Transit in the Era of Automated and Transformative Technologies

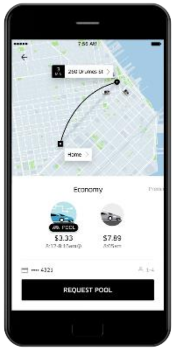
Amer Shalaby, Ph.D., P.Eng.
Associate Director of iCity CATTS

iCity-CATTS Research Symposium

June 28, 2018

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING
Transportation Research Institute

Transit on the brink of major "disruption"



Automation & Connectivity

Integrated Mobility

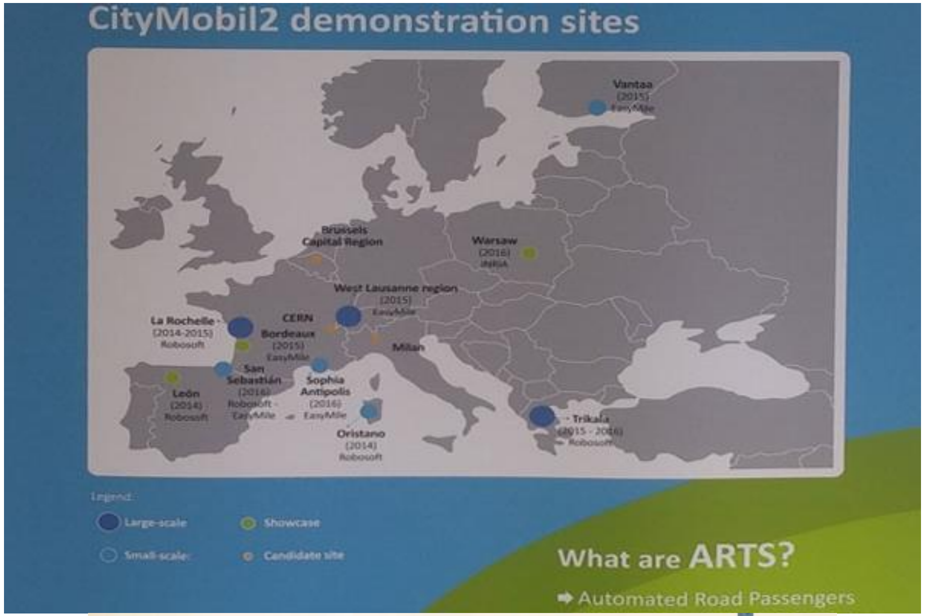
Transit

Electric

Big Data & AI

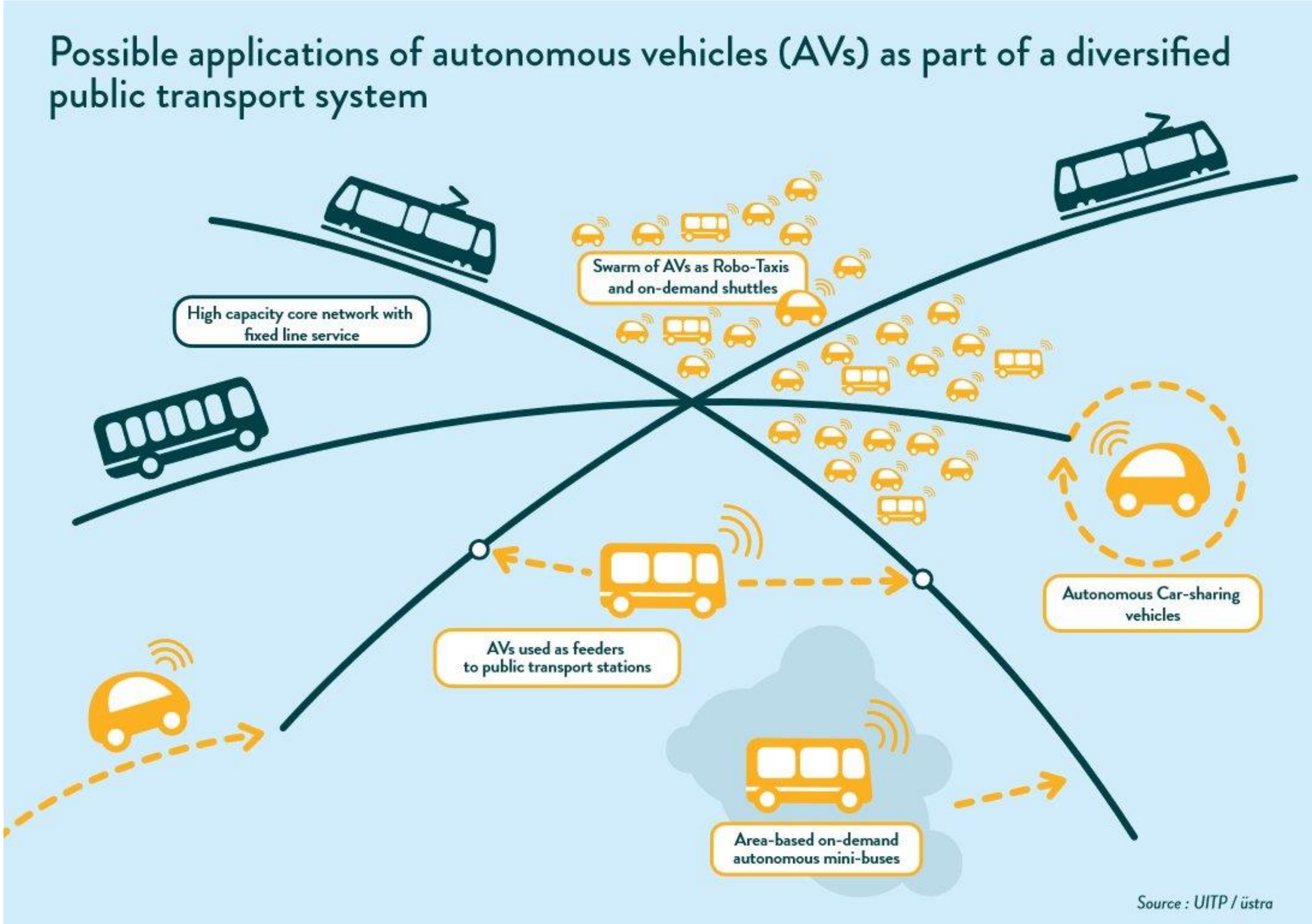
Autonomous Shuttle Trials

- Several pilots around the world
  - CityMobil2 Demos, CarPostal (Sion), pilots in Canada, etc.



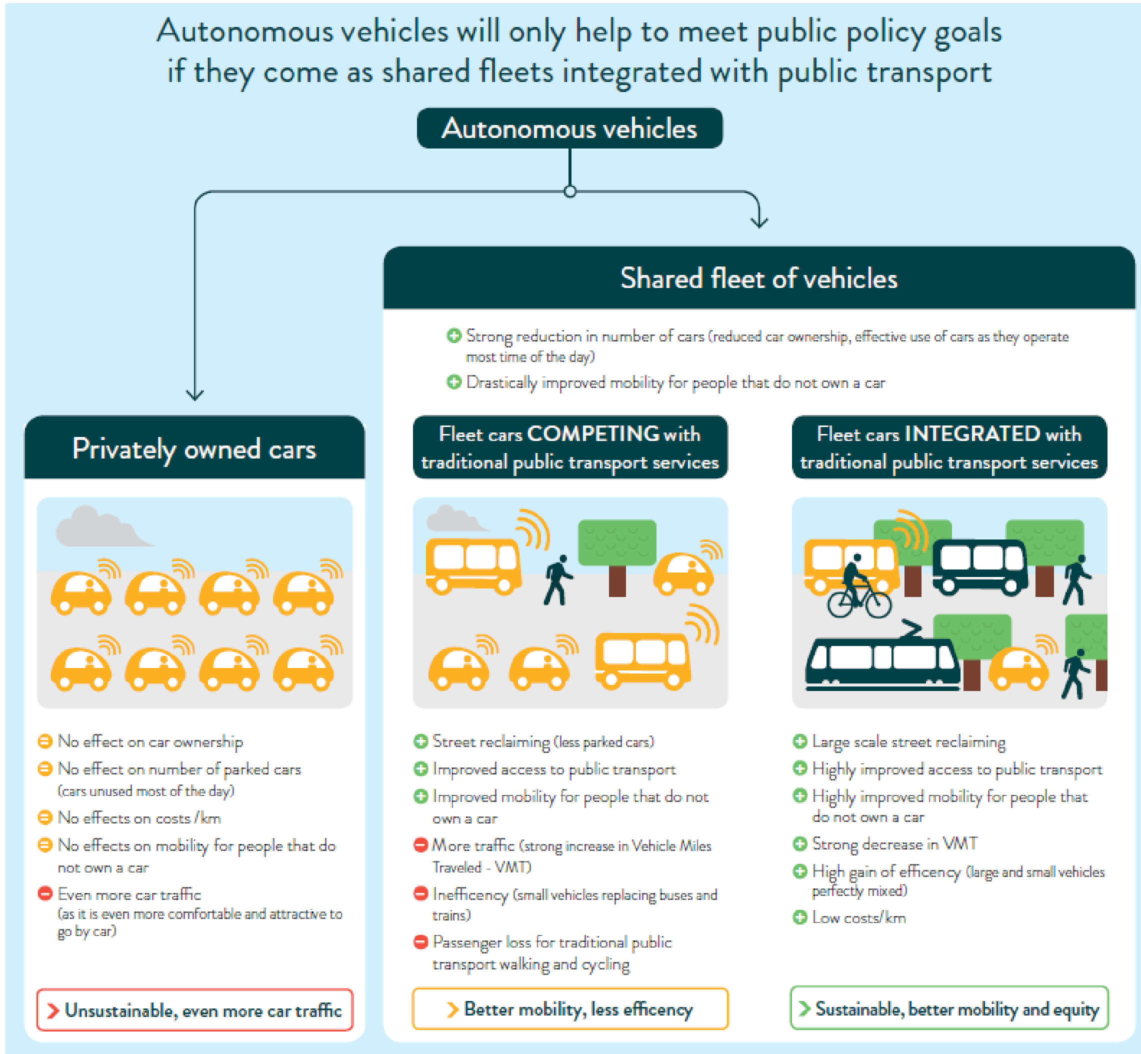
- Small scale, low speed, in dedicated ROW

UITP Vision



Possible applications of autonomous vehicles (AVs) as part of a diversified public transport system
High capacity core network with fixed line service
Swarm of AVs as Robo-Taxis and on-demand shuttles
Autonomous Car-sharing vehicles
AVs used as feeders to public transport stations
Area-based on-demand autonomous mini-buses
Source : UITP / üstra

UITP Vision: “FAVES”



Source : UITP / Martin Röhrleef

AV Strategy in Singapore

"We envisage AV technology complementing existing public transport system by enhancing connectivity to major transportation nodes (MRT stations and bus interchanges), through:

- AV buses providing fixed and scheduled services
- Point-to-point mobility-on-demand services providing first-mile/last-mile connectivity"

Jeremy Yap (LTA), UITP 2017

Phase 3 of CityMobil

- "A new call launched as part of the Horizon 2020 call 2017, named ART 07, is open for new projects in which <u>automation can be applied not only to last mile but to higher speed and higher capacity road transport systems to complement and integrate mass transit</u> and demonstrate that this new millennium transport can be profitable instead of subsidised".

Transit-focused AV Plans

- In its Tactical AV Plan, the City of Toronto is placing special emphasis on transit:

  "*The City of Toronto will take a transit-centric approach to vehicle automation. The City will encourage the adoption of advanced driver assistance systems for public and mass transit vehicles, with the purpose of improving reliability, efficiency, safety, and seamlessness of transit. The City will also encourage the development of advanced driver assistance systems that facilitate increased transit priority*"

iCity-CATTS' Transit R&D Vision

- Facilitate and accelerate the transition to <u>next-generation transit</u> systems through
  - Developing and demonstrating new technologies and service concepts
  - Transforming the service planning, scheduling and operational management processes
  - Developing new data-driven, AI-based analytical tools and platforms for decision support

Planning, Scheduling & Ops of Next-Gen Transit

Service Planning

- Definition & allocation of service areas by type of service/technology
- High frequency bus network design
- First/Last mile planning
- Joint fixed route and DRT services
- Bus platooning in busy corridors
- Other

Scheduling

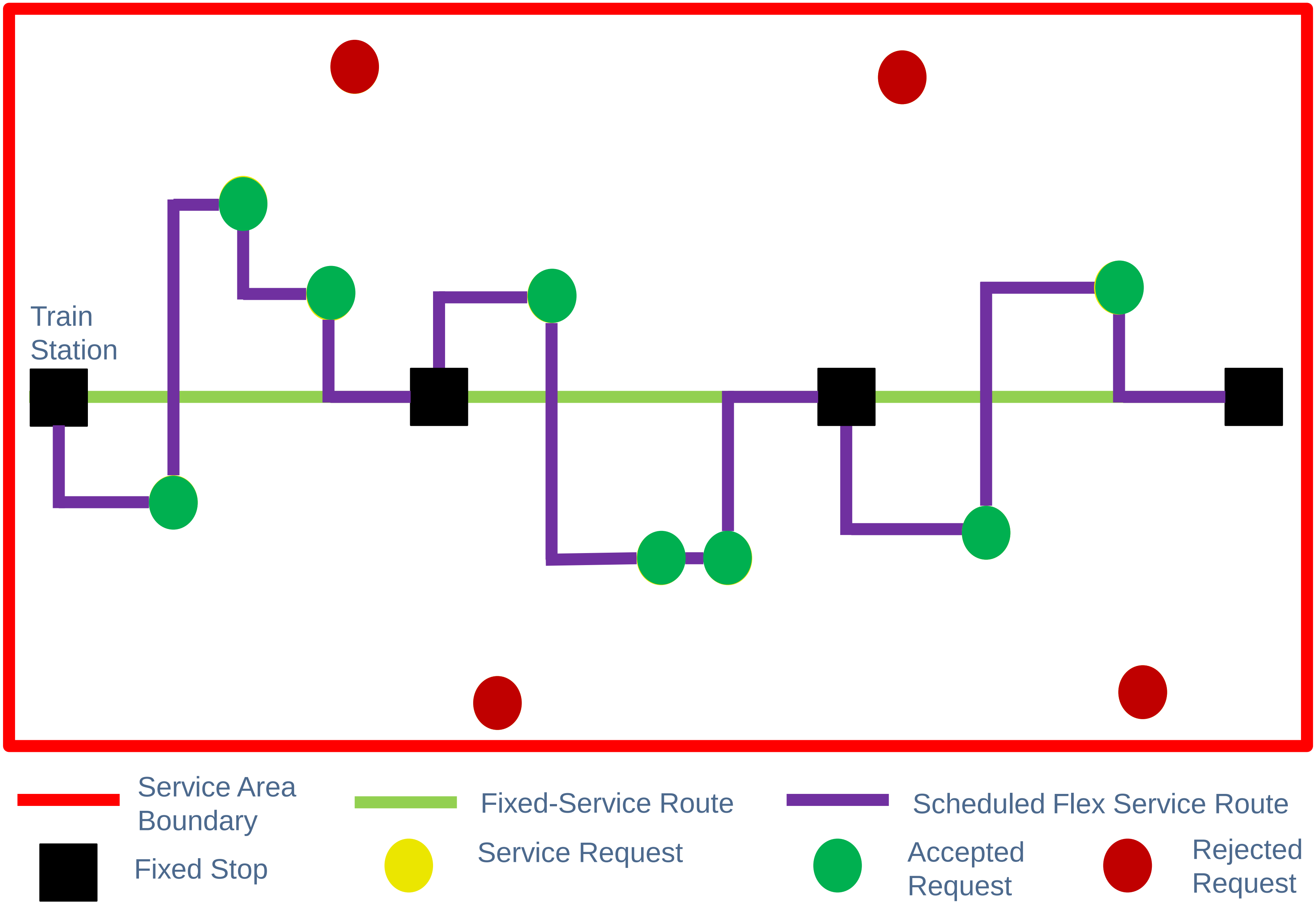
- Bus fleet size & mix determination
- Optimal scheduling of automated bus networks
- Optimal transfer schedule design
- Dynamic scheduling of DRT and ridesharing services
- Other

Operations

- Route management
- Connection management
- Major disruption Management
- Other

Past and Ongoing Transit Research at iCity-CATTS

- Last-Mile Flex-Route Transit
- Transit Signal Priority
- Nexus: Data-driven Connected Platform



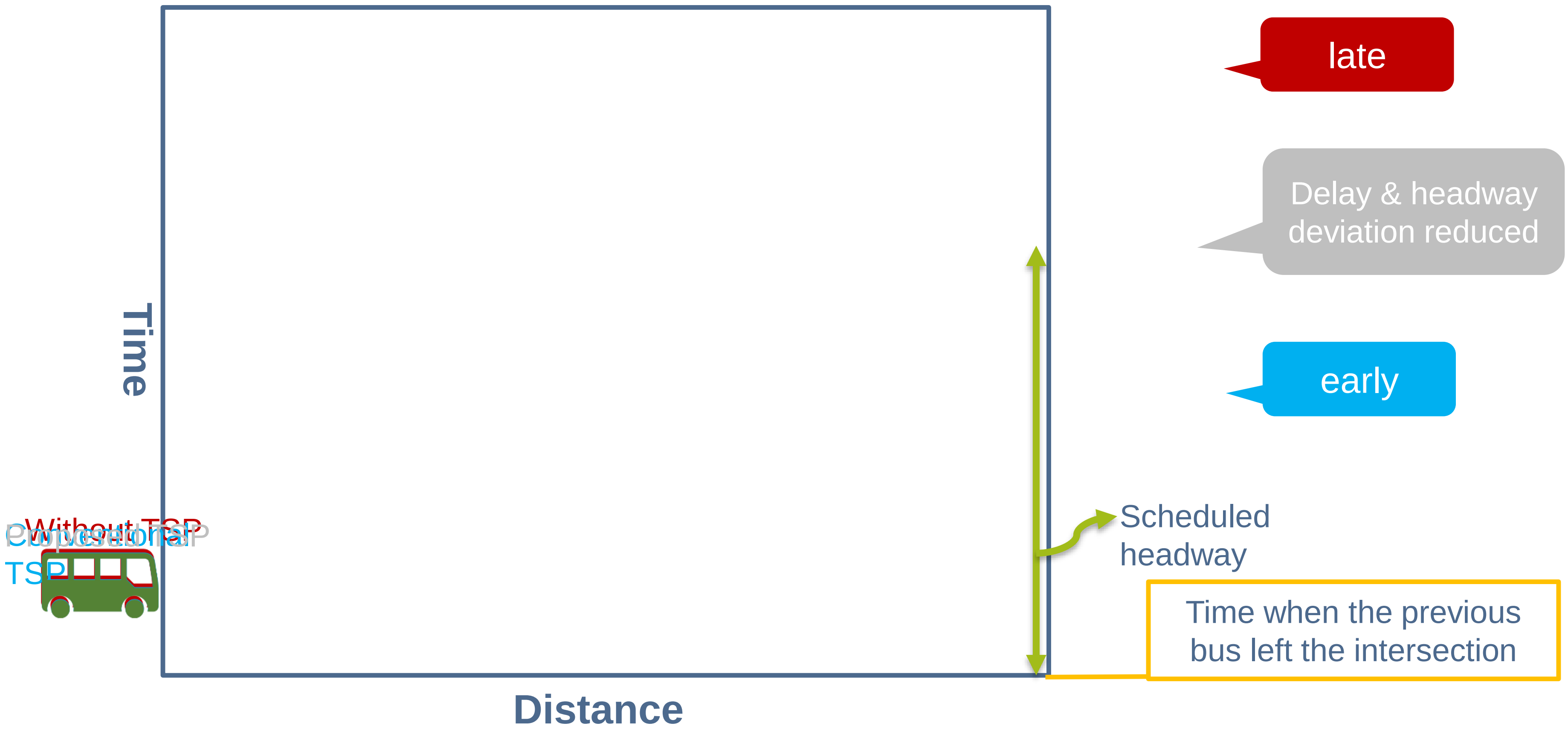
Train
Station
Service Area
Boundary
Fixed-Service Route
Scheduled Flex Service Route
Fixed Stop
Service Request
Accepted
Request
Rejected
Request

LM Flex-Route Transit

- Service planning and design
  - Service area
  - Fixed stop locations
  - Slack time

- Service delivery
  - Scheduling and vehicle routing

Dual Objective TSP



Dual-Objective TSP

Bus t checks in: collect data of the environment state (St), including traffic flow, target travel time (a function of headways), and elapsed time of current signal phase

↓

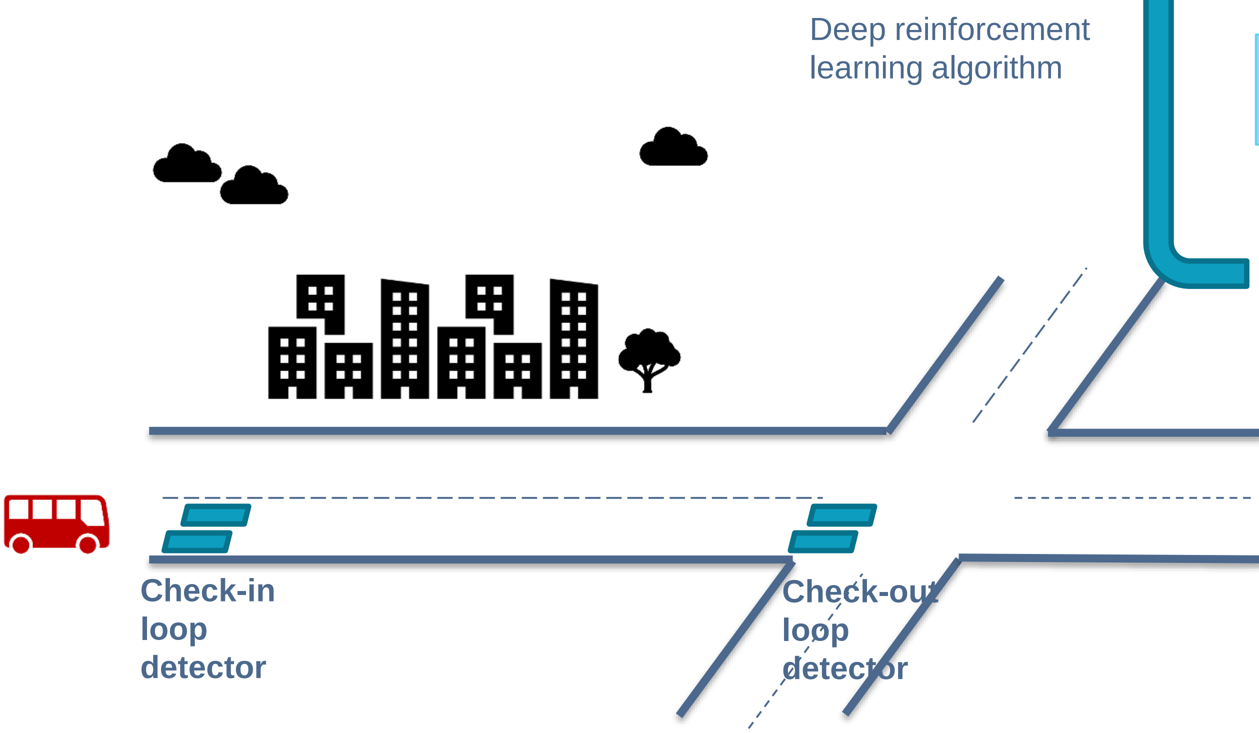
Take an action (At): extend the green, or truncate the red phase

↓

Bus t checks out: collect data of headway to Bus (t-1)

↓

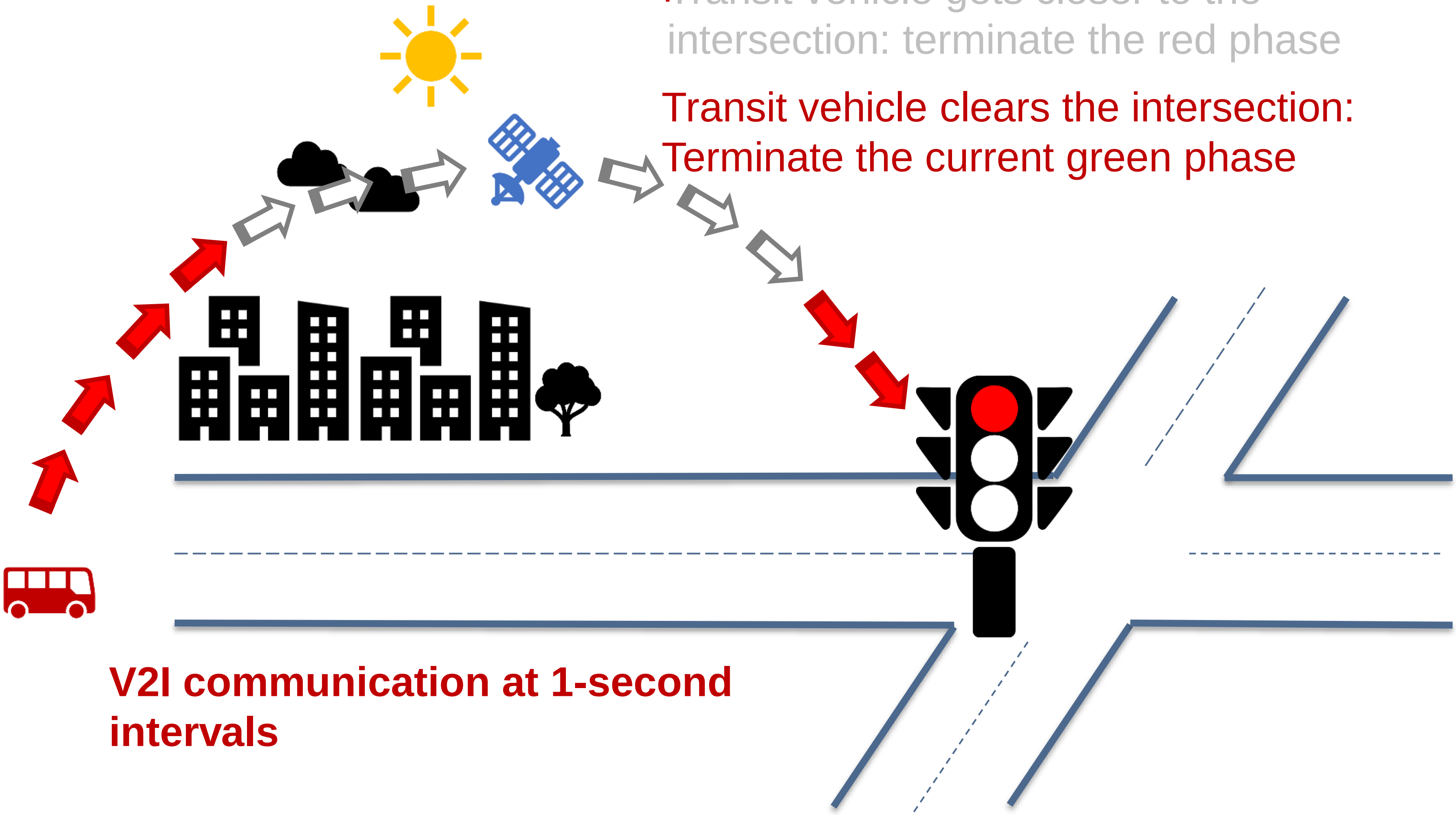
Bus (t+1) checks in: collect data of the state (St+1), calculate reward of action At, update the action-value function



Transit vehicle is far from the intersection: extend the current red phase

Transit vehicle gets closer to the intersection: terminate the red phase

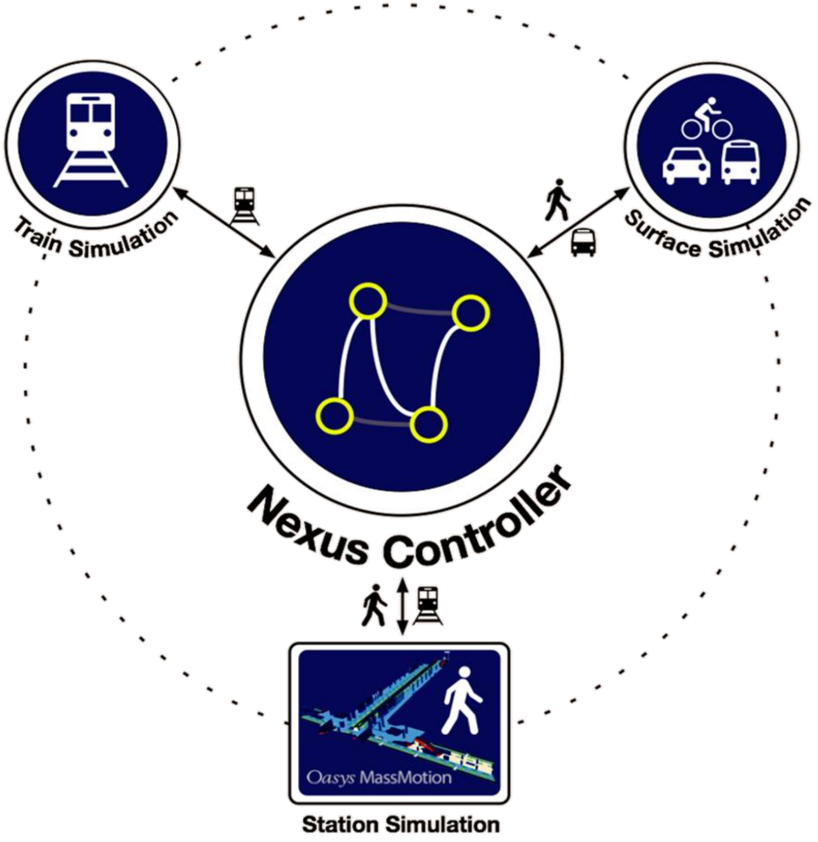
Transit vehicle clears the intersection: Terminate the current green phase



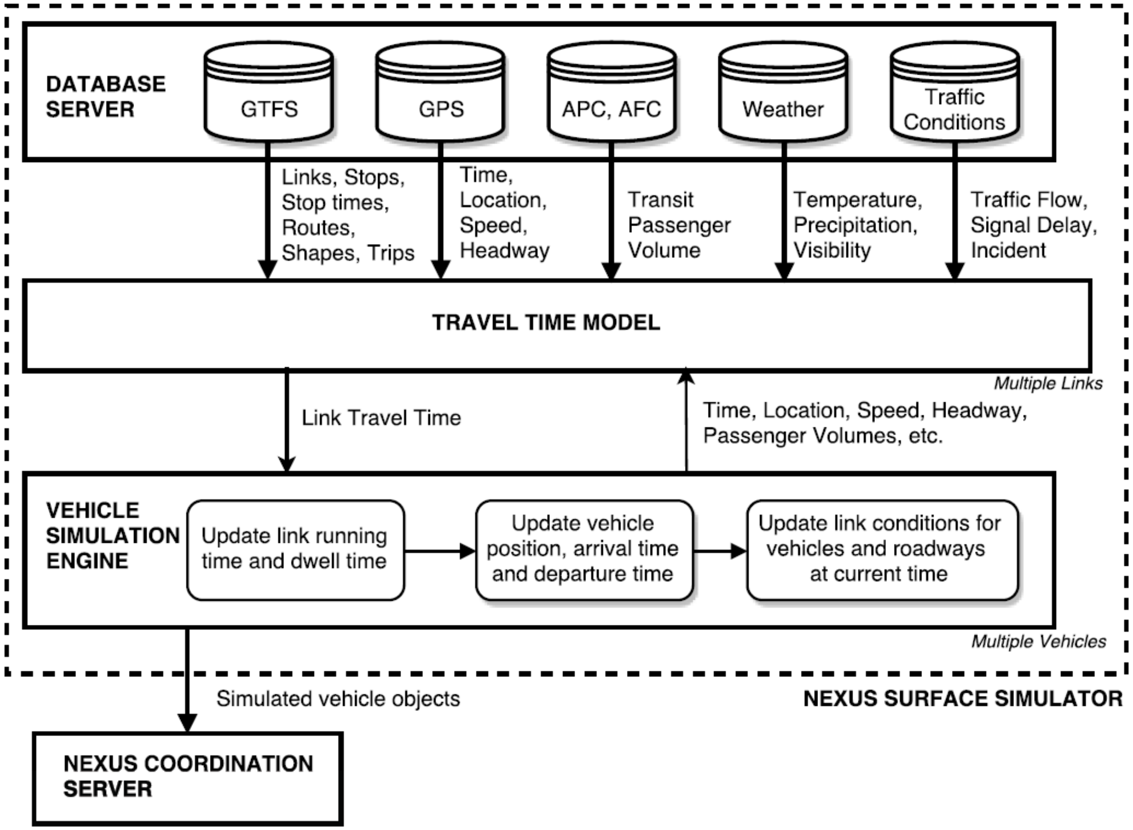
V2I communication at 1-second intervals

Nexus Platform

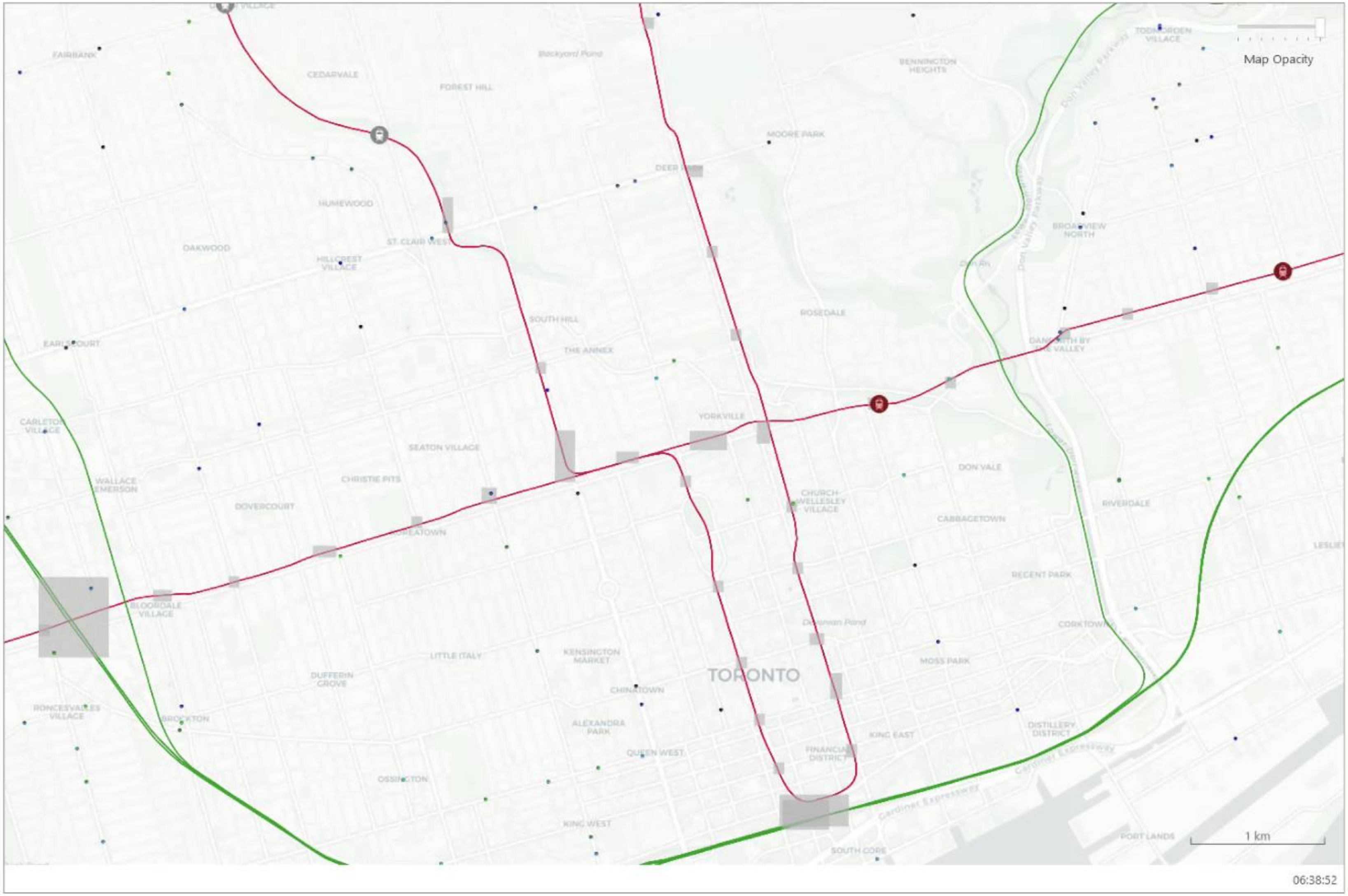
- Data driven connected platform to support:
  - Network planning
  - Capacity analysis
  - Disruption management



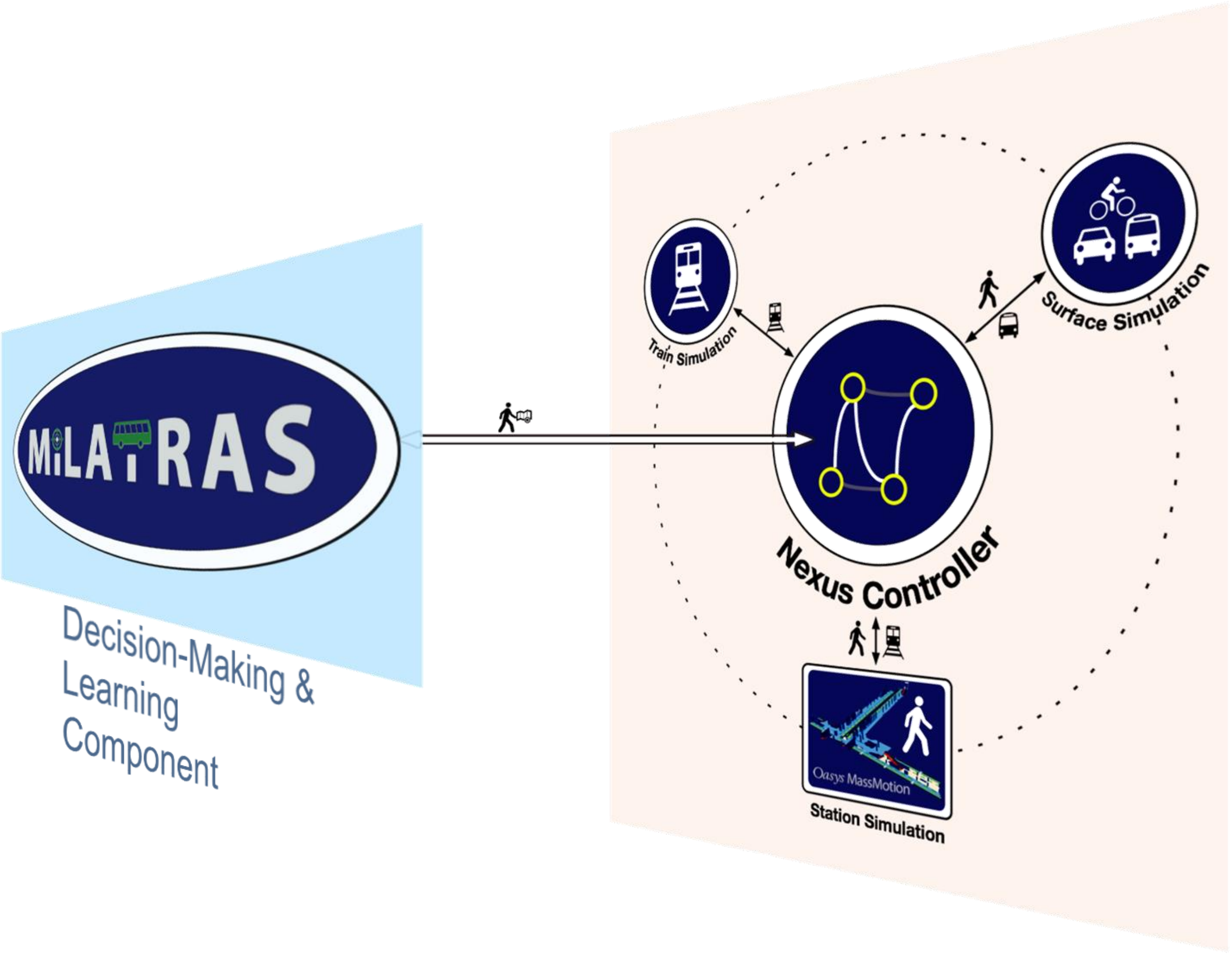
Nexus Surface Simulator



simulator



MILATRAS – Nexus Integration



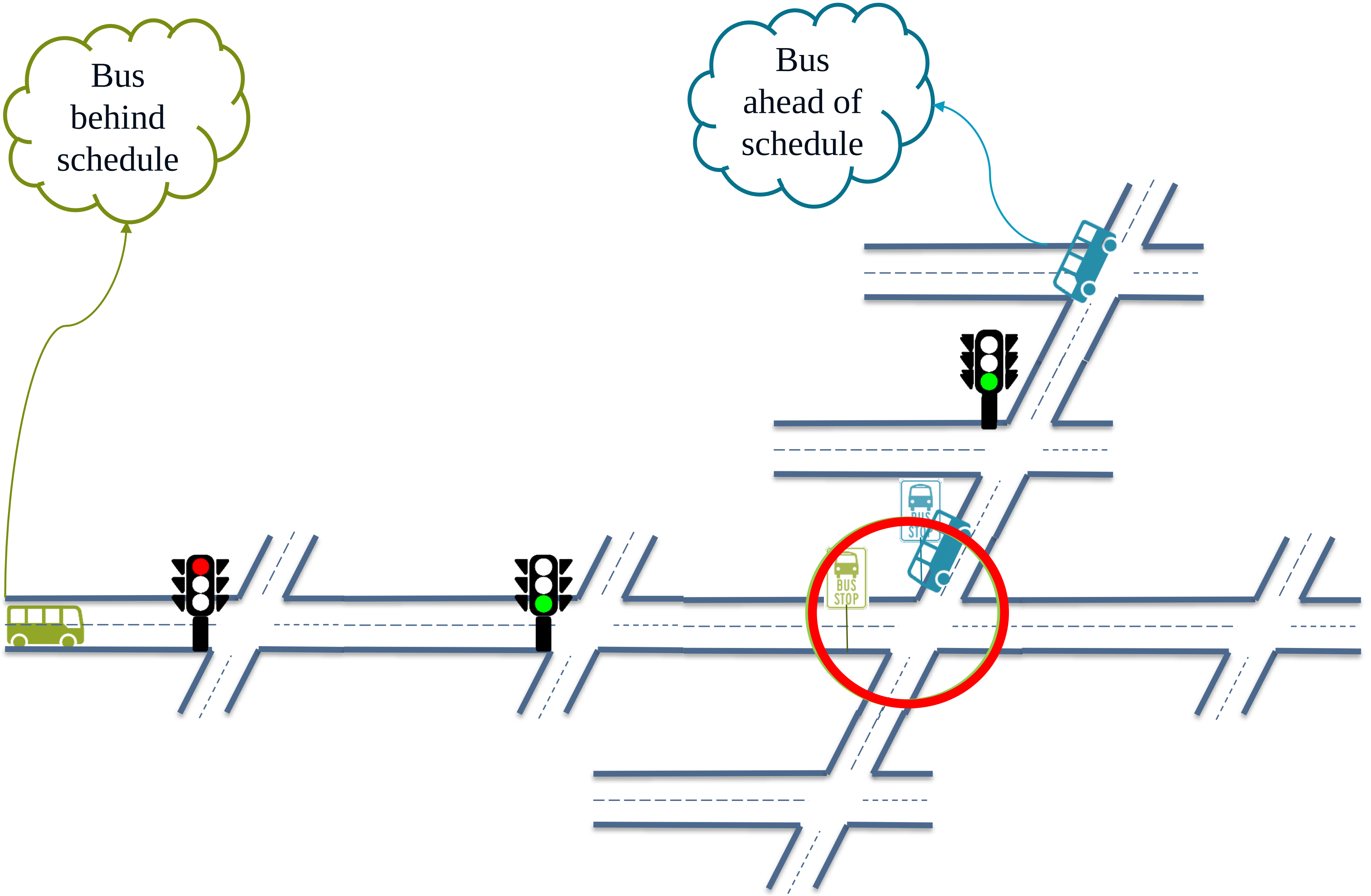
Near-Term Transit Research Agenda

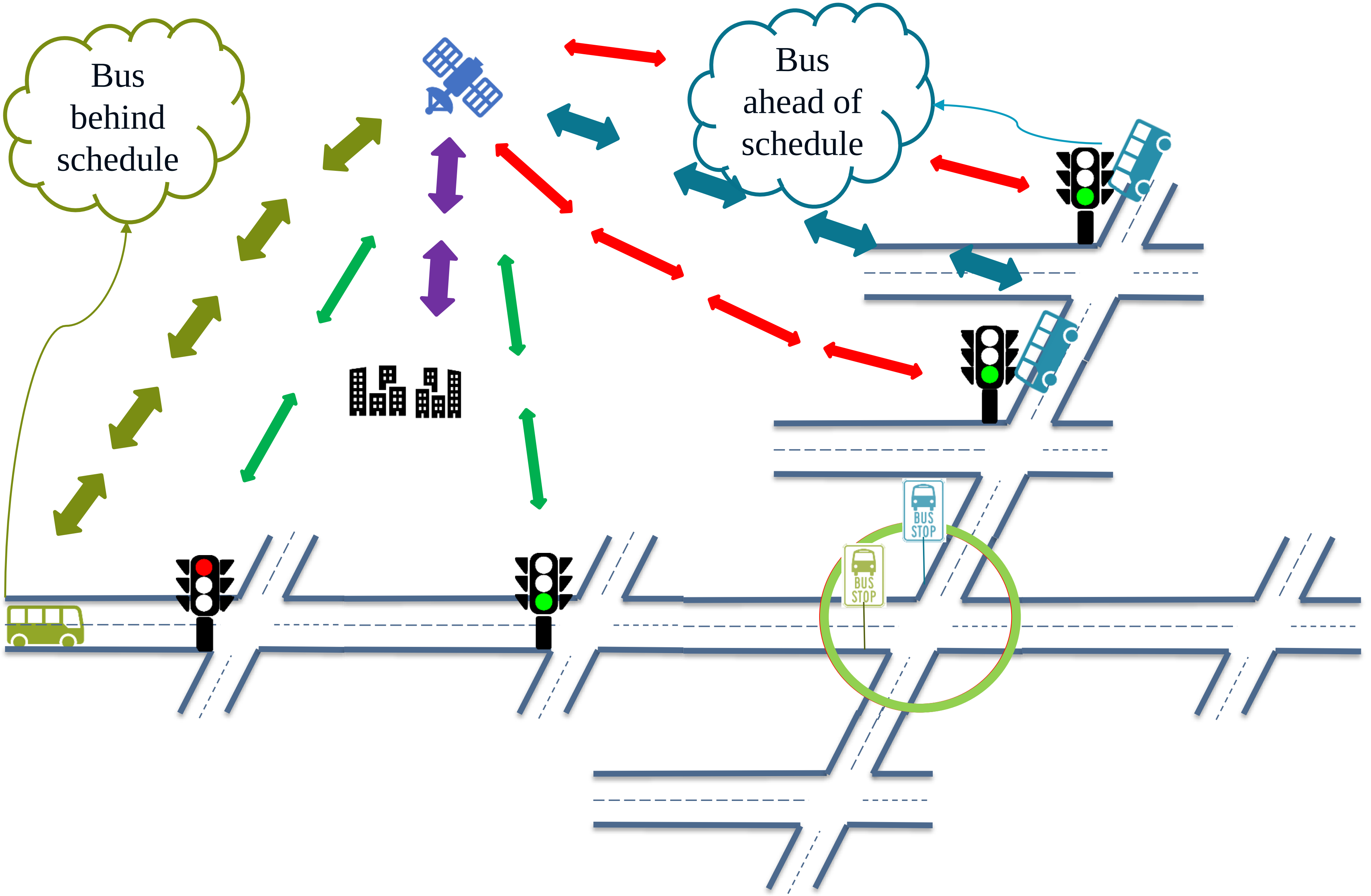
- Connected Buses
- Smart Microtransit
- Miscellaneous

Connected Buses

- Integrated B2I and B2B for fast, reliable and seamless bus operations

- Bus platooning


Bus behind schedule
Bus ahead of schedule
BUS STOP


Bus behind schedule
Bus ahead of schedule
BUS STOP
BUS STOP

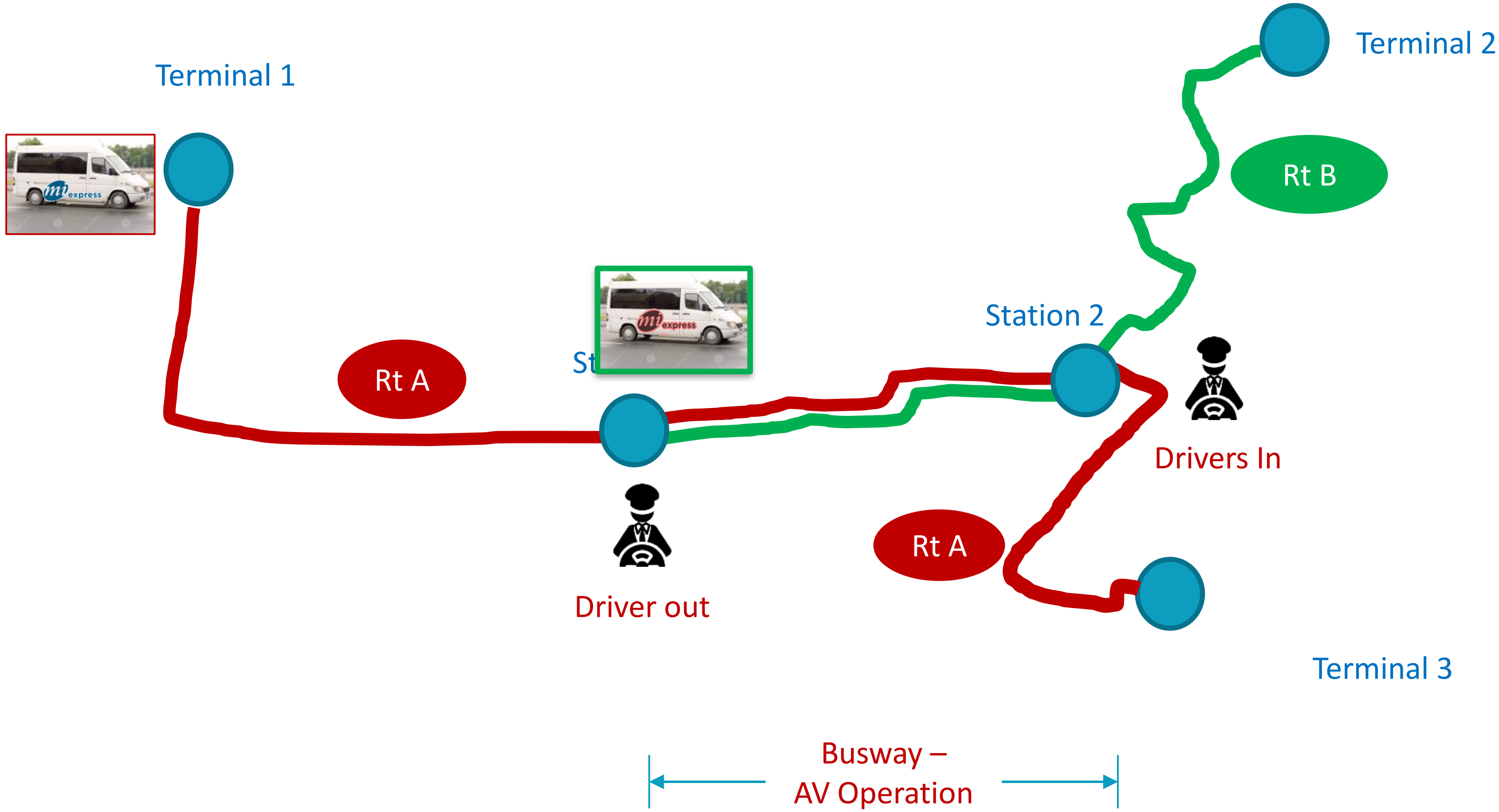
Smart Microtransit

- New service concepts
  - Various levels and combinations of automation
  - Dynamic demand prediction
  - Service integration scenario development and testing

- Data-driven analytical tools for planning, design and scheduling

- Platforms and companion apps

Smart Shuttle Concept 1



Other Research

- Simulation-based optimization of on-route charging stations of electric bus fleets across
- Transit demand management via incentive-based transit commuting programs
- Transit disruption management via smart shuttles
- Transportation justice in the era of automated technologies and integrated mobility systems

Thank You!

The future of transportation is

SEAMless

Shared Electric Autonomous Mobility