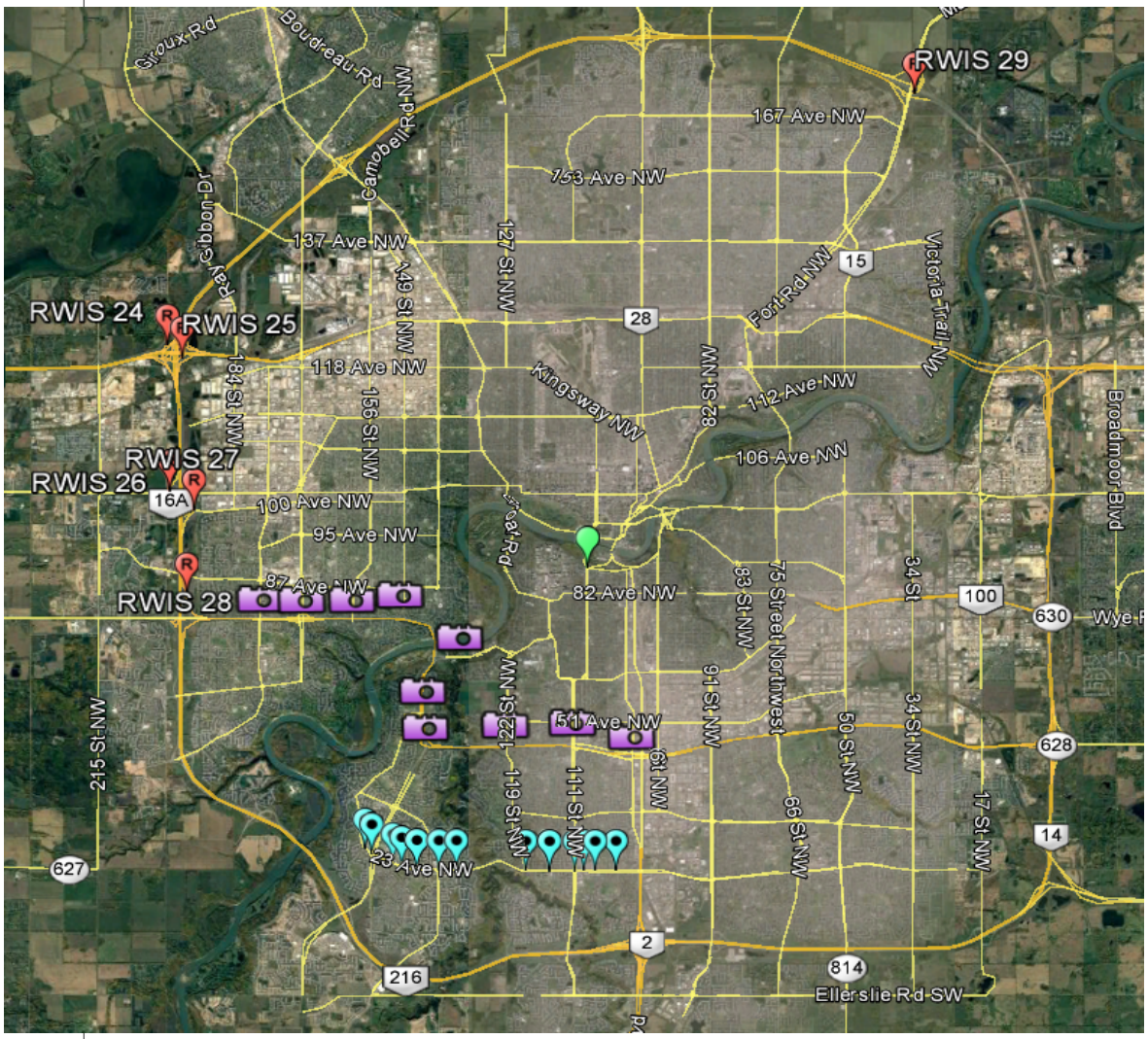
CAV IMPACTS & SCENARIO TESTING

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

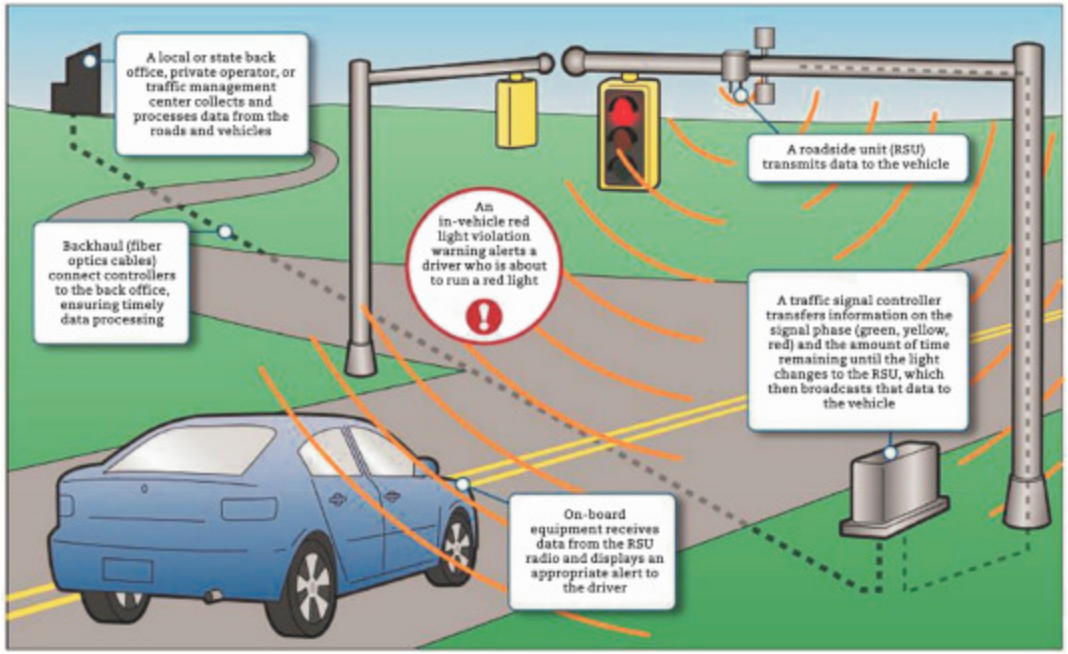
City of Montreal SAV Project
Montreal, QC

- 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**

Stantec's Modeling and T&R Practice Group Initial Focus – Client Needs

- Client Needs Driven by Agency Role:
  - *Planning Needs – MPOs, State DOTs*
  - *Financing Needs – Toll Agencies, Investors*



Initial Focus – Traffic & Revenue Implications

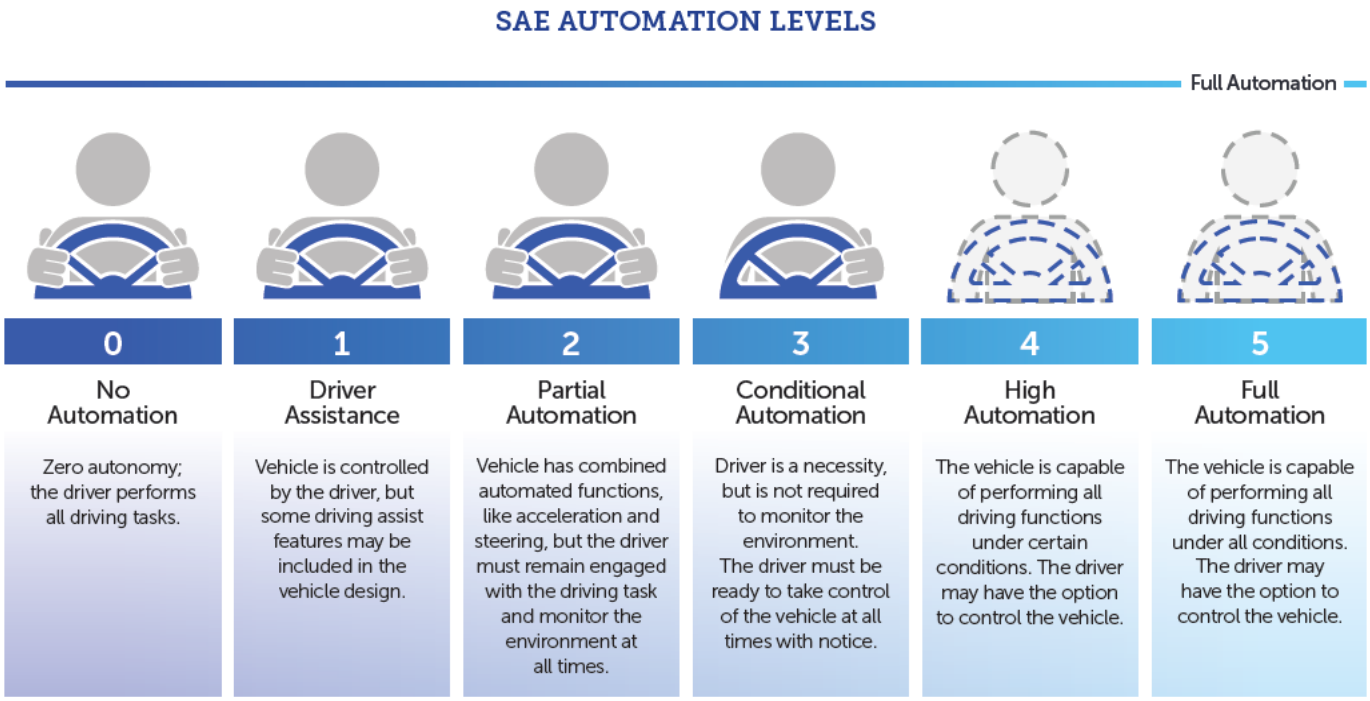
- Impacts & Timeline
- Tolling Agencies
  - Will Vary by Toll Road Type
  - Will Vary by Market Segment – Expanding Intercity Competition
- Rating Agency Dialogue
- Internal Research & Mock Presentations (2017-2019)

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

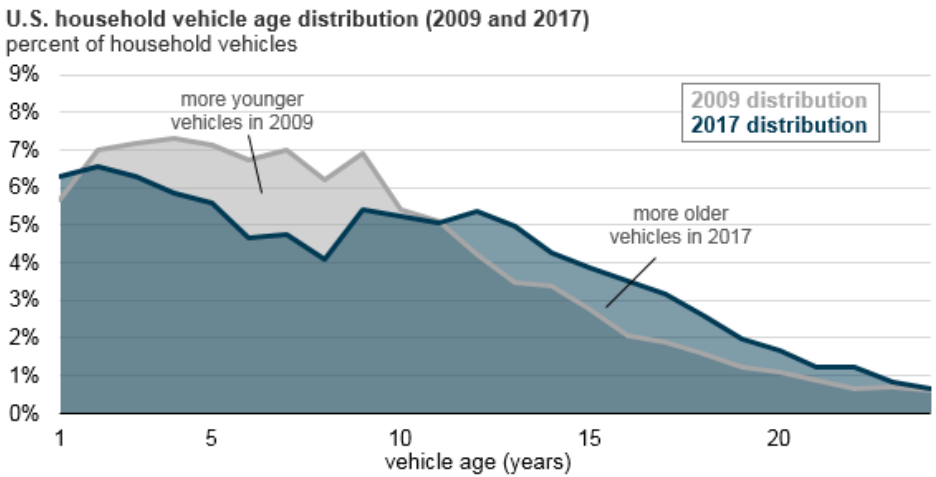
Transition to CAV will take time…….

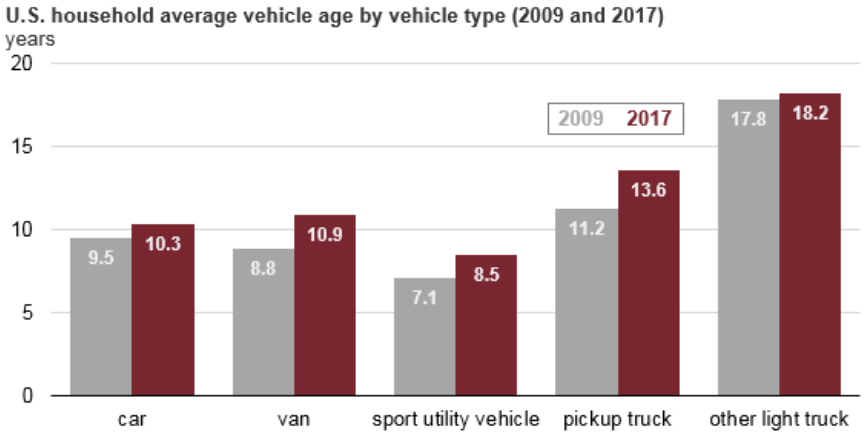


Transition influenced by: Technology, Costs, Regulation, Liability

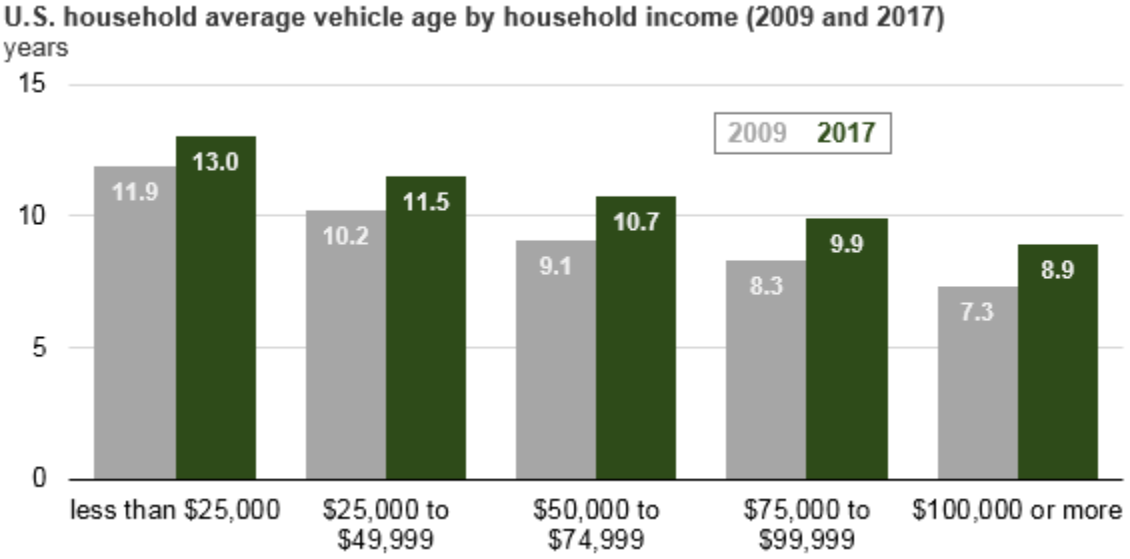
Vehicle Costs Extend Replacement Cycle

Vehicle Life is growing, now 11 years.





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

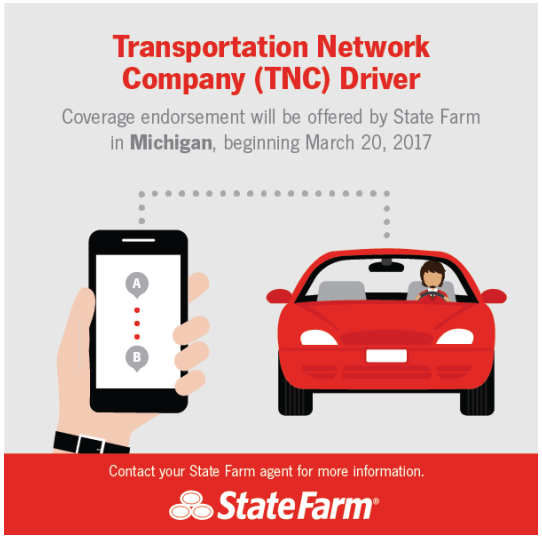
- Impacts will vary by Area Type
- Urban Areas
  - CAVs Replace Existing Mobility Providers
  - Key Generators – Airports
  - Operational Challenges
- Suburbs
  - Replaces Localized Services
  - Higher Incomes Supports MAAS
  - Competes Effectively against non-motorized modes
- Rural Areas
  - Low Density 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



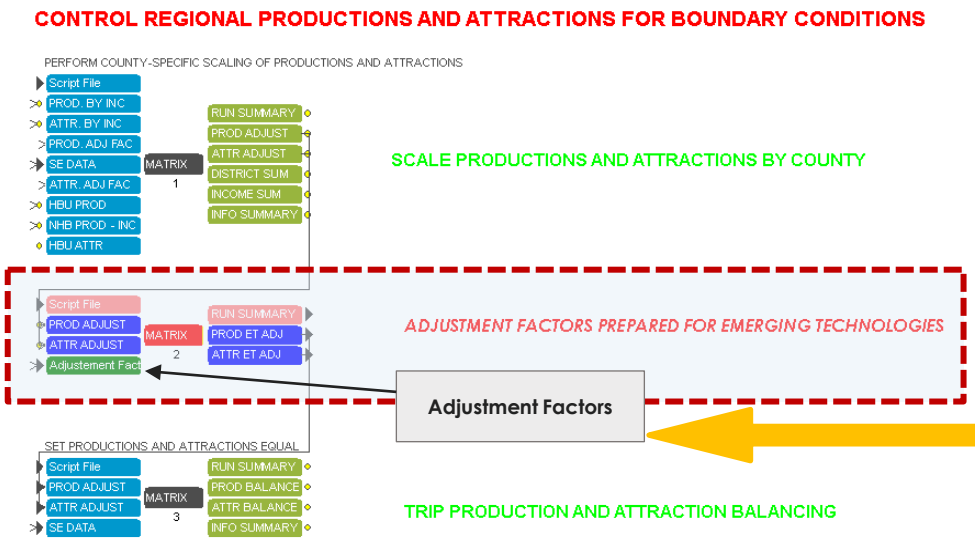
NJRTM-E CAV Scenario Model

- 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

NJTPA
NORTH JERSEY TRANSPORTATION PLANNING AUTHORITY



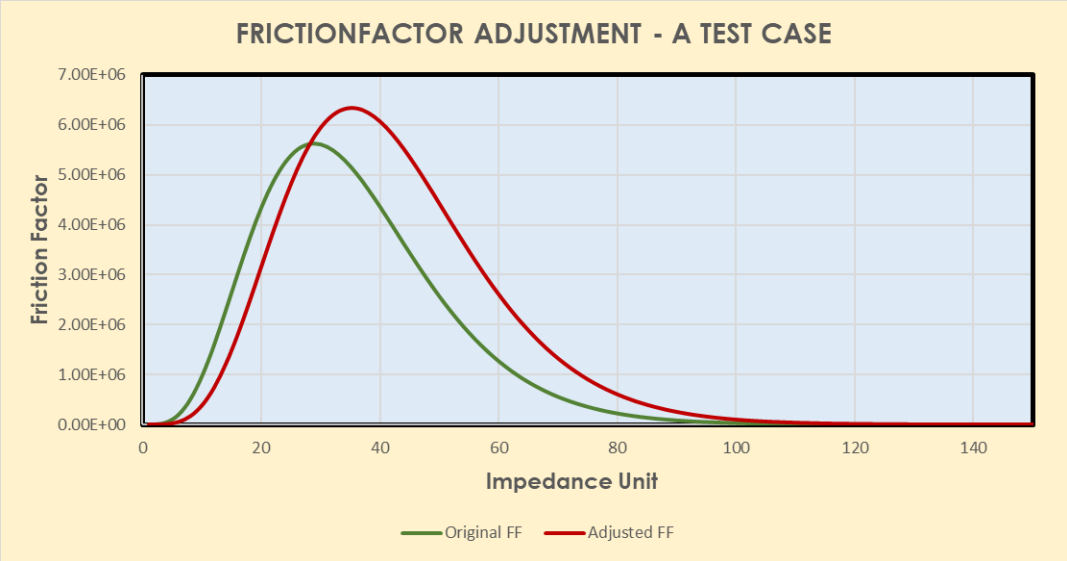
PURP	INC1	INC2	INC3	INC4	INC5
1	1.0000	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000

Note:

Pupose: 1 = HBWD 4 = HBO
2 = HBWS 5 = NHBW
3 = HBS 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

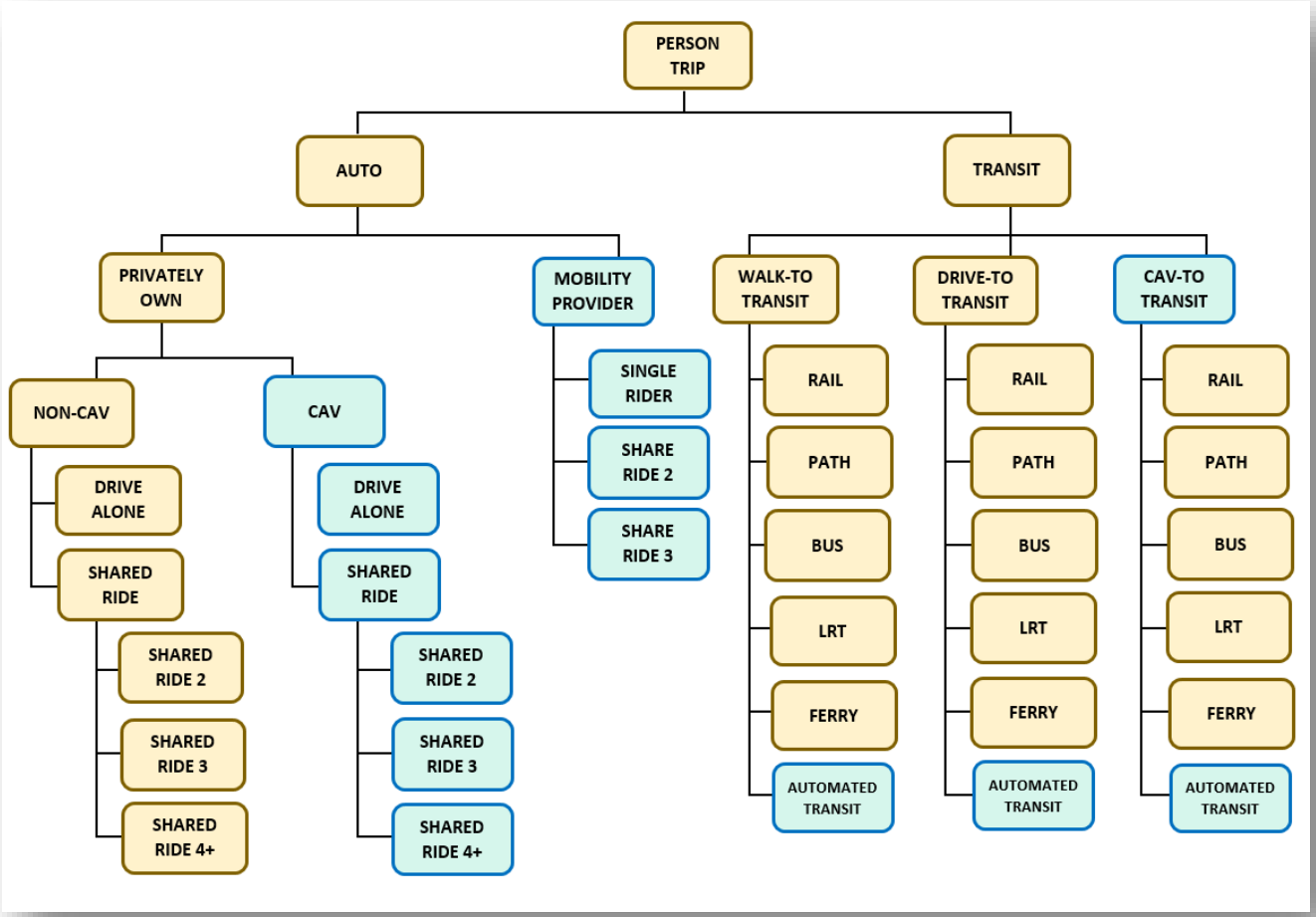
TRIP DISTRIBUTION – Modified Equation



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 CAV ADJUSTMENTS

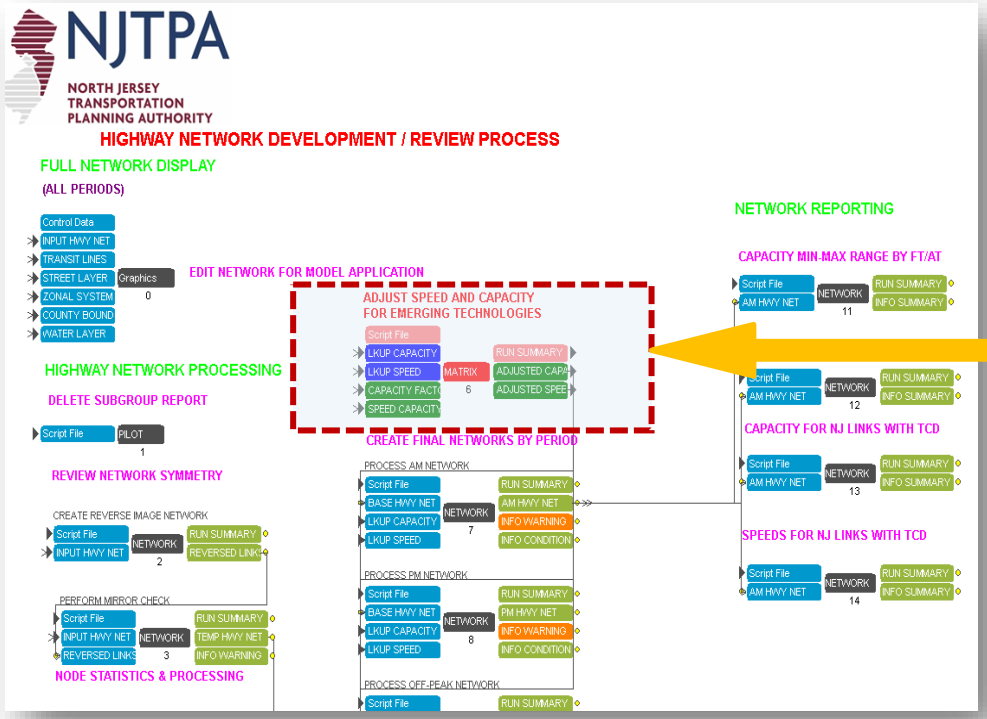


Mode Choice Modifications

- 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

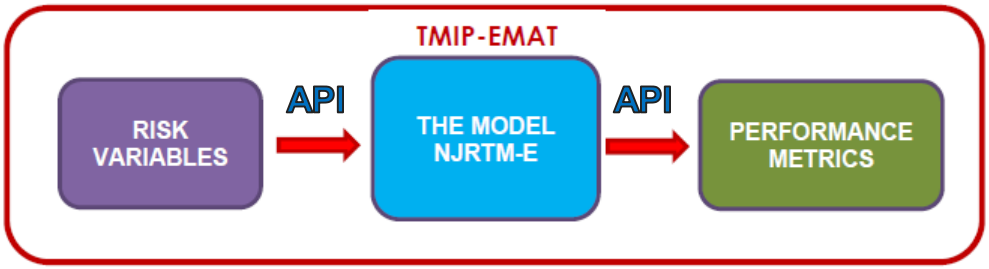
Introduced Speed and Capacity Adjustment Facility Type and Area Type



FT	AT1	AT2	AT3	AT4
1	1.0000	1.0000	1.0000	1.0000
2	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000
10	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000

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.

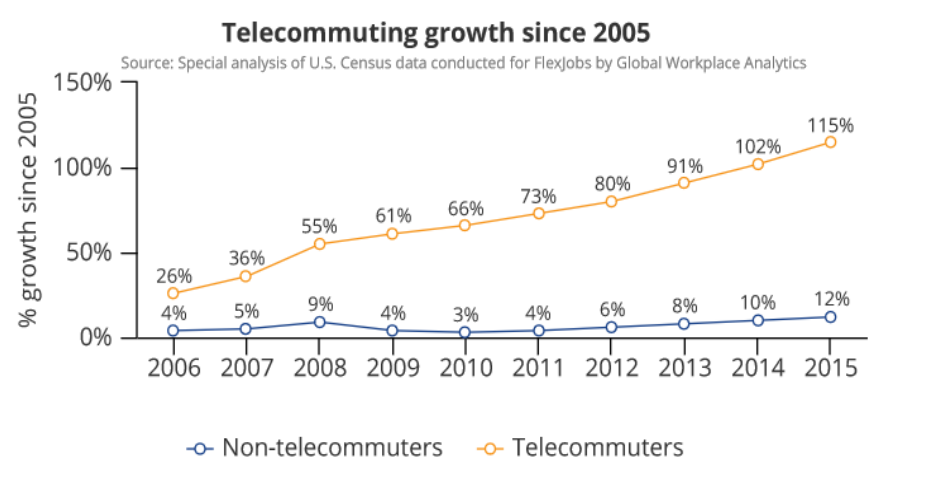
The CAV Model was utilized since the adjustment factors could be easily processed / multiplied by the random numbers generated for the risk analysis.

LOOKING FORWARD

Evolving Travel Conditions and Modeling Implications

TRIP GENERATION WORK FROM HOME TREND

Pre-COVID-19



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

Telecommuting has doubled since 2005

Ever Telecommuted -- by Education, Income and Job Type

Based on employed adults

	% Yes
College graduate	55
Non-college graduate	26
Annual household income $75,000 or more	52
Annual household income less than $75,000	26
White-collar profession	44
Blue-collar profession	16

Aug. 5-9, 2015

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

GALLUP

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

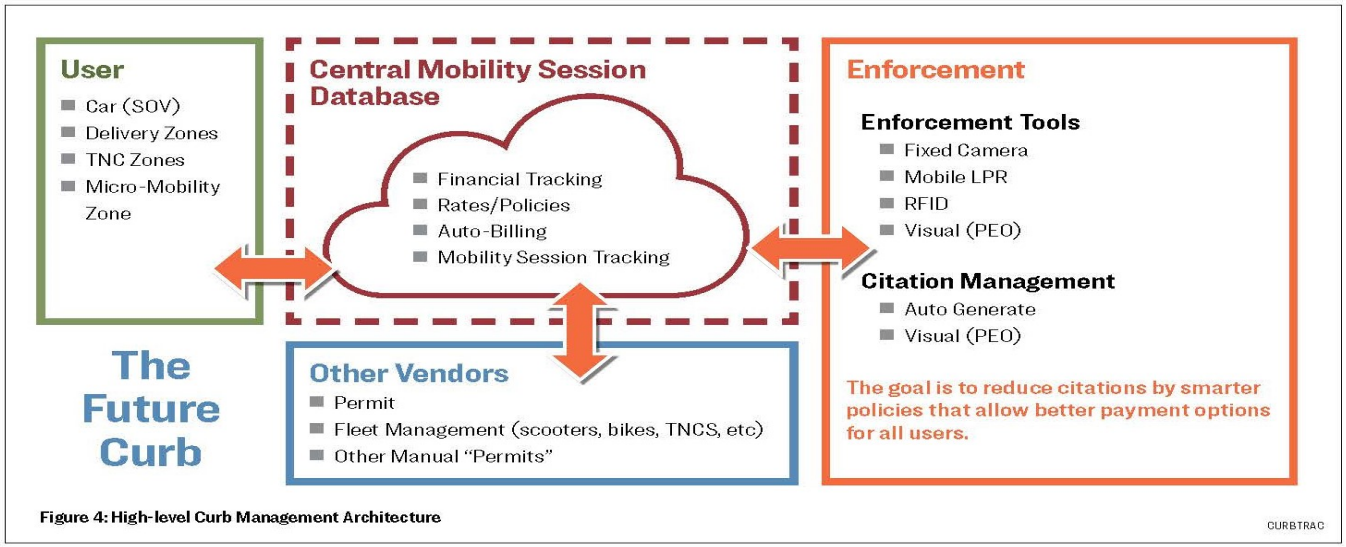


Figure 4: High-level Curb Management Architecture

Evolving Expectations – Trip Generation

- Trip Generation
  - Household Stratification:
    - Owned CAVs
    - No CAVs
- New Normal Trip Rates
  - Reduced Work Travel
    - Productions by Purpose
    - 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
    - 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

Development Site Information	Previous Purpose	Repositioned Purpose
Property Name	Worcester Center Galleria	City Square
Total Acreage	34 Acres	20 Acres
Total Square Feet	-	2 Million
Uses		
Retail (SF)	1 Million	350,000
Office/Medical	-	500,000
Residences	-	1,000 Units
Parking Spaces	4,300	3,900
Hotel	-	168 Rooms

Evolving Expectations – Mode Choice

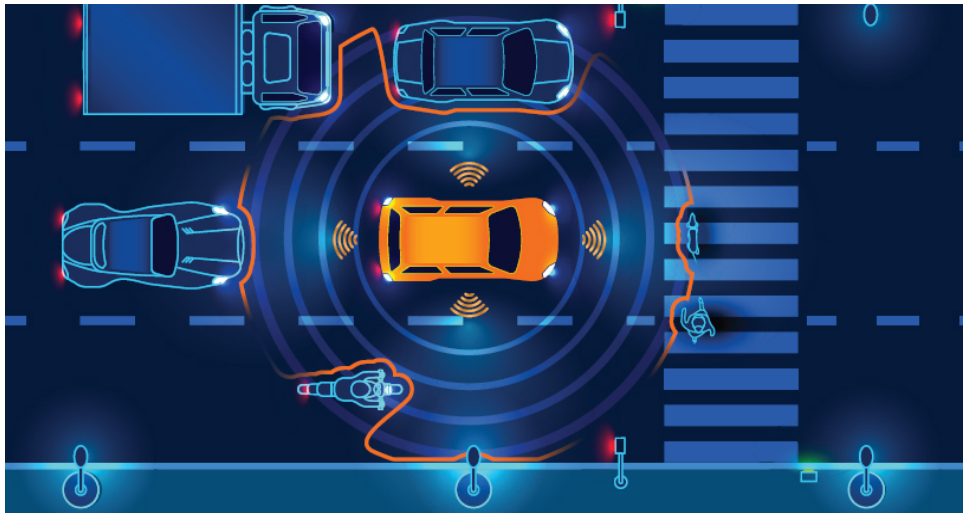
- Has 'Peak Transit' Occurred?
  - Since 2014 – Transit Ridership has Declined 10-15%
  - Local Bus Service declined 15-30%
- Key Factors
  - Uber/Lyft – *Pre-CAV Service*
  - Affordable, Older Reliable Cars & Stable Fuel Prices
  - Growth Share of Non-Motorized Modes:
    - Bikes/Bike Sharing Services
    - 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

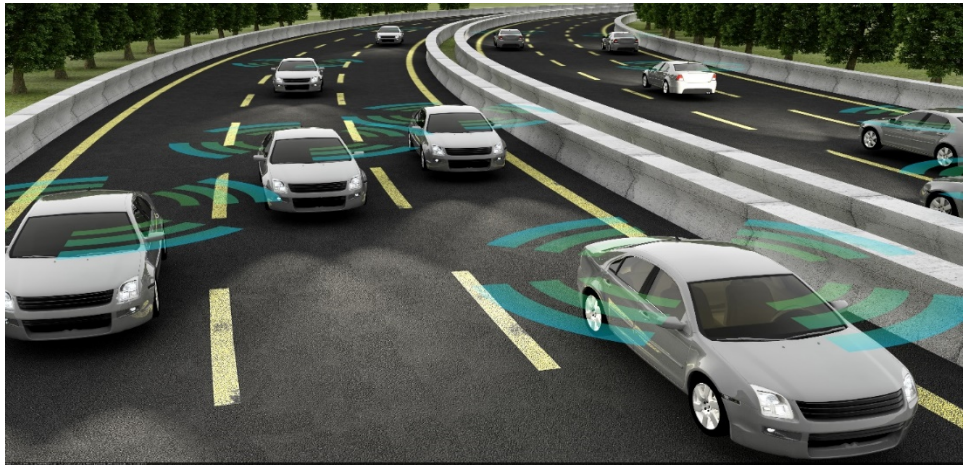
- Alternative Path-Building for CAVs
  - CAV facilities provide reduced travel times, with potential costs
- Transit Impacts
  - Line-Haul 'Premium' Transit in Congested Regions Benefits from increased accessibility
  - Local Bus Service – Reduced Shares
- Increased Competition for Non-Motorized Modes
  - 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

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

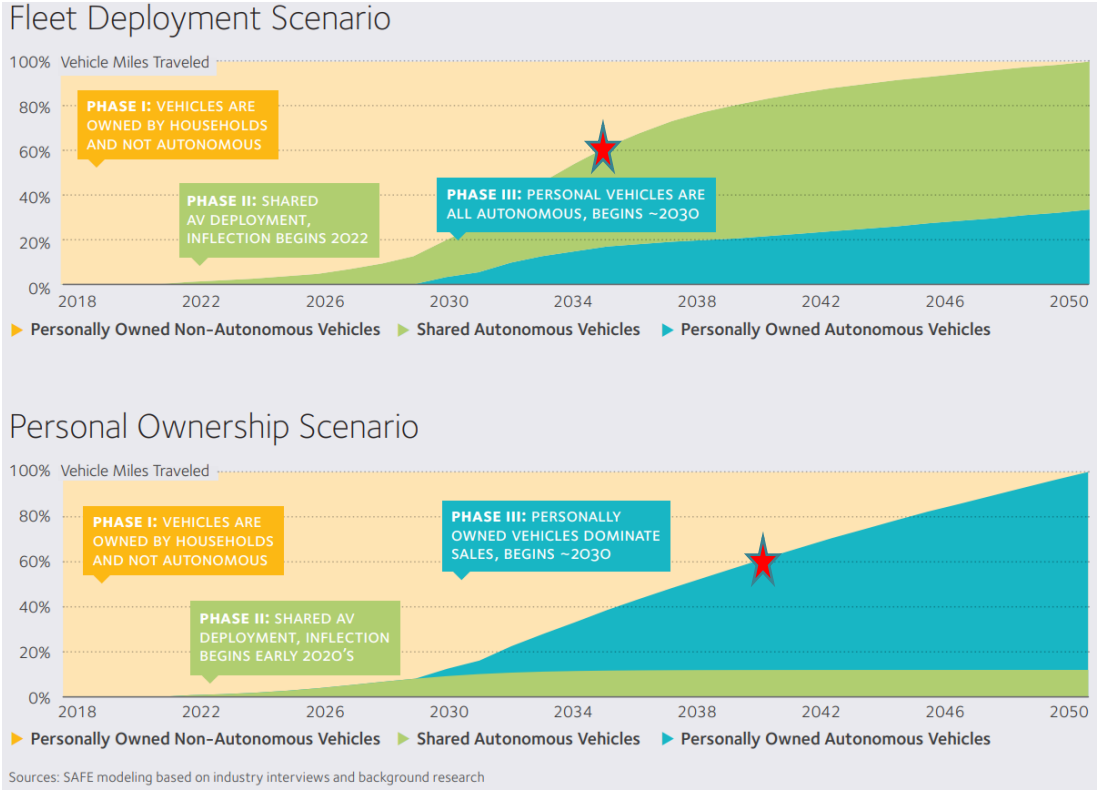
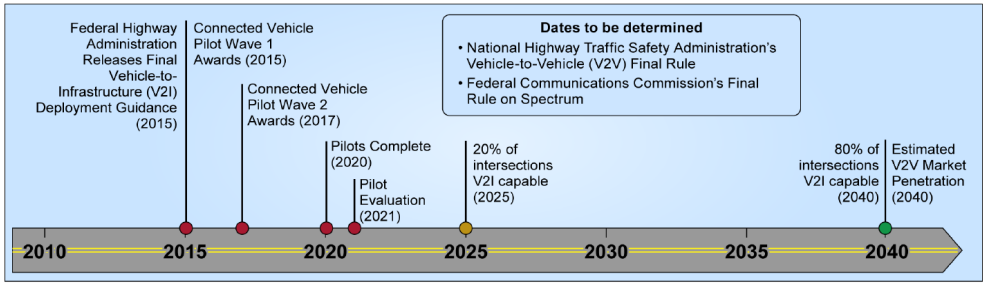


Figure 3: DOT's Planned Connected Vehicle Path to Deployment, 2010-2040



Source: GAO analysis of Department of Transportation documents. | GAO-15-775

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

STANTEC

On-Going Research & Services

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)


Stantec
Discussion – Questions?