CAV IMPACTS & SCENARIO TESTING
Adapting Models for Scenario Testing CAV Impacts

2021 SPRING NCMUG MEETING | APRIL 27, 2021
Stantec’s Early Involvement in CAV Testing

ACTIVE-AURORA CV Testbed Network
Edmonton, Alberta

- Rural Fwy
- Urban Expwy
- Urban Arterial

Partnerships
- City of Edmonton
- Alberta Transportation
- Transport Canada
- University of Alberta
- Stantec
- Telus...

Cooperation
... not competition
Stantec’s Early Involvement in CAV Testing

City of Montreal SAV Project
Montreal, QC

- 1.4km of public route (mixed traffic)
- 3 traffic signals intersections with DSRC communication
- 4 stop sign intersections
- 5 stops – 12min /dir. at avg speed of 15km/h
- Connects Metro Station and Olympic Stadium to Marché Maisonneuve

✓ Feasibility
✓ Planning
✓ Operations
✓ Deployment
✓ Connected Vehicle
Client Needs Driven by Agency Role:
- *Planning Needs* – MPOs, State DOTs
- *Financing Needs* – Toll Agencies, Investors
Initial Focus – Traffic & Revenue Implications

- Impacts & Timeline
- Tolling Agencies
  - Will Vary by Toll Road Type
  - Will Vary by Market Segment – Expanding Intercity Competition
- Rating Agency Dialogue
- Internal Research & Mock Presentations (2017-2019)
Planning Analysis - CAV Scenario Modeling

- Client wanted Model to evaluate Potential CAV Impacts
- Developed in 2017, with initial expectations on Demand and Network Conditions for fully autonomous vehicles
- Applicable for Scenario Analysis
- ‘Known’ Unknowns:
  - What aspects of Demand will be impacted?
  - How will Network Capacity be impacted?
  - Timeline?
- ‘Unknown’ Unknowns
  - Contributing Technology
  - Second-Order Effects....
Journey to CAV

Transition to CAV will take time......

**SAE AUTOMATION LEVELS**

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
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<tbody>
<tr>
<td>0</td>
<td>No Automation</td>
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<tr>
<td>1</td>
<td>Driver Assistance</td>
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<tr>
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</tr>
<tr>
<td>3</td>
<td>Conditional Automation</td>
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<tr>
<td>4</td>
<td>High Automation</td>
</tr>
<tr>
<td>5</td>
<td>Full Automation</td>
</tr>
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</table>

- **Full Automation**
  - The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

**Transition influenced by:** Technology, Costs, Regulation, Liability
Vehicle Costs Extend Replacement Cycle

Vehicle Life is growing, now 11 years.

U.S. household vehicle age distribution (2009 and 2017)
percent of household vehicles

- More older vehicles in 2017
- More younger vehicles in 2009

U.S. household average vehicle age by vehicle type (2009 and 2017)
years

- Car: 9.5 (2009), 10.3 (2017)
- Van: 8.8 (2009), 10.9 (2017)
- Sport utility vehicle: 7.1 (2009), 8.5 (2017)
- Pickup truck: 11.2 (2009), 13.6 (2017)
- Other light truck: 17.8 (2009), 18.2 (2017)

U.S. household average vehicle age by household income (2009 and 2017)
years

- Less than $25,000: 11.9 (2009), 13.0 (2017)
- $25,000 to $49,999: 10.2 (2009), 11.5 (2017)
- $50,000 to $74,999: 9.1 (2009), 10.7 (2017)
- $75,000 to $99,999: 8.3 (2009), 9.9 (2017)
- $100,000 or more: 7.3 (2009), 8.9 (2017)

Lower Income HH hold onto vehicles longer
INITIAL EXPECTATIONS
Initial Expectations – First Order Effects

- Trip Generation Increases as Mobility increases for Elderly, Disabled and Young Travelers

- Trip Lengths Increase
  - Travel Time becomes Productive Time
  - Housing becomes more affordable with more distant (less expensive land)

- Mode Choice Shifts Significantly
  - Transit Wins and Loses
  - CAV – New Mode (MAAS)
  - CAV – Private Ownership

- Highway Assignment
  - Optimum Benefits - Limited Access Facilities
  - Dense Areas will have Mixed Impacts
  - Potential for Systemwide Optimization
Initial Expectations – First Order Effects

- Impacts will vary by Area Type
- Urban Areas
  - CAVs Replace Existing Mobility Providers
  - Key Generators – Airports
  - Operational Challenges
- Suburbs
  - Replaces Localized Services
  - Higher Incomes Supports MAAS
  - Competes Effectively against non-motorized modes
- Rural Areas
  - Low Density May Limit MAAS
  - Lower Income Might Constrain CAV Ownership
Initial Expectations – Commercial

- Transformational – Key Players Dominate Increasing Share
  - Retail Locations Become Localized Warehouses
  - Retailers add Delivery Services
- Delivery Rather than Pickup
- Last Mile - CAV or Drone Delivery
- Significant Time-of-Day Impacts
- Existing Delivery Costs not fully recognized by Consumers
Initial Expectations – TNC Operation

➢ Current Services:
  ▪ Human Dependent
  ▪ Heavily Subsidized

➢ Transition to Autonomous Operations
  ▪ Fleet Operations
  ▪ Maintenance / Repairs

➢ Key Players and Roll Out
  ▪ Airports / Rental Fleets
  ▪ Transforms into MAAS
NJRTM-E CAV Scenario Model

- NJTPA Wanted to Prepare the Model for Evaluating Likely CAV Impacts
- Developed for Scenario Testing
- Limited Resources and Timeframe
- Focused on Selected Model Components
  - Person Travel
    - Generation
    - Distribution
  - Commercial Travel
    - Generation
  - Highway Assignment
- Mode Choice Structure Refinements
TRIP GENERATION CAV ADJUSTMENTS IN NJRTM-E

Introduced Adjustment Factors by Purpose and Income

CONTROL REGIONAL PRODUCTIONS AND ATTRACTIONS FOR BOUNDARY CONDITIONS

- Perform County Specific Scaling of Productions and Attractions
- Scale Productions and Attractions by County
- Adjustment Factors Prepared for Emerging Technologies
- Trip Production and Attraction Balancing

<table>
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<tr>
<th>PURP</th>
<th>INC1</th>
<th>INC2</th>
<th>INC3</th>
<th>INC4</th>
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Note:
- Purpose:
  - 1 = HBWD
  - 2 = HBWS
  - 3 = HBS
  - 4 = HBO
  - 5 = NHBW
  - 6 = NHBO

INC1 = $15K or Less
INC2 = Between $15K and $50K
INC3 = Between $50K and $100K
INC4 = Between $100K and $200K
INC5 = Higher than $200K
Example with gamma function with $A=0.1$ and $B=10$ was performed for income group 3 of the HBW Direct (HBWD) Trip Purpose.

Estimated average distance increased by approximately 16% from 20.28 miles to 23.49 miles.
Mode Choice Modifications

- Implemented New Modes
  - CAV Auto Modes
  - CAV Transit Mode – Dynamic Routing
  - CAV as Access Mode to Transit

- Created Alternative Skims

- Cost Assumptions for Various CAV Modes
  - Private Owned - VMT Charge
  - Fleet Operators - VMT Charge, Applicable Taxes, Operational Costs, and ROI
  - Transit – Consistent Fare Policy

- IVT Coefficients & Image for CAV Modes
  - IVT coefficients – Mode Generic
  - Assumed Mode Specific Constants

- Tested but Not Utilized in Scenarios
HIGHWAY ASSIGNMENT ADJUSTMENTS IN NJRTM-E

Introduced Speed and Capacity Adjustment Facility Type and Area Type

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<tr>
<th>FT</th>
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Note:
FT = Facility Type
AT = Area Type,
Examples of Use - TMIP-EMAT Risk Analysis

Stantec developed and API routine to link the NJRTM-E with TMIP-EMAT. The CAV Model was utilized since the adjustment factors could be easily processed / multiplied by the random numbers generated for the risk analysis.
LOOKING FORWARD
Evolving Travel Conditions and Modeling Implications
TRIP GENERATION WORK FROM HOME TREND

Pre-COVID-19

Telecommuting has doubled since 2005

Source: Global Workplace Analytics & Flexjobs, 2017 State of Telecommuting in the U.S. Employee Workforce

Evers Telecommuted — by Education, Income and Job Type

Based on employed adults

<table>
<thead>
<tr>
<th>Category</th>
<th>% Yes</th>
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<tr>
<td>College graduate</td>
<td>55</td>
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<tr>
<td>Non-college graduate</td>
<td>26</td>
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<tr>
<td>Annual household income $75,000 or more</td>
<td>52</td>
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<tr>
<td>Annual household income less than $75,000</td>
<td>26</td>
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<tr>
<td>White-collar profession</td>
<td>44</td>
</tr>
<tr>
<td>Blue-collar profession</td>
<td>16</td>
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</table>

Aug. 5-9, 2015

Note: White-collar professions are those categorized as being executive/managerial, a professional, specialty, technical, sales or administrative.

Source: Jeffrey M. Jones, In U.S., Telecommuting for Work Climbs to 37%, Gallup, August 2015

Telecommuting by market segments
Unknowns & Second-Order Effects

- Internet Impacts Travel Demand
  - Counter-Balancing Aspects
  - Reduces Regional Travel Demand
    - Magnitude of Travel
    - Enables CAV Vehicles, Reducing Person Trips
  - Optimizes Travel Demand
    - Efficient Zero Occupant Vehicle Usage
    - Alters Time-of-Day Travel Demand
  - Revolutionizes Goods Movement
    - Automated Warehouses and Long-Haul Distribution – 24 Hours/Day
    - Last Mile Delivery – Local CAV delivery & Drones – Night Operations
  - Increases Auto Competition for Intercity Trips
    - Internet provides efficient use of time
Evolving Expectations

- **CAV Fleets - Cost Efficient Operation**
  (Urban Example)
  - Clean/Charge/Maintain – Night Period – Storage Location
  - Cost of Travel Operations
    - Active:
      - VMT charges – which could vary by time of day
      - Cordon charges
      - Service Fees
    - Idle:
      - Parking-related charges
  - Status Decision
    - Active – Ideally Minimum Charge must cover VMT costs, service-related fees & ROI
    - Idle – VMT charge to/from parking location & parking costs
  - Operators will need to optimize and charge according to demand
Evolving Expectations

- **CAV Fleets – Potential Impacts**
  - **(Urban Example)**
    - Excessive CAVs would lead to minimal ride charges
      - Increases Competition for Transit and Non-Motorized Modes for Short Distance Trips
      - Should automatically disperse CAVs to underserved locations to increase likelihood of obtaining paying trips
      - Impacts to Curbside Access, parking space versus drop-off/pickup, possible time-of-day impacts

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**Figure 4: High-level Curb Management Architecture**

- **User**
  - Car (SOV)
  - Delivery Zones
  - TNC Zones
  - Micro-Mobility Zone

- **Central Mobility Session Database**
  - Financial Tracking
  - Rates/Policies
  - Auto-Billing
  - Mobility Session Tracking

- **Other Vendors**
  - Permit
  - Fleet Management (scooters, bikes, TNCS, etc)
  - Other Manual “Permits”

- **Enforcement**
  - **Enforcement Tools**
    - Fixed Camera
    - Mobile LPR
    - RFID
    - Visual (PEO)
  - **Citation Management**
    - Auto Generate
    - Visual (PEO)

The goal is to reduce citations by smarter policies that allow better payment options for all users.
Evolving Expectations – Trip Generation

➢ Trip Generation
  ▪ Household Stratification:
    o Owned CAVs
    o No CAVs

➢ New Normal Trip Rates
  ▪ Reduced Work Travel
    o Productions by Purpose
    o Attractions by Employment Type or Income Group
  ▪ Increased HBO-related Trips

➢ Efficient Zero Occupant Vehicle Usage
  ▪ Private Vehicles – Multi-Task Vehicle Trips
  ▪ Fleet Vehicles – Cost Efficient Operation
  ▪ Commercial Vehicles – VMT declines and Time-of-Day Shifts
    o 75% of Amazon Packages less than 5 pounds

➢ Increases Accessibility for Exurban Locations
Evolving Expectations – Trip Distribution

- CAV and Internet Synergy
- Fewer Trips - Increased Average Trip Length
- Emphasis on Trip Tours, Possible Stratification by Vehicle Type
- Patterns Altered – Focused on New Activity Centers
  - Consolidated Services and Shopping / Socializing
  - Existing Malls - Space for CAV fleets and Superior Network Access

<table>
<thead>
<tr>
<th>Development Site Information</th>
<th>Previous Purpose</th>
<th>Repositioned Purpose</th>
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<tbody>
<tr>
<td>Property Name</td>
<td>Worcester Center Galleria</td>
<td>City Square</td>
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<tr>
<td>Total Acreage</td>
<td>34 Acres</td>
<td>20 Acres</td>
</tr>
<tr>
<td>Total Square Feet</td>
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<td>2 Million</td>
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<tr>
<td>Uses</td>
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<td>Retail (SF)</td>
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<td>Hotel</td>
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<td>168 Rooms</td>
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Evolving Expectations – Mode Choice

- Has ‘Peak Transit’ Occurred?
  - Since 2014 – Transit Ridership has Declined 10-15%
  - Local Bus Service declined 15-30%

- Key Factors
  - Uber/Lyft – *Pre-CAV Service*
  - Affordable, Older Reliable Cars & Stable Fuel Prices
  - Growth Share of Non-Motorized Modes:
    - Bikes/Bike Sharing Services
    - E-Scooters

- The Future of Transit Services
  - Optimize Service to High Density Corridors – Line Haul Routes
  - Convert Key Bus Routes to CAV Bus
  - Reduce Costly Inefficient Local Bus Services
Evolving Expectations – Mode Choice

- **Alternative Path-Building for CAVs**
  - CAV facilities provide reduced travel times, with potential costs

- **Transit Impacts**
  - Line-Haul ‘Premium’ Transit in Congested Regions Benefits from increased accessibility
  - Local Bus Service – Reduced Shares

- **Increased Competition for Non-Motorized Modes**
  - Near Instantaneous Access to urban CAVs
  - Perceived Comfort and Safety
Evolving Expectations – Assignment

CBD/Urban Areas – Limited Benefits
- **Benefits:**
  - Optimized Routing
  - Safety
- **Constraints:**
  - Pedestrian – CAV interaction
  - Cost of Signal System Modifications
  - Congestion from CAVs Trolling for riders

Limited Access Corridors
- **Benefits:**
  - Capacity Optimization
  - Reduced Congestion & Safety
- **Constraints:**
  - Contingent on CAV Adoption
  - Potential to Price Access to Exclusive CAV roadways
Transition - Key Factors

- **Technology – Costs – Market Incentives**
  - Manufacturers and Society Pushing towards Electric Vehicles
    - Electric Vehicles – Fewer Parts and requires less workers to assemble
  - Increased EV Usage Requires:
    - Significant Infrastructure - Public and Private
    - VMT-based Revenue Requirement
  - Level 5 and Level 6 CAVs likely to be expensive

- **Broad Public Adoption of CAVs**
  - Fleet Turnover – EVs Have longer Life Cycle
  - Rental Fleet Operators – Early Adopters
  - Early Usage:
    - Trip Type - Longer Distance Intercity Travel, Vacation Travel
    - Individuals - Business Travelers & Elderly
  - Frequent Use Programs - Incentivize Usage and Brand Loyalty

- **Network Benefits**
  - Contingent on Penetration Levels
  - States may restrict CAV operation in certain areas or conditions
  - Favors Limited Access Facilities in the early years

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*EV Batteries should last between 10-20 years, newer batteries are expected to last beyond 500,000 miles*

*EV are less expensive to repair on an annual basis. Electric motors will last 15+ years*
Transition Timeline

➢ Fleet Composition
  ▪ Fleets vs. Personal Ownership
  ▪ Turnover - EVs Have longer Life Cycle
  ▪ Aggressive CAV Technology Assumptions
  ▪ CAV Dominate Share is Likely 2050

➢ Network Benefits
  ▪ Urban Areas - Combination of Vehicle Penetration & Signalization Updates
  ▪ Some Benefits Achievable at 60% Vehicle Penetration
  ▪ Significant Benefits at the 90% Vehicle Penetration
Investing in AV

**STANTEC GENERATIONAV™**

**AV DEPLOYMENT ACCELERATION**
Comprehensive automated mobility consulting practice including planning, deployment and oversight tools.

**AV INNOVATION ACCELERATION**
Collaborative network of enabling tech and solution providers from start-ups to global leaders.

Stantec’s full spectrum SMART MOBILITY expertise, experience and global client network enables both deployment and innovation.
Products & Tools

Our team of global AV leaders can help you in any stage of your AV planning and deployment.

TOOLS AND TECHNOLOGY:

- Strategy
- Learning Center
- Stakeholder/End-User Research
- Deployment Playbooks/Guides
- GenAV Ally Supplier Portal
- ODD/Ops Risk Assessment
- Safety/Compliance Verification
- Cyber Security Assessment

The Playbook: Steps to a successful AV deployment
Sampling of Current Stantec AV Projects

Las Vegas GoMed Connected and Autonomous Shuttle Program

Deployment of CAV Shuttles in 3 cities (still confidential)

Kanata North Autonomous Vehicle Transit Network Feasibility Study

New England Connected and Automated Vehicles Legal, Regulatory and Policy Assessment

LADOTD IDIQ Contract for ITS System Integration and CAV

CAV Feasibility Assessment (Private Mining Company)
Discussion – Questions?