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Technical Memorandum

June 28, 2023 Project# 22398.11

To: Alex Bettinardi, PE and Tony Knudson
Technical Advisory Committee (TAC) Members

From: Kelly Laustsen, PE; Mike Aronson, PE; Abby Morgan, PhD, PE; Bastian Schroeder, PhD, PE; and Poppy Yang, PhD

RE: Scenario Guidance for Travel Demand Modeling

TASK 3: OREGON SCENARIOS FOR STUDYING CAVs IN TDMs

The Oregon Department of Transportation (ODOT) is developing guidance for analyzing the effects of connected and automated vehicles (CAVs) on roadway operations. This guidance, based on the *Highway Capacity Manual* 7th Edition (HCM7), will be incorporated into an update of ODOT's *Analysis Procedure Manual* (APM).

The HCM7 includes capacity adjustments to account for the presence of CAVs in the traffic stream. These adjustments were developed by an ODOT-led national pooled-fund study, "Planning-Level Capacities for Connected and Automated Vehicles in the HCM." The HCM7's CAV content provides the most thoroughly analyzed and peer-reviewed information to date for evaluating CAV effects on roadway operations. However, as discussed in HCM7 and the new APM content, there is significant uncertainty around the future of CAVs, how they will influence capacity and roadway operations, and their effects on safety, land use, equity, and the environment. Scenario analysis is a technique suggested by both documents to address this uncertainty.

This technical memo is the third in a series of memos being prepared as part of a project to provide ODOT and other public agencies in the state with CAV scenario guidance for travel demand modeling. Technical Memorandum #1 provided high-level guidance on impacts CAVs might have that could be simulated using travel demand models (TDMs) and case studies of how other agencies have used TDMs to study CAV impacts. Technical Memorandum #2 discussed potential adjustments to road capacity that can be made in a travel demand model to account for CAVs, based on the pooled fund study led by ODOT and material included in HCM7. As presented in Technical Memorandum #1, other components of trip-based and activity-based models could be modified to represent CAV impacts as well, although research is more limited as to what factors to change and how to change them.

This memorandum provides additional discussion on factors of most interest to the project Technical Advisory Committee (TAC) for modeling in Oregon and outlines potential CAV scenarios. It reflects feedback from TAC members during TAC Meeting #4 on June 13th, 2023.

Adjusting TDMs to Account for CAVs

There are many potential impacts of CAVs on safety, operational efficiency, travel behavior, transportation accessibility, transportation equity, environmental impacts, and more. There are also limited real-world deployments to inform how CAVs will function and be used in the long term. TDMs are useful tools for studying some of the major anticipated impacts of CAVs. Technical Memorandum #1 listed the CAV considerations that could be included in travel forecasts:

- Auto availability
- Auto occupancy
- Capacity
- CAV ownership/ride-sourcing
- Land use and urban form
- Mode choice
- Operating cost
- Parking cost
- Signal control delay
- Terminal time/access time
- Travel demand
- Trip length
- Value of time
- Zero-occupancy trips

Based on input from the TAC, three key factors for Oregon agencies to consider when modeling CAVs in a TDM include:

- Value of time
- CAV ownership/ride sourcing
- Land use and urban form

The sections below present further discussion on each of these three factors and examples of approaches taken in the case studies reviewed as part of Technical Memorandum #1, followed by a summary of approaches used for the other potential modeling factors. This material was reviewed and discussed by the TAC to document potential approaches that could be explored in future modeling scenarios in Oregon. A copy of the interactive Concept Board used by the TAC during and after the June 13th TAC meeting is provided in *Attachment A*.

Value of Time

CAVs may result in a reduction of users' value of time given the expected reduction in responsibility, stress, and focus needed to ride in a CAV compared to driving a vehicle. Based on the case studies reviewed, some have accounted for this by adjusting perceived travel time, travel time disutility, lost in-auto time, value of work trip travel time for housing choice, or impedance friction factors used to determine trip distribution. Value of time could be adjusted differently for different trip types. Table 1 summarizes changes in value of time observed in the case studies.

Table 1. Approaches to Value of Time

Case Study	Approach
Atlanta Regional Council (ARC)	Decreased travel time disutility by 50%
Capital Area Metropolitan Planning Organization (CAMPO, Austin, TX)	Decreased value of work trip travel time by 50% for personal AV scenario and by 25% in high-occupancy AV scenario
Jacksonville, FL	Increased impedance friction factors for home-based work trips by 2.5% or 5% to simulate that passengers will accept longer trip lengths
Melbourne, Australia	Decreased value of time by 50%
Metropolitan Washington Council of Governments (MWCOG)	Decreased perceived time spent in auto by 50%
North Central Texas Council of Governments (NCTCOG)	Decreased value of time by 35%
Oregon Metro	Decreased auto in-vehicle time by 50%
Puget Sound Regional Council (PSRC, Seattle, WA)	Considered two scenarios: (1) travel time perceived as 65% of actual travel time for high value of time household trips (>$24/h) and (2) travel time perceived as 65% of actual travel time for all trips

Key considerations discussed by the TAC include:

- The impact of CAVs on value of time may vary based on the individual and the trip (e.g. trip type, perceived time constraint, discretionary vs. non-discretionary trips).
- Since CAVs do not exist on the road currently, could investigate value of time for people using existing modes with similar operating characteristics, like a TNC/rideshare vehicle or taxi. However, the experience of riding with a driver versus alone in a CAV may be significantly different.
- The value of time for riding in a CAV may be different if the CAV is privately owned versus a fleet vehicle/shared.
- The current assumptions behind the impact of CAVs on value of time are a best guess. It would be helpful to test out a range of assumptions around value of time and explore the impacts.

CAV Ownership/Ride Sourcing

Whether CAVs are privately owned or shared may impact how they are accounted for in a TDM and the effects they have on transportation choices and patterns. Table 2 provides examples of approaches agencies have taken to assess the impact of CAV ownership.

Table 2. Approaches to Account for CAV Ownership/Ride Sourcing

Case Study	Approach
DC Sustainable Transportation (DCST)	Considered a scenario with private ownership and a scenario with shared AVs. Assumes the following with shared AVs: • More significant decrease in vehicle ownership • Faster pace of electrification • Higher vehicle occupancies • Greater reduction in demand for parking
Jacksonville, FL	Included "paid rideshare" (transportation network companies, TNC) as a mode choice, with the option to specify that TNCs use AVs. Calibrated the auto ownership and mode choice models to reflect three levels: • Low: 3% of trips by paid ride-hail mode; no corresponding effect on auto ownership • Medium: 30% of trips by paid ride-hail mode; 15% reduction in auto ownership • High: 60% of trips by paid ride-hail mode; 30% reduction in auto ownership

Case Study	Approach
Melbourne, Australia	Considered private CAVs versus autonomous ride-sourcing. The study found that the increase in perceived travel cost with shared AVs is likely to be greater than the decrease in perceived travel cost due to increased comfort, despite the decrease in value of travel time and conservative assumptions for cost. The study assumed the perceived cost of travel time per half hour of travel is $7.80, so if the value of travel time is halved for autonomous ride-sourcing, the perceived cost could decrease by $3.90. However, this is outweighed by the higher perceived vehicle operating cost per half hour for a ride-sourced AV ($9.70) compared to a private vehicle ($2.10). Therefore, autonomous ride-sourcing has a perceived cost per half hour of travel that is $3.70 higher compared to travel by a private vehicle.
Oregon Metro	For shared-use scenario, vehicle occupancies were increased by decreasing costs perceived by trips using the "drive with passenger" and "passenger" modes by 50%.
Sacramento Council of Governments (SACOG)	Treated shared CAVs as TNCs and tested TNC utilization rates. This factor resulted in lower vehicle ownership, and greater reliance on TNCs for shorter trips that may otherwise be served by transit, biking, or walking.

Key considerations discussed by the TAC include:

- If CAVs are shared, the pricing and use will be influenced by the supply and regulations.
- CAVs could operate more as delivery vehicles than chauffeurs under an e-commerce fleet ownership scenario.
- CAVs could be used by employers (e.g. Intel sends out CAVs to pick up employees).
- It is important to define CAV ownership, shared-rides (similar to on-demand rides), and pooled-rides (linking multiple shared rides along a similar route). These can be applied to passenger movement as well as freight/goods movement.
- There are equity considerations associated with CAVs, e.g. cost and quality of private transport in a CAV (TNC) versus public transit.
- CAV ownership will be influenced by accessibility and cost.

Land Use and Urban Form

The impacts of CAVs on land use and urban form are likely to take longer to take effect than other direct impacts of CAVs. They could also be controlled or influenced by policy decisions and other levers available to agencies, and interrelated with other factors (e.g., teleworking). CAVs might contribute to land use and urban form changes including:

- Decreased parking demand results in the redevelopment of urban parking lots
- Decreased value of time results in greater sprawl as employees accept longer commute times

Table 3 summarizes approaches agencies have taken to assess potential impacts of CAVs on land use and urban form. Some agencies have used models where land use is reactive to changes in travel behaviors and characteristics (like value of time and mode choice), where other agencies have manually updated land use to reflect presumed changes with CAVs.

Table 3. Approaches to Changing Land Use and Urban Form

Case Study	Approach
CAMPO	Utilized work done by researchers at University of Texas that studied land use and transportation pattern effects of self-driving vehicles. The research used a land use model simple integrated land use orchestrator (LUM SILO) and multi-agent transport simulation (MATSim) to assess land use changes. It considered a scenario where value of travel time was reduced by 50% and where additional changes were assumed, like an increase in vehicle occupancy or higher roadway capacity. The results showed longer average work trip travel times and more households in non-City of Austin Metro areas with AVs.

<table>
<tr><th>Case Study</th><th>Approach</th></tr>
<tr><td>DCST</td><td>Scenarios studied include additional factors beyond CAVs, including land use changes, policies, and mobility service options. The study concluded that AVs can enable more people to live in walkable urban areas by encouraging higher densities in areas further from Metrorail stations without requiring more parking. The scenario analysis assumed that if travel on freeways is easier and faster, people are more enticed to live further from the region's center. The study also included assumptions on retail and employment growth.</td></tr>
<tr><td>Melbourne, Australia</td><td>The land use module of the Land Use and Transport Interaction (LUTI) model uses a multinomial logit model to redistribute population based on accessibility to employment as a factor for residential location decisions. The population by location for the four scenarios are shown below. With a 50% reduction in value of travel time due to AVs and no shift to autonomous ride-sourcing, population in the far outer suburbs increase by 49,500.
<table>
<tr><th></th><th>S1</th><th>S2</th><th>S3</th><th>S4</th></tr>
<tr><th></th><th>BAU</th><th>50% VTT, Private cars</th><th>Ride-sourcing</th><th>50% VTT, ride-sourcing</th></tr>
<tr><td>Inner Suburbs (1-5km)</td><td>556,851</td><td>-22,900</td><td>21,000</td><td>11,600</td></tr>
<tr><td>Middle Suburbs (5-15km)</td><td>1,887,786</td><td>-19,900</td><td>33,000</td><td>41,800</td></tr>
<tr><td>Outer Suburbs (15-30km)</td><td>2,635,319</td><td>-6,700</td><td>5,600</td><td>2,100</td></tr>
<tr><td>Far Outer Suburbs (30km+)</td><td>2,006,025</td><td>49,500</td><td>-59,600</td><td>-55,600</td></tr>
</table>
BAU = business as usual, VTT = value of travel time</td></tr>
<tr><td>NCTCOG</td><td>Assumed that automated vehicles will cause travelers to make longer trips due to the decreases in their travel delay and the value of time for drivers. NCTCOG studied a possible alternative growth opportunity scenario due to AVs and redistributed population and employment.</td></tr>
<tr><td>Orlando, FL</td><td>Modified the model to show changes to the geographic distribution of future population, employment, and visitors across the region by targeting growth in key areas of impact (e.g., premium transit corridors, focused development areas, and industrial or logistics zones).</td></tr>
</table>

Key considerations discussed by the TAC include:

- Future Oregon land use models may provide the opportunity for more sophisticated allocation of land use.
- While Oregon does have urban growth boundaries (UGBs), CAVs could enable people to live and work in different communities if they are willing to accept longer commutes/experience less congestion (e.g. work in Portland and live in Hood River).
- Consider impacts of CAVs on policy objectives (e.g. climate friendly equitable communities). Potential CAV impacts may drive policy decisions.
- CAVs and teleworking may have some overlapping effects. For example, people that may choose to live farther from where they work may already be doing so with teleworking, so the impact of CAVs on housing choice may not be as significant as it would without teleworking.
- The impacts of CAVs on land use may be influenced by the commute times people are willing to accept and potential productivity while traveling (can time in a CAV count towards work hours?).
- Several factors influence potential redevelopment of parking lots, in addition to CAVs (pressure for housing, telecommuting reducing demand, regulations on VMT).
- Could do some exploratory modeling around question of how CAVs will impact land use, with some manual adjustments. Oregon's Statewide Integrated Model (SWIM) is also an option for testing CAV scenarios.

Other Factors

Table 4 in Technical Memorandum #1 presented major factors to consider for modeling CAV scenarios. This table is expanded below to provide specific changes made in the case studies, where available. The table includes the following case studies:

- ARC: Atlanta Regional Council
- CAMPO: Capital Area Metropolitan Planning Organization (Austin, TX)
- DCST: DC Sustainable Transportation (Washington, DC)
- FDOT ACES Guidance: Florida DOT automated, connected, electric and shared-use vehicles (ACES) guidance
- Jacksonville, FL
- Melbourne, Australia
- Montgomery County, MD
- MWCOG: Metropolitan Washington Council of Governments
- NCTCOG: North Central Texas Council of Governments
- ODOT: Oregon Department of Transportation
- Oregon Metro (Clackamas, Multnomah, and Washington counties)
- Orlando, FL
- PSRC: Puget Sound Regional Council (Seattle, WA)
- SACOG: Sacramento Council of Governments (California)
- SJCOG / MCAG: San Joaquin Council of Governments / Merced County Association of Governments (California)

Further details on these case studies, including the scenarios they analyzed, are provided in Technical Memorandum #1.

Table 4. Potential Model Adjustments

Factor	Considerations	Approach Taken in Case Studies
Auto availability	• May increase if more households/individuals have access to a vehicle with shared CAVs • *Resource: Milam et al., 2019*	• +10-20% *(Montgomery County)* • All households have access to at least one vehicle *(MWCOG)* • Moved all zero-car households into lowest non-zero auto ownership category *(Oregon Metro)*

Auto occupancy	• May increase if CAVs are primarily high-occupancy vehicles
	• *Resource: Milam et al., 2019*
		• Auto occupancy
		  o Approximately doubled for high-occupancy AV scenario *(CAMPO)*
		  o Doubled average rate *(MWCOG)*
		• Costs perceived by trips using the "drive with passenger" and "passenger"
		  o -50% *(Oregon Metro)*

Factor	Considerations	Approach Taken in Case Studies

Capacity	• Could vary by location, roadway type, and context
	• May increase because of closer headways between CAVs
	• Average road capacity/reliability may increase because of decreased incidents
	• May decrease if vehicles not connected or operate more conservatively than human drivers
	• *Resource: HCM7/APM provides capacity adjustment factors for some facility types; Milam et al., 2019*
		• Capacity
		  ○ +50% *(ARC)*
		  ○ +15-75% based on scenario, area type, and facility type (*FDOT* ACES)
		  ○ +0-12% based on automation and technology *(Jacksonville, FL)*
		  ○ +5-33% link capacity and -0-3% volume delay function (*NCTCOG)*
		• Freeway capacity
		  ○ +50% with 100% market penetration (*DCST)*
		  ○ +10-20% (*Montgomery County)*
		  ○ Increase to 3,300 vehicles per hour per lane (vphpl) *(MWCOG)*
		  ○ Between 1,500-3,000 vplph (*ODOT)*
		  ○ +65% (*Oregon Metro)*
		• Freeway and major arterial capacity
		  ○ +30% *(PSRC)*
		• Highway capacity
		  ○ +10-50% (*SACOG)*
		• Not specified (*Orlando, FL)*

CAV ownership / ride-sourcing	• Whether CAVs are private or shared may impact destination choice, mode choice and land use patterns (e.g., shared CAVs may lower public transport and private car modal shares) • *Resources: Boesch et al., 2018; Chen & Kockelman, 2016*	• See Table 2
Land use and urban form	• Residence and/or business locations may be more scattered and dispersed due to the increased accessibility to employment areas and the decreased value of travel time • *Resources: Gelauffet al., 2017; Kim et al., 2015; Meyer et al., 2017; Thakur et al., 2016; Zhang, 2017*	• See Table 3
Mode choice	• CAVs may make auto trips more attractive • Trips may shift from transit to CAVs or CAVs may make transit more attractive (if provide first-mile/last-mile access) • Trips may shift because of other model changes (value of time, costs) or trip tables may be modified • *Resource: Milam et al., 2019*	• +2.5-15% auto trips, shift 5% transit trips to AV (*FDOT ACES)*

Operating cost	• May decrease if CAVs are shared
	• Could also adjust perceived per trip costs
	• *Resource: Milam et al., 2019*
		• Vehicle operating cost
		  ○ -70% *(ARC)*
		• Perceived operating cost
		  ○ $9.70/half hour for ride-sourced AV and $2.10/half hour for private vehicle (*Melbourne, Australia*)
		• Cost $1.65/mile when all autos are AVs (*PSRC)*

Parking cost	• May decrease if demand for parking decreases with CAVs
	• *Resources: Bischoff& Maciejewski, 2016; Chen et al., 2016; Fagnant et al., 2015; Martinez & Viegas, 2017; Spieser et al., 2014; Milam et al., 2019*
		• Parking cost
		  ○ Varied *(ARC)*
		  ○ -25-50% (*Montgomery County)*
		  ○ -50% (*MWCOG, Oregon Metro, PSRC)*

Factor	Considerations	Approach Taken in Case Studies

Signal control delay	• May decrease if ITS improvements made at intersections	• Control delay
		  ○ -2.5-10% (*NCTCOG)*
		• Link saturation flow at signalized intersections
		  ○ +5-33% (*NCTCOG)*

Terminal time/access time	• May decrease assuming CAVs pick up/drop off close to travelers' origins/destinations and self-park
	• *Resources: Milam et al., 2019*
		• Access time
		  ○ -1-2 minutes (*FDOT ACES)*
		  ○ -25-50% (*Montgomery County)*
		  ○ 0 (MWCOG)
		• Auto out of vehicle time = 0 (*Oregon Metro)*

Travel demand	• May be coded as an input or may be the result of other model changes
	• May increase due to new user cases (children/teenagers, adults without driver's license or mobility-impaired people, etc.)
	• *Resources: Kröger et al., 2018; Childress et al., 2015; Hörl et al., 2016; Liu et al., 2017; Milam et al., 2019*
		• Not specified (*Orlando, FL)*
		• Non-work vehicle trips
		  ○ +10-20% (*Montgomery County)*
		  ○ +25% (*MWCOG)*
		  ○ +25% (*Oregon Metro)*

Trip length	• May increase because of other model changes (e.g., value of time), or may be a direct model input	• Not specified (*Orlando, FL)*
Value of time	• May decrease if perception of travel time changes • May adjust perceived travel time, travel time disutility, lost in-auto time, value of work trip travel time for housing choice, impedance friction factor • Can consider work, non-work or all purposes • *Resource: Milam et al., 2019*	• See Table 1
Zero-occupancy trips	• May need to be added if CAVs operate without passengers	• +10-20% vehicle trips to account for zero-occupant trips (*Montgomery County)* • Assumed zero-occupancy trips due to repositioning of AVs (*SACOG)*

Oregon Scenarios for Studying CAVs

Scenarios that agencies in Oregon could consider modeling to explore the future impacts of CAVs fit into three different approaches:

- **Reactive Approach**: how could the impacts of CAVs be modeled if they develop be without any intervention (e.g. no policies developed or investments made around CAVs)?
- **Policy Approach**: how could different policy levers be modeled to understand how they might change the impact of CAVs?
- **High-Investment Approach**: how could different investment levers be modeled to understand how they might change the impact of CAVs?

Each of these scenarios is further described in Table 5. Depending on available resources, TDM scenario development could test each of these approaches individually or test a scenario that combines multiple approaches.

Table 5. Potential Oregon Scenarios

	Approach		
	Reactive Approach	**Policy Approach**	**High-Investment Approach**
Description	Considers impacts of CAVs without any intervention	Considers impact of policy levers	Considers impact of investment levers

Considerations/ Potential Scenarios	• Potential use cases: shared-use, CAVs for first-/last-mile connections, private fleet, freight, e-commerce/ delivery
	• Impacts of CAVs and teleworking could be interrelated
	• Impacts of CAVs may be highly influenced by Oregon land use laws
	• Consider impacts of poorly maintained infrastructure where CAVs may not be able to operate efficiently (reducing capacity impacts)
		• Consider goals and how policies may help reach these goals (e.g., safety-focused policies might require better connectivity across OEMs; environment-focused policies might tax zero occupancy trips at a higher rate)
		• Might assume CAV adoption tied to electrification, so all CAVs are electric
		• Potential policy levers:
		  o State example: VMT fees, taxes
		  o Local examples: parking pricing, time/space restricted use, incentive transit
		• Local policies are unlikely to incentivize personal CAV ownership
		• Policies may be aimed at raising the cost to travel and balancing out costs of home ownership across a region
			• Investments could include good preservation and maintenance, including paint and pavement quality
			• Supportive CAV investments might conflict with existing state policies around reducing urban footprints and increasing urban densities
			• Potential investment levers:
			  o Reallocate curb space in congested areas to allow more drop-offs and less parking
			  o Prioritize large investments on rural freeways at the outer edges of metropolitan areas
			•

Potential Model Changes/ Enhancements	• First step for modeling shared CAVs is to develop a taxi/TNC mode • Ability to easily change parameters that may represent how CAVs impact travel • Ability to test pricing changes for rides in CAV TNCs versus human-driven TNCs • Network capacities, value of time, access/egress time for CAV passengers	• Policies may change assumptions around land use, parking, auto operating cost adjustments for CAVs, fares for CAVs, minimum age for CAV passengers	• May see larger capacity gains where agencies invest in infrastructure (and lower capacity gains where infrastructure is not as well maintained)

Next Steps

Technical Memorandum #3 was reviewed and discussed by the project TAC in TAC Meeting #4. Feedback from the TAC was used to shape the final report for the project.

Attachment A
TAC Meeting #4 Concept Board

R

Reactive

Impact of CAVs without any intervention

What does a reactive scenario look like (e.g. what is the range of CAV penetration and CAV use cases)?

- Shared-use CAVs
  • TAC Meeting #1
- CAVs for first mile/last mile connections
  • TAC Meeting #1
- Private fleet and freight adoption
  -Peter B
- Given Oregon land use laws, I think land use is the biggest wild card. How might tight UGBs push people out, how might the ability to add units to SF-lots bring people in, or garage conversion...
- E-commerce / delivery is likely one of the biggest ways that AVs might change future travel demand. How much delivery moves to the sky...
- Remote working is another interesting aspect to future scenarios, not sure how much it relates to CAV specifically, but I think it is a wild card for all our future scenarios

What model changes are important to consider for modeling a reactive approach to CAVs?

- Need to develop a taxi/TNC mode for the models as a first step to estimating shared CAV use.
  • Ray
- The ability to easily change parameters that may represent how CAVs impact travel.
  • Ray
- Testing a variety of parameter settings to represent different fleet compositions
  • Ray
- Pricing for rides in CAV TNCs vs. human TNCs
- Many of these have already been highlighted: Network capacities, Value of Time, access/egress time for CAV passengers (Metro assumes 2-5 minutes on each end of trip for SOV/HOV drivers to walk to/from automobile. This could be reduced to 0-1 minute assuming CAVs pickup at curb). These aren't specific to just reactive scenarios.

P

Policy

Impact of policy levers

What are reasonable policy levers to consider (e.g., state or local policies on usage fees, zero-occupancy fees, parking pricing, land use, etc.)?

- Some policy levers (e.g., tax policies) are at the State level and would be taken as given at the local level.
  • Ray
- Incentive shared CAVs/transit
  • TAC Meeting #1
- Time/space restricted use
  • TAC Meeting #1
- It is difficult to imagine the current cities or counties in the MPO providing incentives to use or purchase CAVs.
  • Ray
- VMT/parking pricing
  • TAC Meeting #1
- Tie adoption of CAV technology to 'electric vehicles'. No CAVs using combustion engines.
- Parking pricing is a tool for reducing congestion and encouraging use of transit, biking, etc. Decreasing parking pricing would be counter to those goals, plus, the lost revenue would need to be made up from another source (Law of the Conservation of Taxes and Fees). Increasing parking pricing seems likely (see city of Portland's recent budget discussions) as well as expanding the areas where a fee is collected.
  • Ray
- Potential parking policy? Increase 'density' of parking by utilizing 'stacked garages'. Might maintain parking charges, but increase # of CAVs that can be parked in existing footprint.
- When thinking through policies, I think the conversation needs to think through what the goal(s) are, what policies might be leaned on to try and reach those goals, and then what metrics the community might be trying to use to determine if the policy lever is working

  Safety is a common goal - related to CAVs communities might want to monitor the crash rate of CAVs - if CAVs were making things worse might need policies to ensure better connectivity across OEMs

  GHG production - is VHT going up, might need to tax zero occupancy at a higher rate

What model changes could be made to assess the impact of policy levers?

- Land use assumptions, parking assumptions (cost, distance, time), auto operating cost adjustments(?), fares for CAVs operated by for-profit/transit agencies. Minimum age for passengers?

I

High-Investment

Impact of investment levers

What are reasonable investment levers to consider (e.g., install supportive CAV tech on key corridors, create dedicated CAV-only lanes, etc.)?

- Reallocate curb space in congested areas - more drop-off, less parking
- To Alex's point -> This would be a policy in conflict with existing state policies around reducing urban footprints and increasing urban density. The current CFEC rules are meant to reduce per capita VMT. However, if CAV adoption coincided with 'electrification of the fleet', maybe we need to re-evaluate CFEC rules with regards to promoting a reduction in GHGs! Lots of competeing policies here!
- It feels like if we (as a state) were really going to "invest", what we would need to do is lower and balance out the cost of home ownership (similar costs across a region, so people can choose where they want to live), at the same time raising the cost to travel
- Maybe rural freeways are the first facilities to see large investments. These would be the portions of freeways at the outer edge of the metropolitan areas. Best to test in statewide models?
- For CAV investment, we would want really good preservation and maintenance - good paint and pavement quality - good for active modes too - like to separate bikes with really good easy to see delineation. Our models assume the road is really well maintained, we don't have a poorly maintained link attribute...
- Maybe we need to consider the impacts of 'poorly maintained' infrastructure in our current models? A reduction in capacity for facilities that are not currently being maintained to the highest standards?
- Pricing policy gets interesting - does the user "see" the cost or not in a ride hail... Specifically thinking about toll roads here

What model changes could be made to assess the impact of investment levers?

- Seems like these are the same model changes as reactive, policy scenarios, but maybe at different scales. For example, large infrastructure investments might lead to larger network capacity gains (larger market penetration).

Factors to Adjust in TDMs

Factor	Comments/Questions	Priority
Value of Time	Given the ability of ActivitySim to have every "person" in the region included in the modeling, VoT should be more nuanced than past modeling usage. • Ray Need to reflect that people with a perceived time constraint likely have a higher VoT than those that do not, regardless of income (e.g., the parent needing to pick up a child at a daycare that is about to close). • Ray The more unanswerable question is: Will the assumed reduction in stress (etc.) from driving result in people valuing their time and not traveling more, or increase their willingness to travel further (and thus for a longer amount of time)? • Ray Should commute trips in CAVs have different VoT adjustment than other types of trips in CAVs? Or discretionary vs. non-discretionary? Current practices tend to either assign a higher VoT to those HH in higher income brackets, or a single number to everyone. • Ray Accounting for other factors that each person considers when determining their VoT should be considered. Although this will likely be beyond the scope and difficult to calculate. • Ray When coming up with a value for VoT for CAV use, would this be more similar to someone driving, riding in a taxi, or in a bus? • Since CAVs do not exist, we should look at the VoT of people using existing modes that offer similar operating characteristics. So a shared, summonable CAV is similar to taxi/TNC use. • Are there studies on the VoT of people using taxis or TNCs? • Would the VoT for riding in a CAV be different if it is privately owned v. shared ride? • As we think about VoT for one mode, we should examine what the VoT is for other modes and ensure that they are in alignment. • Ray Peter bring up a good point about types of trips and time constraints. You might have tight time constraints or penalties . So regardless if you enjoy the trip, you might loose your job if you are late.	High Medium Low
CAV ownership/ride sourcing	How many CAVs are required in an urban area to provide sufficient travel options at peak periods for a given percent of the population? (i.e., if five percent of the population that travels in the peak period wants a CAV, how many CAVs are needed assuming they are not shared?) How would availability be modeled? • Ray Could I add to this Factor - e-commerce fleet ownership. COVID really shifted how we should think about CAVs - CAVs might be more on the delivery side, than the chauffeur side It feels like COVID taught us that about ~30% of the trips we used to make could be done from home or things that we could outsource to delivery companies... Important to define CAV ownership, shared-rides (similar to on-demand rides), and pooled-rides (linking multiple shared rides along a similar route). These can be applied to passenger movement, as well as freight/goods movement. For the years when the supply of CAVs is less than the demand, how does that affect pricing when used in a shared/TNC mode? • Ray Maybe employer-paid CAVs for bringing employees to the office? Or business-owned CAVs to bring customers to their business. Could also be used to deliver. Equity issues - private transport (TNC) vs public transit. Paid being better than public. I guess no worse to equity than Taxis... Cost of using a shared CAV will be affected by state and/or local regulations that are meant to limit the societal impacts from their use (e.g., reducing deadheading trips to meet the VMT/capita targets). • Ray	High Medium Low
Land use and urban form	"*Decreased value of time results in greater sprawl as employees accept longer commute times*" • There will still be a limit to how many hours in a day a person is willing to travel for work and miss the rest of life. • It is unclear what "longer commute times" means. Is this for people traveling 20 minutes today to travel 40 minutes in the future? More? • One question to resolve is whether the employers will recognize Work from Vehicle as equivalent to being in the office. If the commute is one hour each way, will the worker need to be in the office for eight hours or six hours (if Work from Vehicle counts). This assumes the job can be done remotely or away from the office, and thus applies to only certain types of employment. • Oregon UGBs *kinda* prevent this from happening in the way that currently takes place in most other states (i.e., drive until you qualify). Currently there is not the large decrease in housing cost as there was pre-COVID for the smaller cities away from the metropolitan areas. • The interaction of this with the telework option for 20-30 percent of the workers may negate growth in exurbs/satellite towns from CAVs as those that can telework, and that want to move, will likely have already done so. • Ray Land use and urban form, in Oregon, are subject to many state and local regulations, plus the private markets. Determining which will be the most important driver for development and redevelopment will be difficult, and likely change for each parcel. • Ray Redevelopment of parking lots/spaces • In central cities post-COVID, many parking lots are not filled during work hours (especially in CBD portions where work-from-home is prevalent among the companies). Depending on the situation, other pressures (e.g., need for housing) may result in the redevelopment of those lots prior to wide-spread availability of CAVs. • State regulations on VMT/capita reductions for metropolitan areas may encourage the retention of parking lots/spaces in the early years of CAV availability. Instead of sending the CAV "home" during the workday, it might be parked like the other vehicles. • Ray It would be great for the final report to provide some guidance on land use tests/scenarios we might want to run with Oregon's Statewide Integrated Model (SWIM)	High Medium Low
Auto availability		High Medium Low
Auto occupancy		High Medium Low
Capacity		High Medium Low
Mode choice		High Medium Low
Operating cost		High Medium Low
Parking cost		High Medium Low
Signal control delay		High Medium Low
Terminal time/access time		High Medium Low
Travel demand		High Medium Low
Trip length		High Medium Low
Zero-occupancy trips		High Medium Low
Others?	For me, 2 big eye openers for me 1. E-commerce is likely where this is shifting. - need to talk about that 2. Land use and pricing is such a big policy lever- that is typically outside of the things that transportation planners get to think about, but I think we need to force land prices as part of this discussion around how to mitigate the negative impacts of future tech	