iCity-CATTS

What Does the Future Hold for Smart Transportation in Canada?

Overview: Centre for Automated and Transformative Transportation Systems

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Transformative Transportation?

“A new transportation system emerges from a groundswell of market-driven innovation in technology, service provisioning and social organization, with government providing frameworks and platforms for bottom-up change”

http://reprogrammingmobility.org/trends/
The First Revolution - October 1\textsuperscript{st}, 1908: Ford Motor Company Unveils Model T

The promise: Travel farther, faster, in comfort and style!
21\textsuperscript{st} Century: The Three Revolutions

- Automated (and connected), green (/electric) and shared.
- Disruptive and transformative,
- Same promise, but 21\textsuperscript{st} century high tech!
- Same issues, on steroids!
- The fundamentals of mobility are changing again.
- Bold vision for the future of transportation and cities, but equally high risks and potential for crises.
- Immediate need to develop quantitative tools to guide the evolution of our cities in the era of disruptive technologies,
- Empower people and business, protect the environment, harness and maximize potential and minimize risks.
Causes of Disruption and Transformation

- Automation and connectivity
- Greener powertrain, low emission, low carbon
- Everything as a Service (MaaS, VaaS, RaaS)
- Innovative multi modality
- Innovative goods delivery
- e-ride hailing / sharing
- Behavioral and Attitudinal changes

Everything as a Service (MaaS, VaaS, RaaS)
The Ripple Effects

The economy

The environment and health

Cities and land use

Energy

Transportation Systems: Demand, Supply and Performance

Transformative Trends: Driverless, MaaS

Technology
Automated and Transformative Transportation:

Opportunities to Harness and Expand

- Empower individuals by enhancing mobility choices
- Improve congestion and reliability
- Reduce accidents
- Reduce emissions and carbon footprint
- Reduce parking requirements
- Free up and reallocate road space
- Free up commuter time

Transformation
Automated and Transformative Transportation:

Risks, Unknowns and Unintended Effects

- Increase in vehicle kilometers traveled
- Increased sprawl
- Reduced road capacities and traffic flow instability
- Unknown behaviour of mixed autonomous and non autonomous vehicles
- Unknown impact of e-sharing
- Less frequent but more severe accidents
- New regulations
- Infrastructure needs to support autonomous vehicles
- Robot pedestrian conflicts
- Transformation

New regulations
Infrastructure needs to support autonomous vehicles
Robot pedestrian conflicts
Transformation
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Fundamental Dilemma:

- As travellers face new choices
- They will do what is best for them, individually, even if detrimental to the system
- Unmanaged, the system will evolve towards undesirable state

Policy makers, planners, operators, engineers and researchers must mind the user but must also mind the system and make it evolve in an orderly manner

What is our vision for the cities we want to live in?
iCity-CATTS: The Initiative

- July 1\textsuperscript{st}, 2017: UofT Launches The Centre for Automated and Transformative Transportation Systems (CATTS),
- Not about automating a car but about a million of these on the road!
iCity-CATTS: The Vision

- Centre for:
  - Quantifying transformation
  - Enabling positive transformation
  - Sustaining cities under transformation:
    - Social, Environmental and Economic Sustainability
  - Reusable Virtual City Analysis Platform:
    - Travel demand, transportation supply and systems (roads, transit, freight, active transportation)

- Key Characteristics:
  - Multi-disciplinary multi-sector collaboratory:
    - Academia, Industry, Technology Experts, Government
  - Cities and metropolises scale,
  - Integrated, quantitative and evidence-based approach.
Partners and Funding to Date

- **Committed:**
  - Universities of Toronto, Waterloo and Ryerson, California Irvine
  - City of Toronto
  - City of Mississauga
  - Region of York
  - Region of Peel
  - ESRI Canada
  - GM Canada
  - Toronto Atmospheric Fund
  - IBI Group
  - Residential Civil Construction Alliance of Ontario – RCCAO
  - Waterfront Toronto
  - MaRS Innovation

- **In Progress:**
  - Province of Ontario
Yes, The Boldest Vision Is: Automated, Connected, Green, Shared
Beyond Speculation
Centre for Automated and Transformative Transportation Systems

- Identify questions
- Optimize future systems
- Create control systems
- Inform policy
- Predict future scenarios
- Analyze demand and supply
- Quantify effects
How to, The Foundation:
Analyzing Transformative Transportation Systems

Data (AT and Regular)
- Stated Preference Surveys (SP)
- Transportation Tomorrow Survey (TTS)

Demand Models
- AV and mobility tools ownership
- Activity/trip generation and distribution
- Land use impact of automation
- Mode choice with AVs
  - ......

Travel Patterns
- AVs
- Cars
- Transit
- Freight

Network Models:
- Dynamic multimodal network model for the GTA (Aimsun GTA-DTA model)
- Automation models (Adaptive and Collaborative Adaptive Cruise Control)
- Environmental Models

Decision Making:
AV policies: regulation, infrastructure
Business Model: car and ride sharing, TaaS
Congestion Control: pricing, parking, freeway control, signal control

Automation Scenarios:
Level of Automation
Market Penetration
The Foundation:
Analyzing Transformative Transportation Systems

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Demand Models
- AV ownership
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Supply Models:
- Dynamic multimodal network model for the GTA (Aimsun GTA-DTA model)
- Automation models (Adaptive and Collaborative Adaptive Cruise Control)
- Environmental Models

Automation Scenarios:
Level of Automation
Market Penetration
Transportation Demand and Land Use: Impact of Transformative and Automated Transportation
Infrastructure Networks

- Dynamic Simulation (DTA) with Automation
- Adaptive Cruise Control,
- Collaborative Adaptive Cruise Control (Platooning)
- Automating Lane Changing and Merging
- Dynamic Headway Control
- Dynamic Speed and Acceleration Control
- V-2-I based traffic management

Source: modeling connected vehicles using Aimsun
Infrastructure Control and Management: Exploiting Automation and Connectivity

SOV, HOV, ZOV

CONGESTION PRICING
Sustainability and the Environment

Diagram showing the connection between individual tours, trajectories, environmental models, and health risk estimates.

- Demand models
- Network models
- Individual tours and trajectories (walk, ride the bus, ride share)
- Environmental models (emission modelling, all motorized modes, propagation models)
- Activities and exposure (Daily KM spent in active transportation)
- Socio-economic characteristics
- Health risk estimates (cardiovascular, respiratory, various forms of cancer)

Note: The diagram illustrates how various models and trajectories affect health risk estimates.
Freight Transportation Demand

**Facility Location Choice**
- Proximity to AV-appropriate facilities
- Proximity to labour force (skilled vs less skilled)

**Freight Trip / Tour Generation**
- Staging / coordination of truck platoons

**Freight Mode Choice / Carrier Choice**
- Response to reduced truck transport costs

**Urban Pickup / Delivery**
- Changes in parking requirements, loading, unloading,
Automated vehicle parking

- **Parking demand will change**
  - mode choice, activity choice, drop-off / pick-up location, parking location and duration, and response to pricing and enforcement

- **Parking supply may change**
  - potential replacement of downtown on-street and garage parking with drop-off / pick-up zones, and AV parking at the outskirts

- **Parking design will change**
  - AV parking lots
Future Transit
The Evolution from Mass to MaaS Transit!
Putting the Pieces Together:
What If - Quantitative Impact Assessment

**Inputs:**
- Demographics and Socioeconomics
- Network Data
- Demand Data
- Mode Split
- Vehicle Fleet
- Pedestrians
- Scenario Specification
- .....

**Impact Assessment and System Performance:**
- Travel Times & Congestion
- Reliability
- Carbon Foot Print
- Economic impacts
- Mobility, Accessibility, Jobs
- Sustainability
Putting the Pieces Together: Integrated Solutions NOT More of the Same Problems

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 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)

- Unsustainable, even more car traffic

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)
- Inefficiency (small vehicles replacing buses and trains)
- Passenger loss for traditional public transport walking and cycling

- Better mobility, less efficiency

Fleet cars INTEGRATING with traditional public transport services:
- Large scale street network (highly improved access to public transport)
- Highly improved mobility for people that do not own a car
- Strong decrease in traffic
- High gain of efficiency (perfectly mixed)
- Low costs/km

- Sustainable, better mobility and equity

Down the tubes
United States, public-transport use, per person
2008=100

New York | Boston | San Francisco

Los Angeles | Chicago | Washington, DC

Sources: Census Bureau; TransitCenter

The Economist June 23rd 2018

Source: UITP / Martin Rührleff
Putting the Pieces Together:
Everything as a Service for Seamless Mobility

Road as a Service (RaaS) → Vehicle as a Service (VaaS) → Ride as a Service (RaaS) → Mobility as a Service (MaaS)

Consumed By:
- Ministry of Transportation
- Municipalities
- Private Road Operators (i.e., 407)

1. Car Sharing Companies such as GM Maven, Zipcar.
2. Private Citizens
2. Micro-Transit Services

Emerging Business Model based on 3Ps (Public-Private Partnership) model, such as "Whim app"
Putting the Pieces Together: 
The New Mobility Revolution: Think Ahead This Time

Triple Bottom Line Sustainability
Principal Research Team

- Eric Miller, UTTRI Director
- Baher Abdulhai, iCity CATTS Director, Traffic Control Focus
- Khandker Habib, Demand and Planning Focus
- Marianne Hatzopoulou, Sustainability and the Environment Focus
- Matt Roorda, Freight, Parking and Curb Space Focus
- Amer Sahalaby, iCity CATTS Associate Director, Transit Focus
Extended Research Team

Baher Abdulhai, Civil Engineering
Chris Bachmann, Civil, U Waterloo
Jeff Brook, Dalla Lana School of Public Health
Timothy Chan, Mechanical and Industrial Engineering
Mohamed El-Darieby, Software Systems Engineering
Greg Evans, Chemical Engineering & Applied Chemistry
Steve Farber, Geography and Planning
Bilal Farooq, Civil, Ryerson University
Marianne Hatzopoulou, Civil Engineering
Chi-Guhn Lee, Mechanical and Industrial Engineering
Hugh H.T. Liu, Institute of Aerospace Studies
Heather MacLean, Civil Engineering
Eric J. Miller, Civil Engineering
Khandker Nurul Habib, Civil Engineering
Daniel Posen, Civil Engineering
Matthew J. Roorda, Civil Engineering
Scott Sanner, Mechanical and Industrial Engineering
Shoshanna Saxe, Civil Engineering
Angela Schoellig, Institute of Aerospace Studies
Amer Shalaby, Civil Engineering
Shahrokh Valaee, Electrical and Computer Engineering
Michael Widener, Geography and Planning
Research Themes

Theme 1: Quantifying Transformation
- Passenger Demand Changes
- Freight Demand Changes
- Supply, systems and infrastructure performance changes

Theme 2: Enabling Positive Transformation
- Goals: TBL sustainability
- Management and policy to harness automation
- MaaS and TaaS, Integrated Mobility
- E-sharing
- Greener: zero carbon

Theme 3: Sustaining Transformation
- Triple Bottom Line Sustainability Pillars:
  - Economic
  - Environmental
  - Social
- Evaluate trade-offs
- Quantify the effects of themes 1 and 2 not only on transportation but on GHG emissions, health, environment, economy
AGENDA

8:30-9:00  Registration and Coffee
9:00-9:30  Welcome, Opening Remarks, and iCity-CATTS overview, Professor Eric Miller and Professor Baher Abdulhai
9:30-10:30 Themes and Project Overview Presentations – I, Moderated by Prof. Baher Abdulhai
   • Understanding Impact of Transformation on Travel Demand and Travel Behavior, Professor Khandker Nurul Habib
   • Traffic and Control and Management with Vehicle Automation and Connectivity in the 21st Century, Professor Baher Abdulhai
10:30-10:45 Coffee Break
10:45-12:00 Themes and Project Overview Presentations – II, Moderated by Prof. Baher Abdulhai
   • Transit in the Era of Automated and Transformative Technologies: Opportunities and Research Needs, Professor Amer Shalaby
   • Implications of Automation on Parking, Curb Space, and Urban Goods Delivery, Professor Matthew J. Roorda
   • Implications of Automated Vehicles on Urban Sustainability, Professor Marianne Hatzopoulou
12:00-1:00 Lunch Break
1:00-3:00 Partners’ Talks, moderated by Dr. Judy Farvolden
   • Mississauga Moves: City in Transformation, Hamish Campbell, RPP, Project Lead, Parking Master Plan-City of Mississauga
   • City of Toronto AV Tactical Plan, Ryan Lanyon, Transportation Services, City of Toronto
   • Zero sum NOT a game, Ted Graham, GM Canada
   • Human-Focused Design to Technology-based Transportation Solutions, Bruce Mori, IBI Group
   • Catalyzing Innovation in the Mobility Sector, Sasha Sud, MaRS
   • Automated Vehicles: The Road Ahead for Municipalities, Sabbir Saiyed, Region of Peel
   • Preparing for the Impacts of Technology on the Future of Transportation in York Region, Lauren Crawford, Manager Transportation Long-Term Planning, York Regional Municipality of York
   • Integrate, Collaborate, Harmonize, Bern Grush, Harmonize Mobility- RCCAO
3:00-3:15 Concluding Remarks, Professor Baher Abdulhai
3:15-3:30 Coffee Break
3:30-5:00 Partner’s Planning Workshop (Closed session with partners only), moderated by Professor Baher Abdulhai