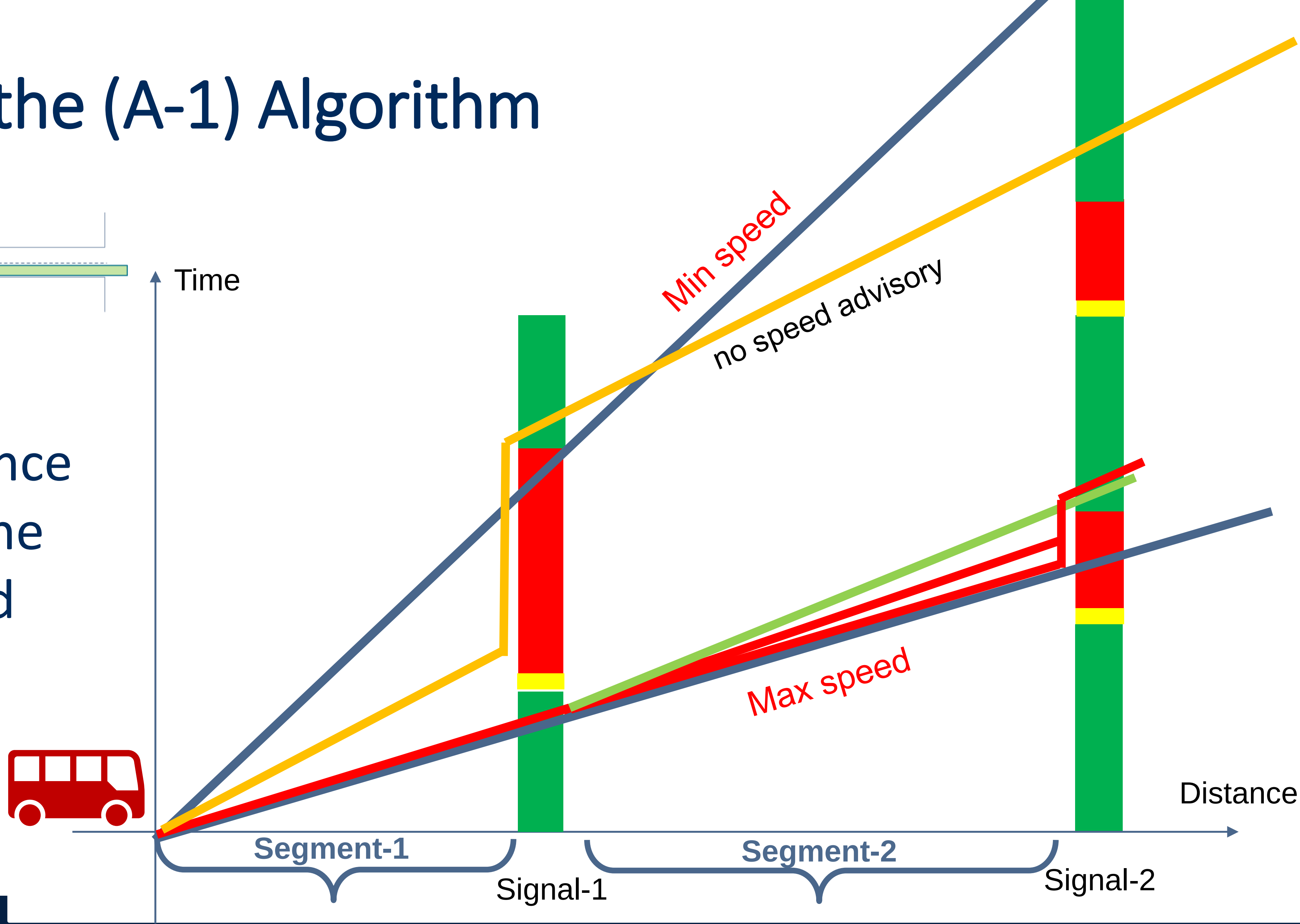
- Four algorithms with four different objectives are developed.

	Arrive at green	Comfort	Headway	Energy
A-1 (Arrive at green)	✓			
A-2 (Comfort Algorithm)	✓	✓		
A-3 (Headway Algorithm)	✓		✓	
A-4 (Energy Algorithm)	✓			✓

Description of the (A-1) Algorithm

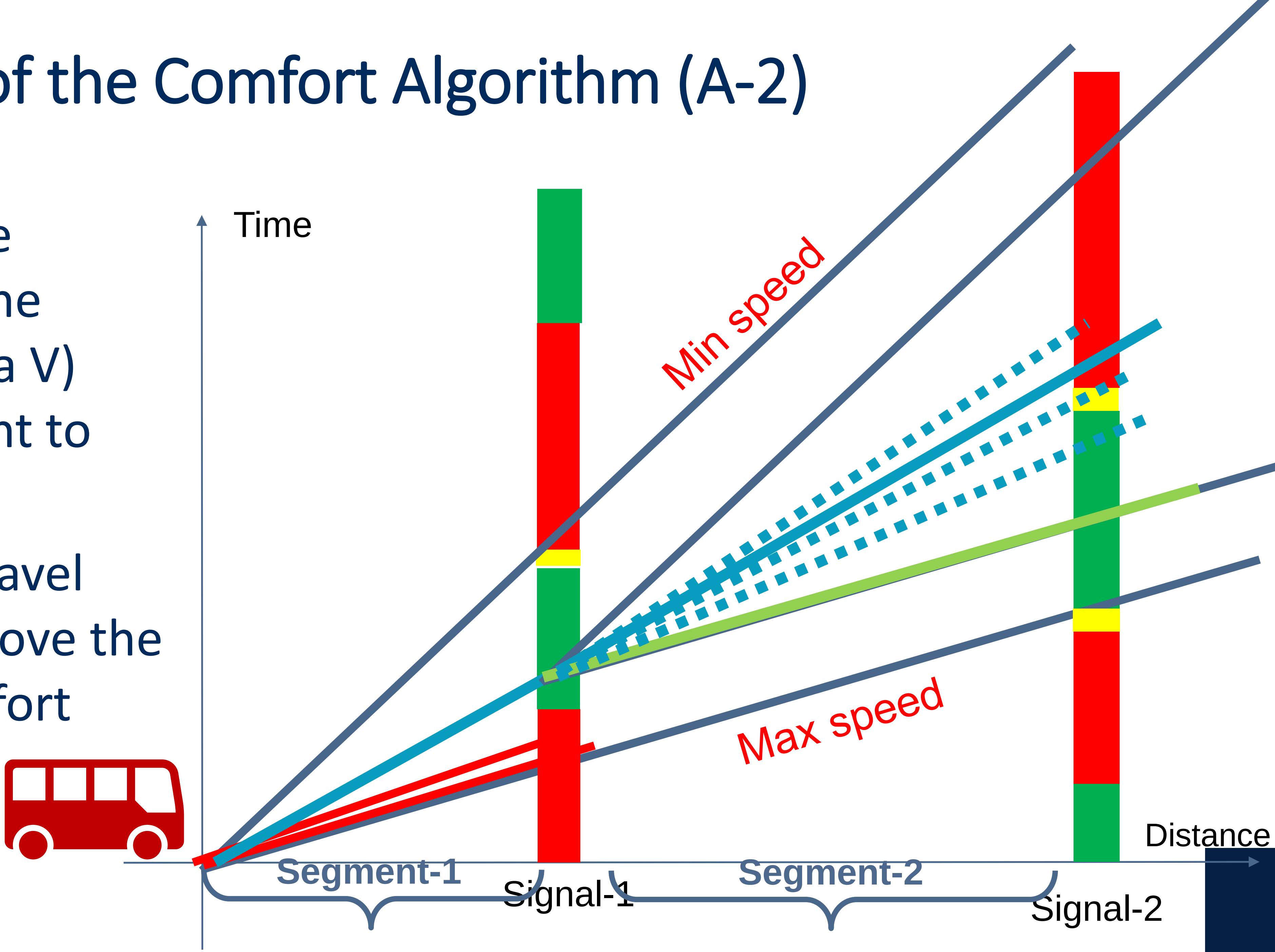


- Same performance as traveling at the maximum speed



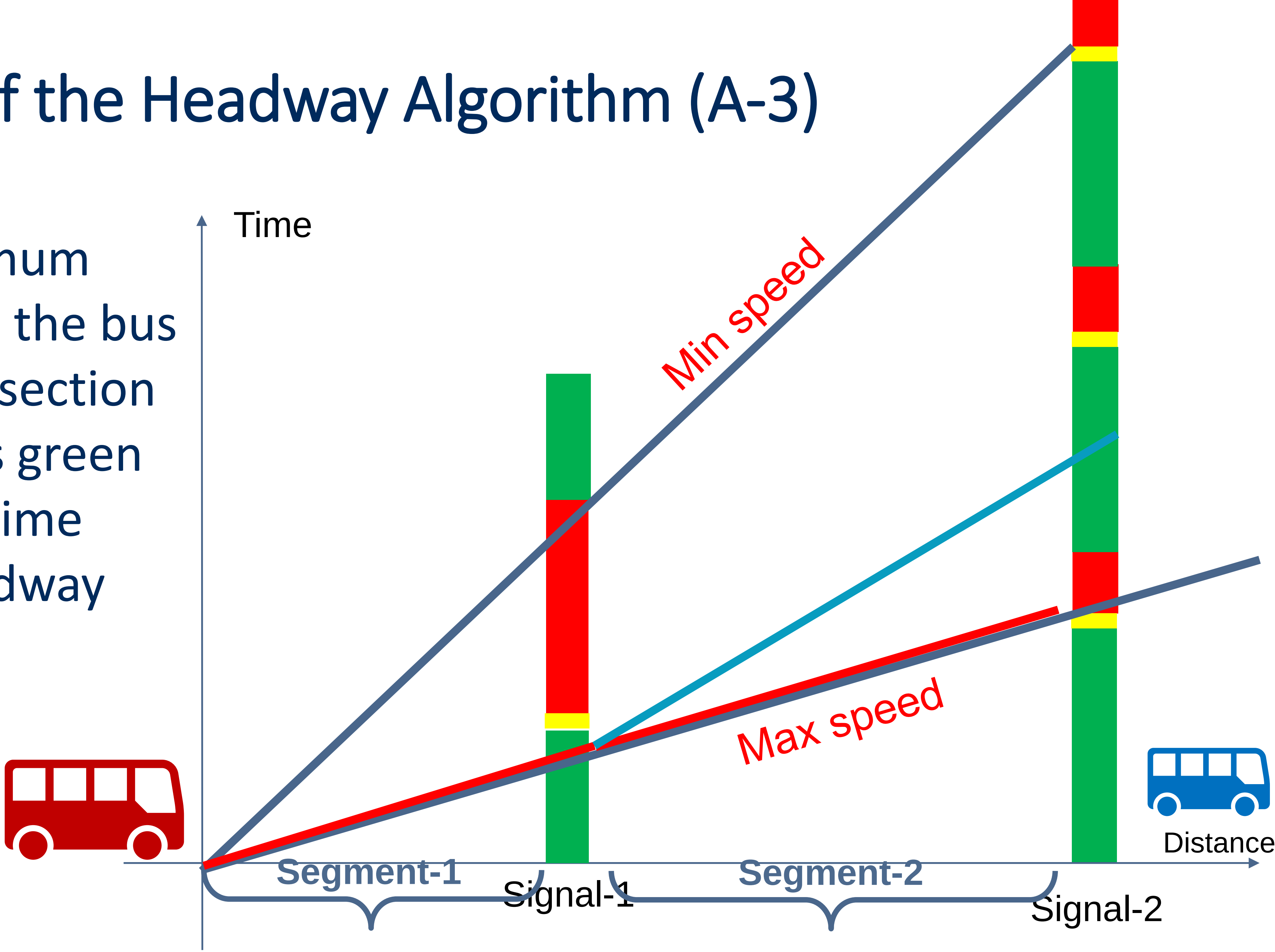
Description of the Comfort Algorithm (A-2)

- Minimize the changes in the speeds (delta V) from segment to segment
- Sacrificing travel time to improve the level of comfort



Description of the Headway Algorithm (A-3)

- choose the maximum speed that allows the bus to reach the intersection while the signal is green and at the same time maintain the headway regularity

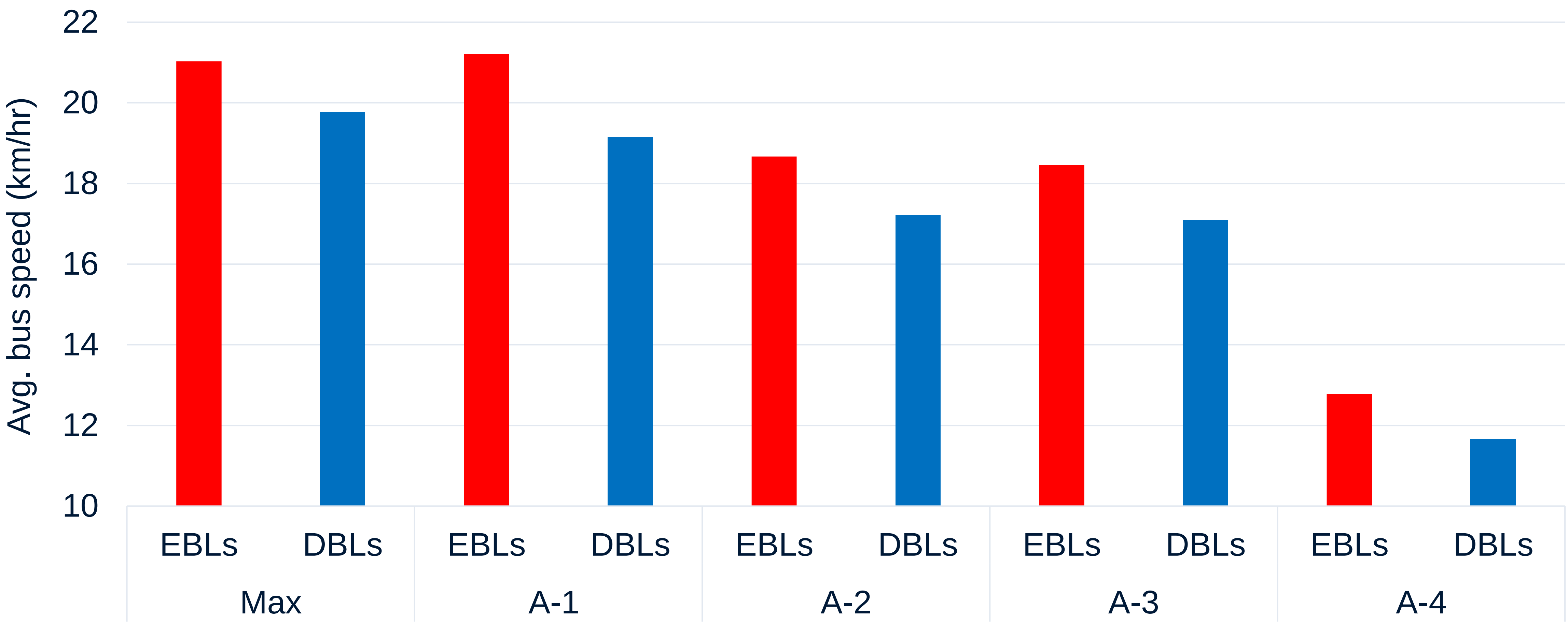


Description of the Energy Algorithm (A-4)

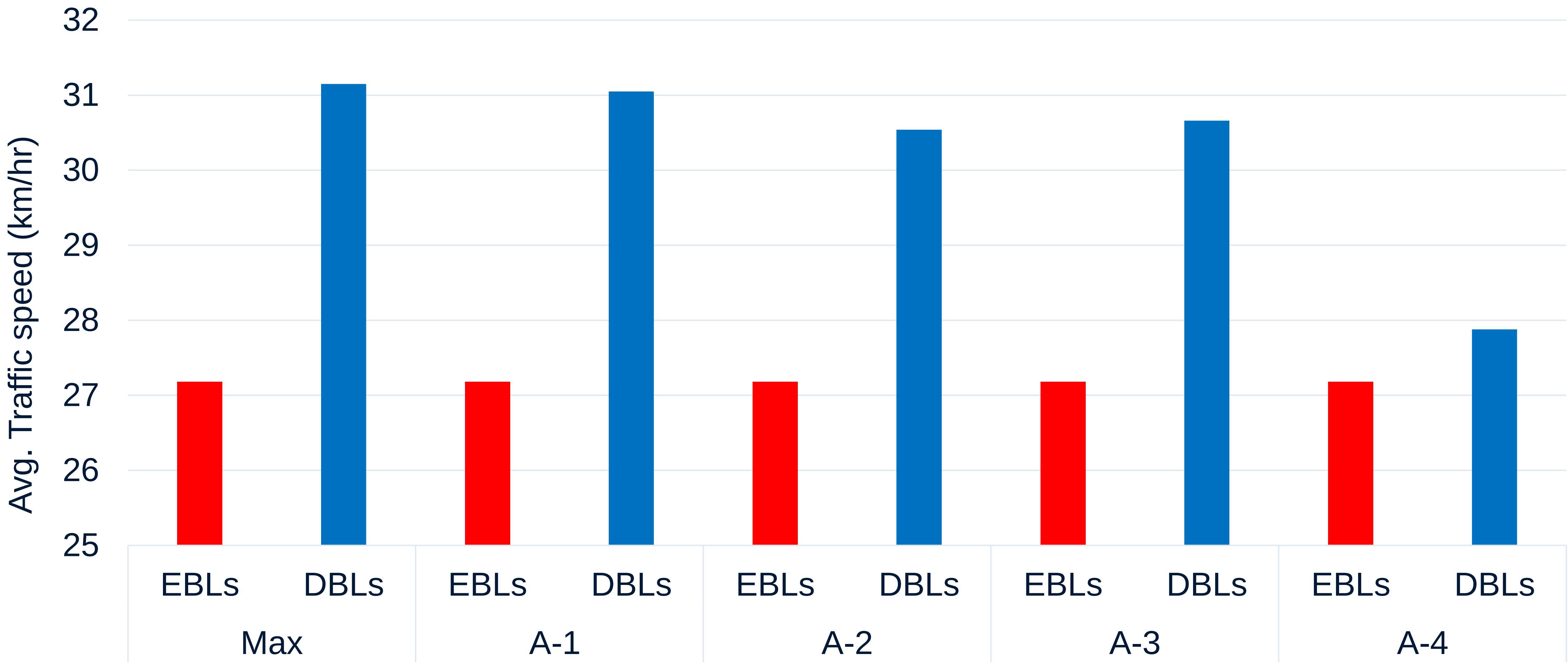
- Minimize the bus energy consumption rate based on Abdelaty and Mohamed (2022)
- $E_c = -0.885 + 0.38\,g + 0.012\,SoC_i + 0.260\,R_C + 0.036\,HVAC + 0.005\,P_L + 0.065\,D_{Agg} + \mathbf{0.128\,S_D} + \mathbf{0.007\,V_a} + 0.173C_D$

Where: E_c is the energy consumption rate (kWh/km), g = road gradient, SoC_i is the bus initial state of charge, R_C is the road condition (dry, wet, icy), $HVAC$ is the Heating, ventilation, and air conditioning, P_L is the passenger loading, D_{Agg} is the driver aggressiveness in terms of acceleration and deceleration, S_D is the stop density represented as the average number of bus stops per km (including stops for dwelling and stops at the intersections), V_a is the average bus speed, and C_D is the drag coefficient.

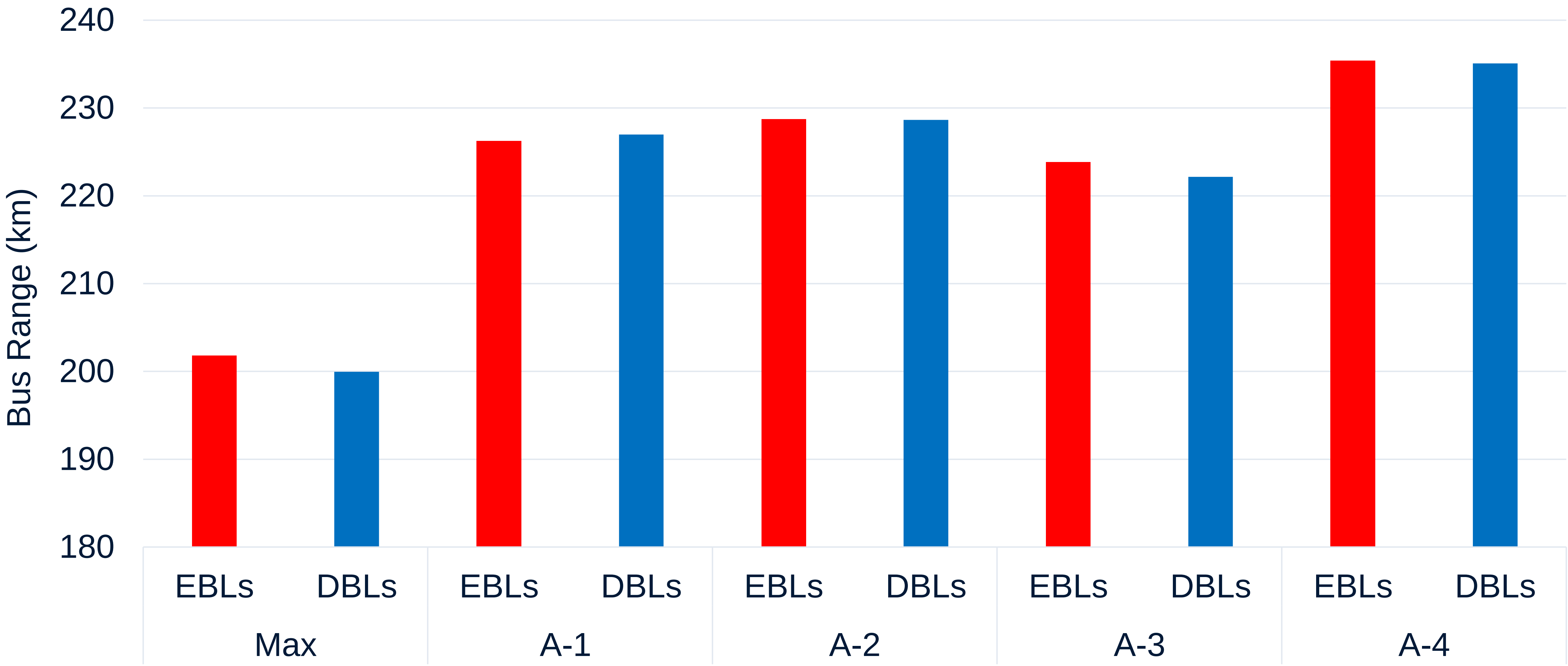
Results (Average bus speed)



Results (Average traffic speed)

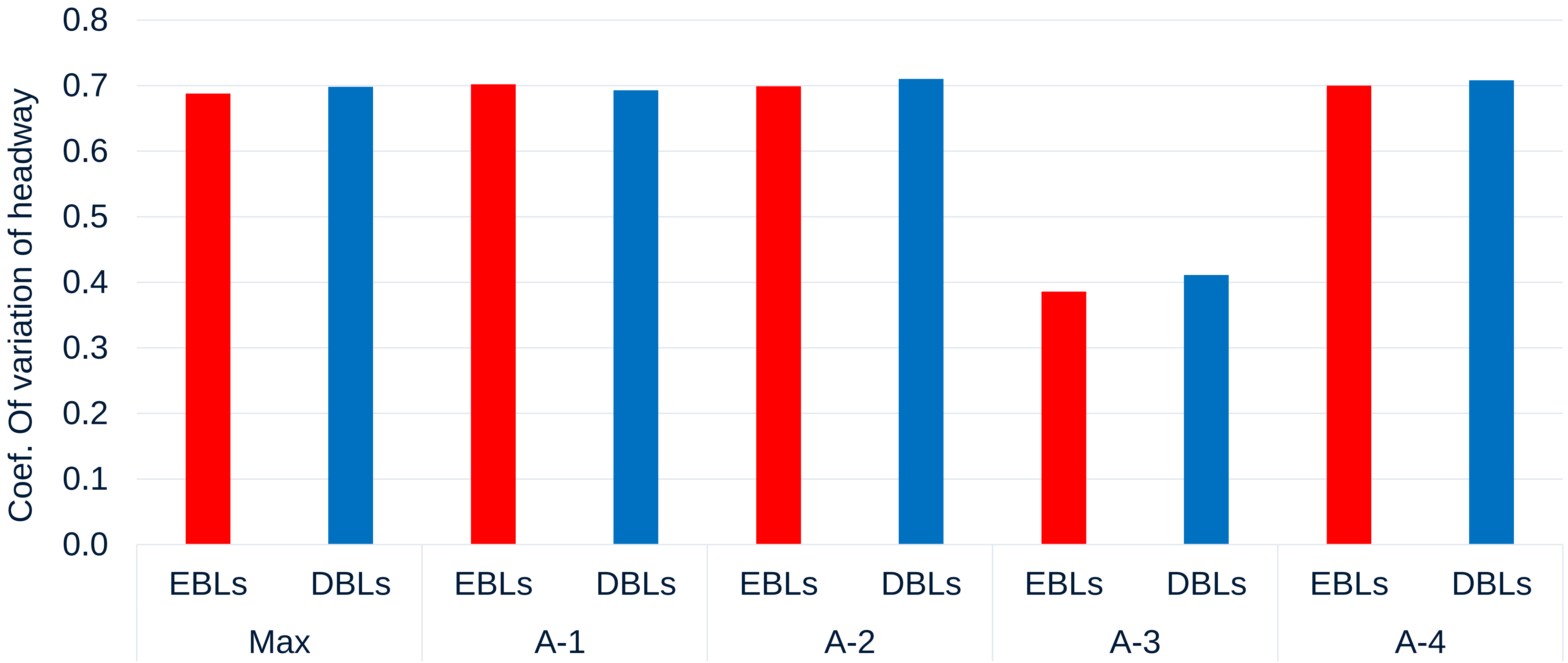


Results (Bus range) battery with 350 kWh capacity

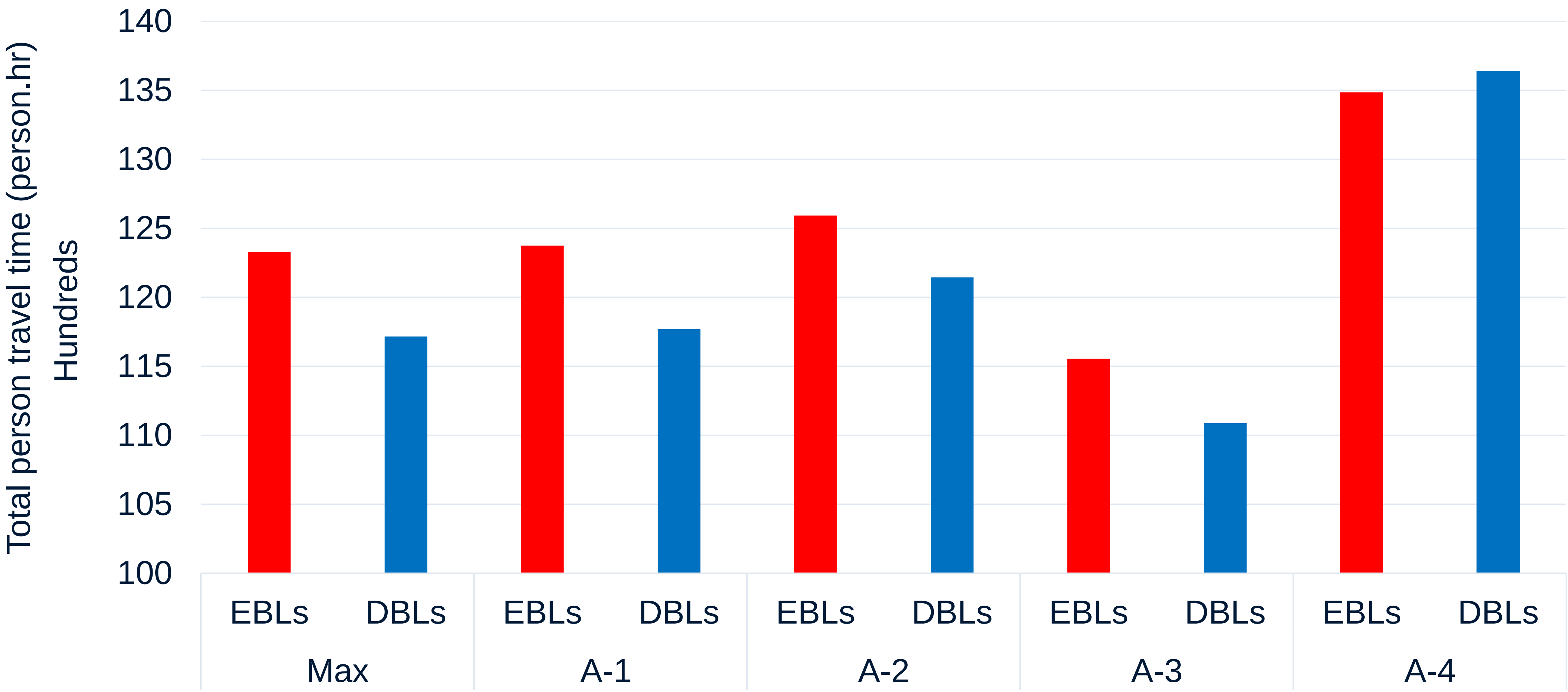


TAL
CATTS
CENTRE FOR AUTOMATED AND TRANSFORMATIVE TRANSPORTATION SYSTEMS

Results (headway deviation)

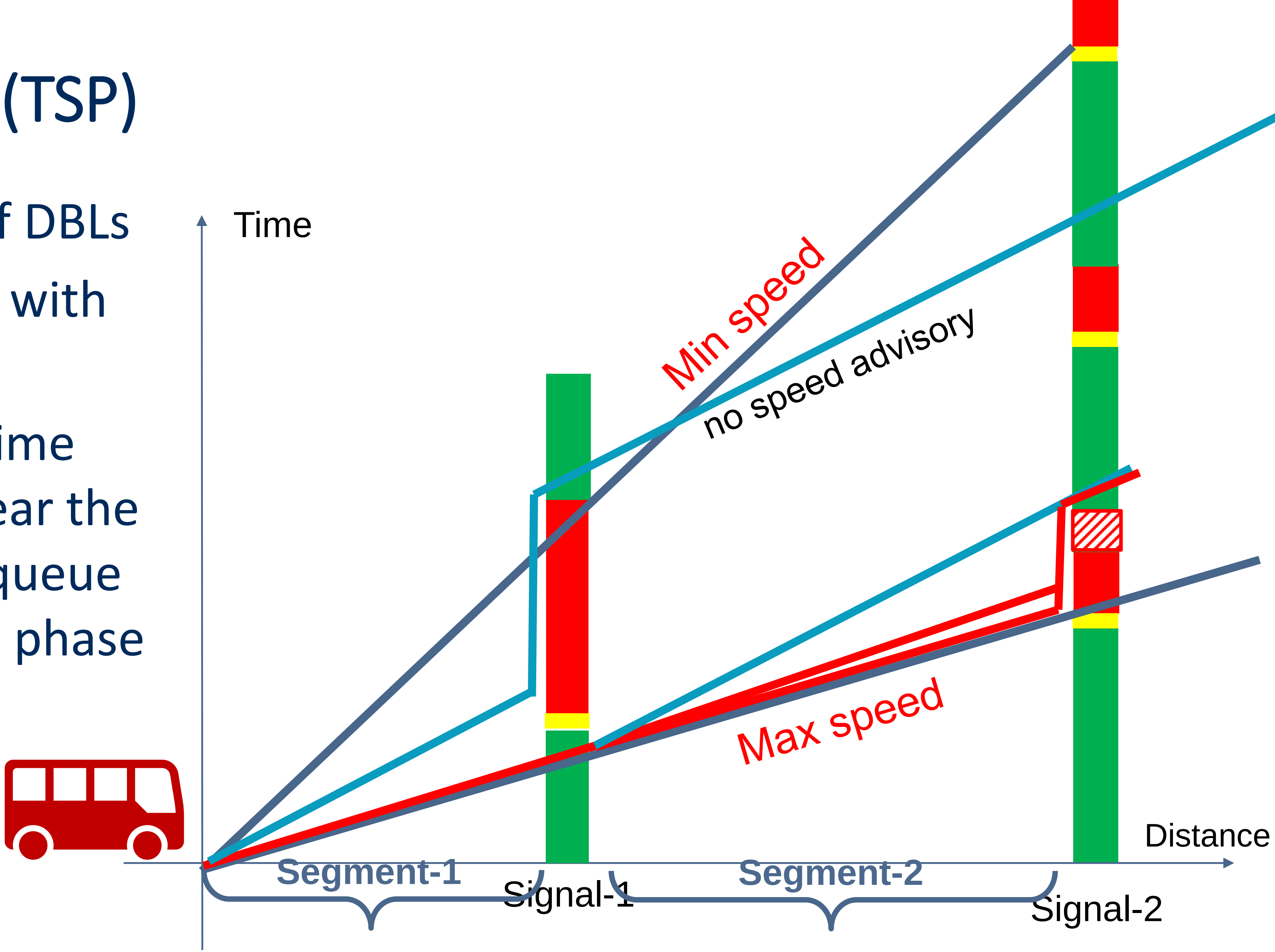


Results (Total person travel time)

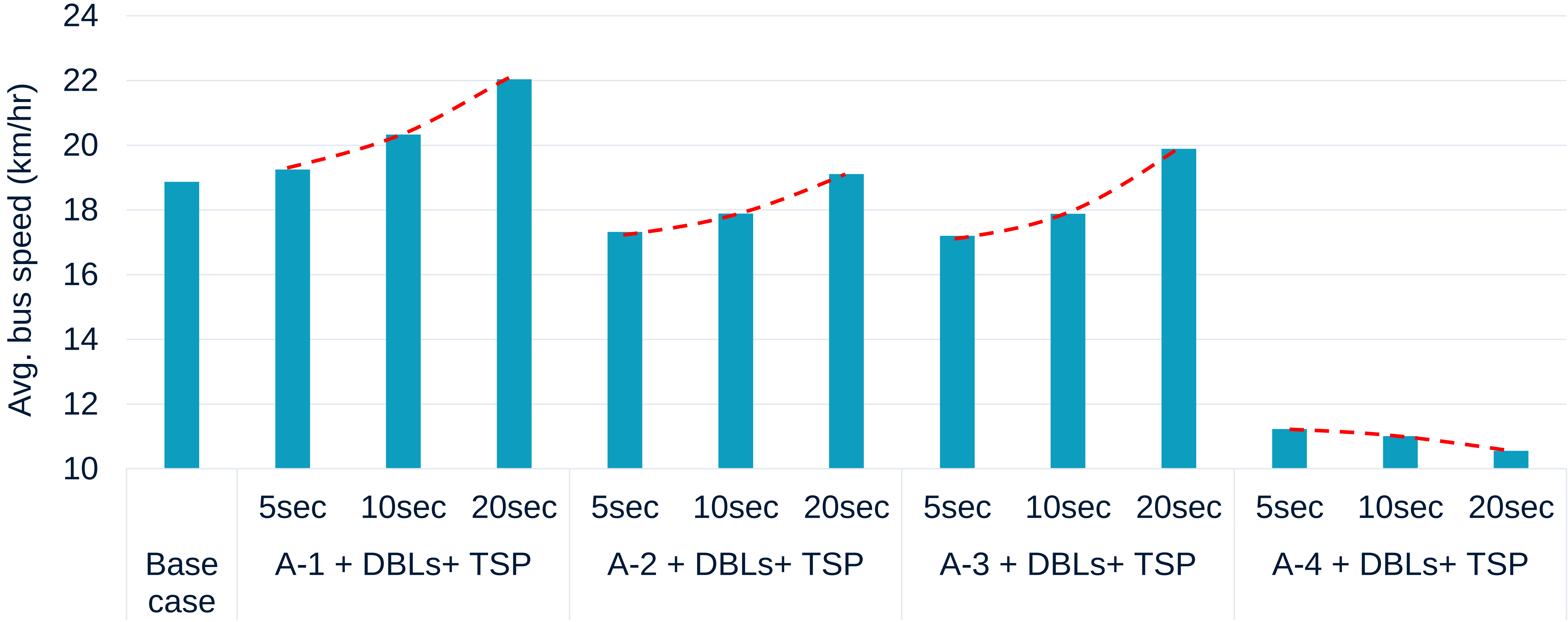


Time Priority (TSP)

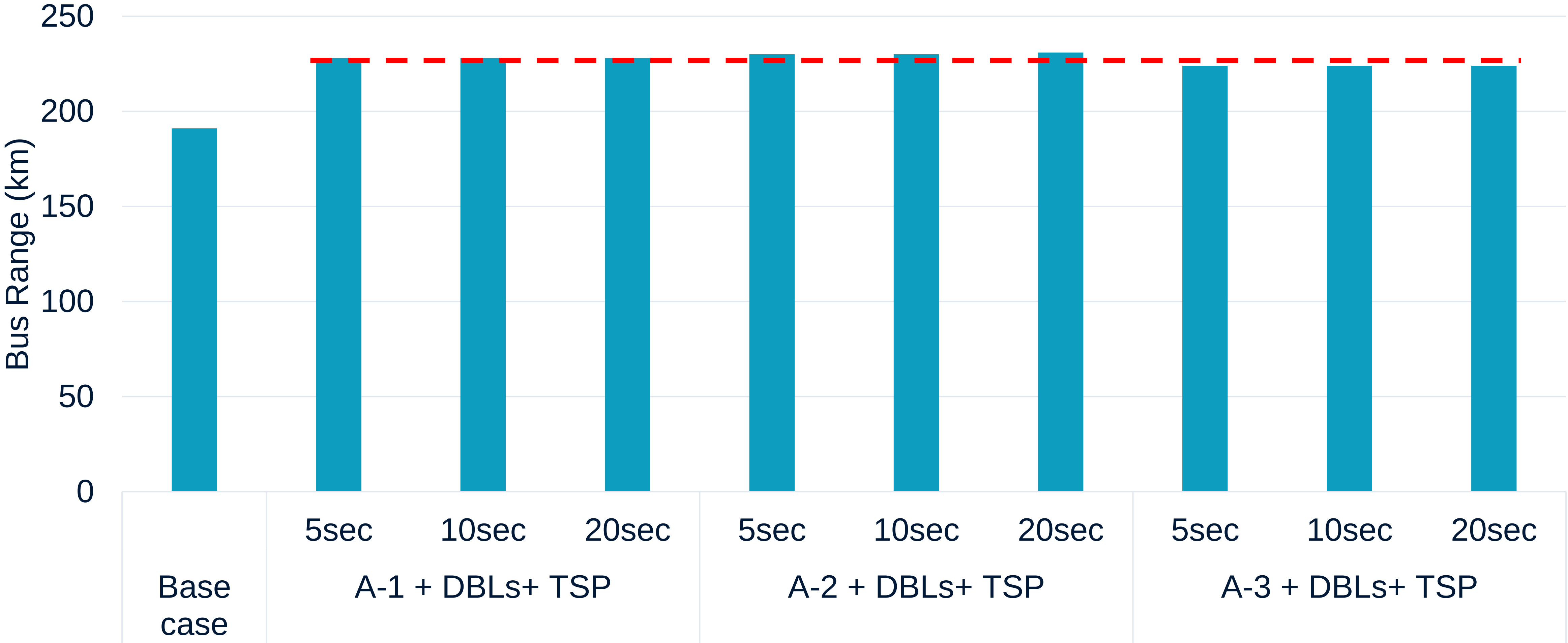
- For the case of DBLs
- Unconditional with red truncation
- To offset the time required to clear the accumulated queue during the red phase



Results (Average bus speed)



Results (Bus range) battery with 350 kWh capacity



TAL
CATTS CENTRE FOR AUTOMATED AND TRANSFORMATIVE TRANSPORTATION SYSTEMS

Conclusions

- Benefits of the DAS:
  - 50% reduction in the total number of bus stops
  - 30 to 50% higher levels of comfort
  - 15 to 21% lower bus energy consumption rates
- A-3 can substantially improve the headway regularity and enhance the regularity LOS from LOS E or F to LOS C,
- Resulting in a major reduction in the passenger waiting times at the bus stops.

Conclusions

- A-3 with DBLs is the optimum scenario as it achieves the lowest total person travel time
- As a result of the significant improvement in transit service performance that offsets the minor negative impacts on the general traffic.

Questions

Additional Slides

Dynamic Bus Lanes Clear distance

- A clear distance of 150 m and EBLs achieve similar levels of transit service performance