Transit in the Era of Automated and Transformative Technologies

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iCity-CATTS Research Symposium

June 28, 2018
Transit on the brink of major “disruption”
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
- AVs used as feeders to public transport stations
- Autonomous Car-sharing vehicles
- Area-based on-demand autonomous mini-buses

Source: UITP / ëstra
UITP Vision: “FAVES”

Autonomous vehicles will only help to meet public policy goals if they come as shared fleets integrated with public transport.

Shared fleet of vehicles:
- Strong reduction in number of cars (reduced car ownership, effective use of cars as they operate most time of the day).
- Drastically improved mobility for people that do not own a car.

Privately owned cars:
- No effect on car ownership.
- No effect on number of parked cars (cars unused most of the day).
- No effects on costs/km.
- No effects on mobility for people that do not own a car.
- Even more car traffic (as it is even more comfortable and attractive to go by car).

Fleet cars COMPETING with traditional public transport services:
- Street reclaiming (less parked cars).
- Improved access to public transport.
- Improved mobility for people that do not own a car.
- More traffic (strong increase in Vehicle Miles Traveled - VMT).
- Insufficiency (small vehicles replacing buses and trains).
- Passenger loss for traditional public transport (walking and cycling).

Fleet cars INTEGRATED with traditional public transport services:
- Large scale street reclaiming.
- Highly improved access to public transport.
- Highly improved mobility for people that do not own a car.
- Strong decrease in VMT.
- High gain of efficiency (large and small vehicles perfectly mixed).
- Low costs/km.

> Unsustainable, even more car traffic
> Better mobility, less efficiency
> Sustainable, better mobility and equity

Source: UITP / Martin Poblenz
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 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 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 next-generation transit 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
LM Flex-Route Transit

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

- Service delivery
  - Scheduling and vehicle routing
Dual Objective TSP

- Without TSP
- Conventional TSP
- Proposed TSP

Delay & headway deviation reduced

Time when the previous bus left the intersection

Scheduled headway

late

early
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

Deep reinforcement learning algorithm
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

DATABASE SERVER
- GTFS: Links, Stops, Stop times, Routes, Shapes, Trips
- GPS: Time, Location, Speed, Headway
- APC, AFC: Transit Passenger Volume
- Weather: Temperature, Precipitation, Visibility
- Traffic Conditions: Traffic Flow, Signal Delay, Incident

TRAVEL TIME MODEL
- Link Travel Time
- Multiple Links: Time, Location, Speed, Headway, Passenger Volumes, etc.

VEHICLE SIMULATION ENGINE
- Update link running time and dwell time
- Update vehicle position, arrival time and departure time
- Update link conditions for vehicles and roadways at current time

NEXUS SURFACE SIMULATOR

Simulated vehicle objects

NEXUS COORDINATION SERVER
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
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*