CAV Scenario Planning Report

Introduction

Transportation technology is advancing quickly. As progress is made, it becomes more important to consider the potential impacts to the transportation network. Connected and Automated Vehicles (CAV) are already on Minnesota roads, with companies developing new advancements every day. The Minnesota Department of Transportation (MnDOT) wants to proactively plan for these advancements, ensuring roads are safe and efficient for all users. MnDOT's approach to this planning includes investing strategically, spurring innovation that remains nimble and questions assumptions, and building transparency through knowledge sharing with the public and other organizations.

In winter 2018/2019, MnDOT used scenario planning as part of an innovative approach to determine how plans and programs will address CAV technologies. The effort also helped to educate local partners and stakeholders while giving MnDOT staff new perspectives on the promises and potential problems with different scenarios.

Scenario planning

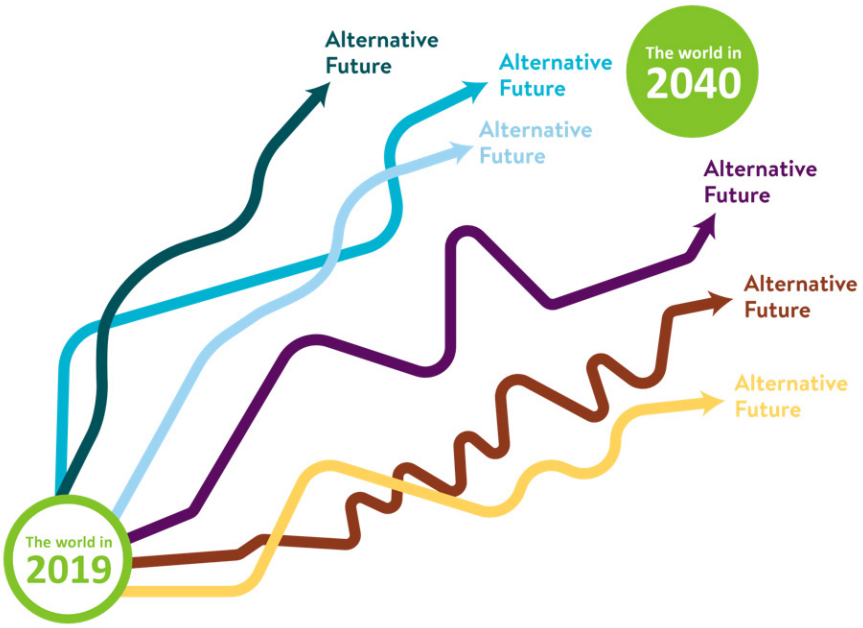
Scenario planning addresses uncertainty in long-range planning. No one knows exactly how CAV will impact the future, but scenario planning looks at a few different versions of the future to see a range of possibilities and craft proactive policies.

Purpose

MnDOT's scenario planning process was designed to see how well current policies address CAV issues, and what policies may be beneficial in the future. There will likely be rapid technological change with CAV. It is important to acknowledge that today's understanding of future conditions is not as reliable as it would ideally be. It is better to assume uncertainty about the future. With many possible futures on the table, scenario planning requires finding commonalities, crafting strategic approaches that speak to multiple possible futures, and considering what the ideal outcome would be during a time of uncertainty and change.

Scenarios

MnDOT developed four scenarios that each describe a possible future Minnesota in the year 2040 (view the scenario fact sheets in Appendix B). Each scenario assumed varied levels of automation, connectivity, electrification and sharing. The scenarios ranged from describing a future with incremental change from today's technology to a future with a fleet of fully automated vehicles operating as part of a robust multimodal system. The implications of each scenario were distinct to allow for unique group discussion at the workshops based on scenario-specific challenges and opportunities.

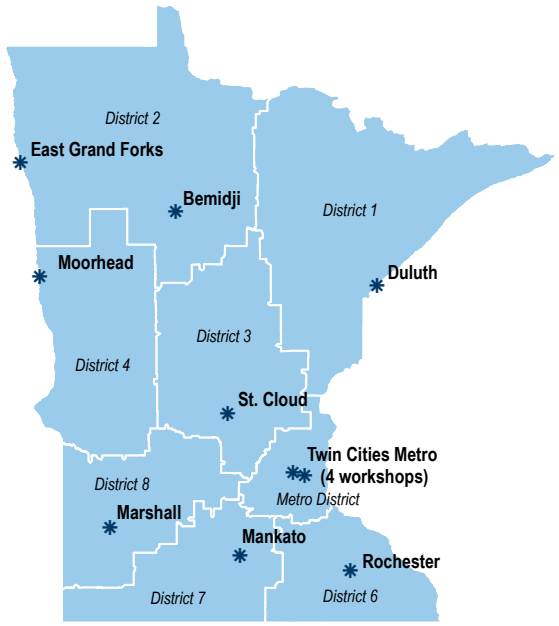


October 2019

DEPARTMENT OF TRANSPORTATION

Engagement strategy

MnDOT conducted 12 workshops throughout the state, seeking input from staff from city, county and regional planning and engineering departments, metropolitan planning organizations, and transit agencies. Other participants included representatives from nonprofit social services, other nonprofits, private businesses, and a limited number of MnDOT staff. The purpose of the workshops was for participants to learn about CAV, think about implications for Minnesota, and identify challenges, opportunities, and potential responses to CAV.



Workshop locations

Feedback format

Each workshop began with an overview of CAV and the scenario planning process. Participants were then separated into breakout groups to have a detailed conversation focused on one of the four scenarios.

Group members completed two worksheets (see Appendix C) and engaged in a moderated discussion to provide feedback on their scenario.

The first worksheet asked attendees to brainstorm potential impacts of the scenario and to classify the impacts as an opportunity, a challenge or both. Moderators urged attendees to think about economic, environmental, social, and health implications, among other topics.

The second worksheet presented MnDOT's current direction and planning based on the statewide plans and asked attendees to determine if current strategies would become less or more important if their scenario was in fact the future.

Examples of these strategies included:

- Creating more separation between bicycles and motor vehicles
- Developing new services for first mile/last mile transit connections
- Electrifying the bus fleet
- Identifying roadway construction projects ten years in advance

Key Terms

Automation: Degree to which vehicles are automated and driver is in control or is needed.

CAV: Connected and Automated Vehicles (CAV) is an umbrella term used to describe vehicles with connectivity and automation. Also used to describe the broader field of connected and automated vehicles.

Connectivity: Degree to which vehicles can communicate with other vehicles, infrastructure, or other devices.

Electrification: Growth in electric vehicles and charging and other infrastructure to support their use. While not necessary for automation, future automated fleets are typically assumed to be electric.

Mobility on Demand: Mobility on demand (MOD) describes the integration of multiple modes of travel such that a user is directed toward the optimal mobility service to meet their transportation needs. The user interface is typically envisioned to be a smartphone app that allows access to, integration of, and payment for services.

Shared Mobility: Shared mobility refers to the shared use of a vehicle, bicycle, scooter or other transportation mode. The intent of shared mobility is to allow users to access transportation on an as-needed basis and without necessarily needing to own it.

Scenario Technology Indicators: How is it different from today?

	Connectivity	Automation	Electrification	Sharing
Scenario 1: Advancing Technology	LOW – 15% of vehicles can communicate with other vehicles, roadside infrastructure (e.g., traffic signals) and devices (e.g., smart phones) – Truck platooning on rural expressways and interstates is common	LOW – 15% of vehicles are highly automated – Highly automated shuttles only in approved zones	LOW – 5% of vehicles are electric (up to 15% in urban areas), still an increase from today – Shuttles in approved zones are electric	LOW – Public agencies and private entities are only beginning to work cooperatively – Shared mobility fleets (e.g., Uber, Lyft) and public transit work together in many cities – 5-10% of travel done using mobility-on-demand (up to 20% in cities), usually as non-shared rides
Scenario 2: Connected Infrastructure	HIGH – 75% of vehicles can communicate with other connected vehicles, roadside infrastructure, and other devices – Truck platooning on rural expressways and interstates is common	MED – 50% of vehicles are Level 3 AV – Freight vehicles and services are highly automated	MED – 15% of vehicles are electric (50% in urban settings)	LOW – Public agencies and private entities share data for the purpose of making connected applications work – There are multiple providers and platforms, which are not integrated across locations – 5-10% of travel done using mobility-on-demand (up to 20% in cities), usually as non-shared rides
Scenario 3: Private Automation	MED – 50% of vehicles can communicate with other vehicles, roadside infrastructure, and other devices – Truck platooning is common on rural expressways and interstates	HIGH – 75% of vehicles are highly automated – Shared mobility fleets are highly automated – Freight vehicles and services are highly automated	MED – 15% of vehicles are electric (50% in urban settings) – All shared mobility fleets	MED – Shared mobility fleets and public transit complete in many cities – Most data is still proprietary, which results in competition for space, congestion, fewer efficiencies
Scnario 4: Integrated Mobility	HIGH – 75% of vehicles can communicate with other connected vehicles, roadside infrastructure, and other devices	VERY HIGH – 75% of vehicles are highly automated – Shared mobility fleets are highly automated – Freight vehicles and services are highly automated	HIGH – 75% of vehicles are electric – All shared mobility fleets are electric	HIGH – Data sharing allows for an efficient, integrated system of private vehicles, shared mobility fleets, transit and freight – 75% of travel done using mobility-on-demand, often as shared rides – Private ownership of fully automated vehicles is uncommon, particularly in urban areas and regional centers

Scenario 1: Advancing Technology

Introduction

Scenario 1 envisions a future with moderate technological advances and wider adoption of the CAV technologies available or in advanced stages of testing in 2019. This means that while there would be continued progress and innovation in CAV, connected and highly automated vehicles would not be common. The highest levels of automated technology common in this scenario are in the form of shuttles operating in limited and approved areas (such as a circulator on a college campus).

Feedback

Opportunities

Safety was the most frequently cited opportunity in this scenario. Advances in safety technology will make the road safer for all users. Today's technology helps drivers stay in the lane, avoid crashes, and spot people walking and biking.

Challenges

Participants noted concerns about the slow pace of adoption of technology, who would benefit first and most in this scenario, the continued barriers for older adults and people with disabilities, and general challenges with the lack of progress. If in 2040 the automobile landscape looks mostly like 2019, there will be some lost opportunities. More technological advances may bring increased equity and sustainability, as shown in the other scenarios.

Takeaways

Participants were skeptical of a future with little progress. Scenario 1 portrays a distant future that doesn't look much different than today. Participants are excited about CAV technology because it promises a drastically different future that mitigates some of the damage caused by automobiles, while increasing access and equity for everyone. Given the gradual technological advancements in this scenario, there weren't as many new possibilities to discuss compared to the other three scenarios.

Scenario 2: Connected Infrastructure

Introduction

In Scenario 2, the public sector invests in connected infrastructure to encourage CAV adoption. Private companies are slow in their development of automated vehicle technology. Automated technology is common but dependent on connected infrastructure. Features like detecting lane departure or bicyclists and pedestrians are available, similar to the features in the newer cars today. The public sector has invested a lot of money in these connected technologies to allow infrastructure and cars to communicate.

Examples of connected infrastructure include:

- Signs displaying travel speed and times to various points
- Stoplights communicating with cars about when the next red light is so cars can select safe travel speed while minimizing stopping
- Connected parking spot information devices showing availability and pricing of parking spots

Feedback

Opportunities

In addition to the safety benefits described in Scenario 1, Scenario 2 includes the efficiency benefits associated with more technologically advanced infrastructure. Participants noted use of personal vehicles and smart features as key benefits. Connected infrastructure takes some of the guesswork out of driving and could make longer trips more pleasant. Congestion would be more predictable, leading to less variability in trip length. Participants also liked the idea of being able to switch between automated driving functionality on select highways and driver-controlled functionality on local streets. Participants discussed the benefits that come with both automated truck and car platooning on highways. Platooning involves grouping vehicles together, increasing road capacity and decreasing the distance between vehicles, allowing them to accelerate or brake at the same time.

Challenges

The main concern for participants was the expense of building a connected infrastructure system. Upgrading or replacing old infrastructure with connected infrastructure would take a long time and require significant investment. Participants also worried about what would happen if there were technological failures in the connected system. Participants expressed concern and skepticism about the availability of the connected infrastructure in rural contexts, which highlights issues of geographic distribution of benefits.

Takeaways

Scenario 2 delivers on some of the promises of a more technologically advanced future. Most significantly, cars and trucks can communicate with the infrastructure they are using. The increase in information the driver has available allows them to drive more efficiently. This scenario offers the flexibility to drive autonomously, while also retaining some driver control when necessary. But Scenario 2 may be expensive. The infrastructure projects could be daunting, and the prospects of a system malfunction was concerning for some participants. The ownership model for personal vehicles doesn't look much different from current day. Lastly, the new technology enhances the driver experience, but doesn't change the paradigm.

Scenario 3: Private Automation

Introduction

In Scenario 3, fully automated cars are common. Cars that can drive themselves are affordable to most families, and many private companies operate them in fleets as a mobility on demand service. Mobility on demand describes the integration of multiple travel modes, where the user is directed toward the optimal mobility service to meet their transportation needs, likely via an app interface. Most trips remain single occupant trips. Congestion increases as empty fleet vehicles drive searching for their next customer and more people have the ability to use private vehicles. Truck platooning is common in rural areas, connectivity and communication between vehicles is possible, and rides are not typically shared.

Feedback

Opportunities

With cars operating at highly automated levels, opportunities increase for people who may not be able to drive themselves. Participants appreciated that in this scenario older adults and people with disabilities gain mobility as technological advances allow cars to operate without a driver. Rural and suburban populations also benefit from the affordability of driverless technology. Lengthy commutes become less cumbersome when people who would have otherwise been driving the car can now do other things during the ride. In cities, where fleet-based ridesharing services are more prevalent, the cost of a trip may become more affordable with more companies and cars on the road.

Challenges

Related to the opportunity of there being more ridesharing services available is the worry that the private sector, when left to its own devices, will not choose to serve everyone equitably. Some geographic regions may be underserved. People of differing abilities may require specialized vehicles to pick them up and there is little incentive for tailored service that doesn't charge the customer more. Participants worried about how public agencies may be involved—too little involvement endangers the public interest because private companies may not reach their profit margins serving every part of the community. There would also be many empty vehicles driving the streets leading to congestion and challenges with pick up and drop off locations.

Takeaways

People understand the framework of competing private fleet services, but have little faith that private companies will create a future that works for everyone without government oversight. There were also questions about the pace of technological adoption, and the interaction between highly automated cars and less advanced, older cars. There are many details to think about in this scenario, including insurance, liability, pricing, regulation, and equity.

Scenario 4: Integrated Mobility

Introduction

Scenario 4 sees on-demand CAV ride-hailing and transit services expand and integrate with other modes of transportation. Related policy makes it possible for car ownership rates in cities drop significantly as an affordable ride is easily available. Most vehicles are electric and highly automated, even private vehicles. Data sharing allows for an efficient system of private vehicles, shared mobility fleets, transit and freight. Benefits are spread across all users, including non-motorized modes and people with limited mobility.

Feedback

Opportunities

Participants expressed excitement about the reliability of travel and the ability to multitask while on the way. They also lauded the environmental benefits of a fully electrified system. Scenario 4 relies on data sharing, government regulation and coordination between multiple providers and modes, which could ensure greater equity in transportation service and cost to customers. It would also ensure seamlessness between the construction of connected infrastructure and the rollout of automated cars and trucks. With a more unified effort, communication between infrastructure and vehicles could be smoother.

Challenges

Participants acknowledged that this scenario may be expensive. It would essentially be a paradigm shift in how we currently think about, build, and use transportation. This scenario also leans the most on technology, which would lead to greater risks in the case of a technological breakdown. Electrified vehicles currently encounter issues in cold weather, and automated vehicles would have to easily operate in Minnesota winters. Overall, participants expressed some hesitancy in being so dependent on technology in terms of safety and reliability.

Takeaways

This scenario was heavily favored by many participants, while they acknowledged it would be a big undertaking. There was enthusiasm for an interconnected transportation system that served all customers across all modes. Participants emphasized the need for a centralized and coordinated policy in order to make this happen.

The scenarios, broadly

Participants were excited about the mobility benefits that CAV technology can bring. More detailed analysis of the workshop discussions can be found in Appendix D. In each of the future scenarios, there are potential improvements to safety, which was an important priority for many people. In the scenarios that involved higher levels of automation, people with disabilities or an unwillingness or inability to drive would be more able to get around.

In scenarios where the levels of electrification are high, participants were excited about the environmental benefits that come with reducing the use of gasoline.

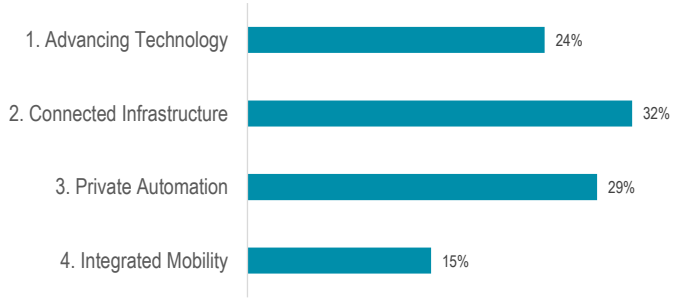
Participants worried about the monetary cost of infrastructure as well as the personal cost of having to pay for newer vehicles or pay higher insurance rates for their older vehicles. If this system-wide change occurs, all will have to adapt.

In each scenario, participants expressed concern about whether or not everyone would be served by the emerging technology. Geography, income, ability, and many other characteristics may determine who benefits the most from these advances. Understanding and addressing those potential disparities was a high priority for many participants.

At the end of each workshop participants were asked to indicate which of the four scenarios they considered most likely to occur and which scenario they most wanted to occur. Overall, Scenario 4 (Integrated Mobility) was most desired, but considered least likely. This suggests that, with regards to likelihood, Scenario 4 is considered difficult to achieve, consistent with the state of technology today and the state of public-private cooperation. With respect to desirability, on the other hand, the result suggests a common vision or desire (with some variations) from a wide range of participants for the future of CAV in Minnesota.

Which scenario do you think is most likely to happen?

Greater Minnesota



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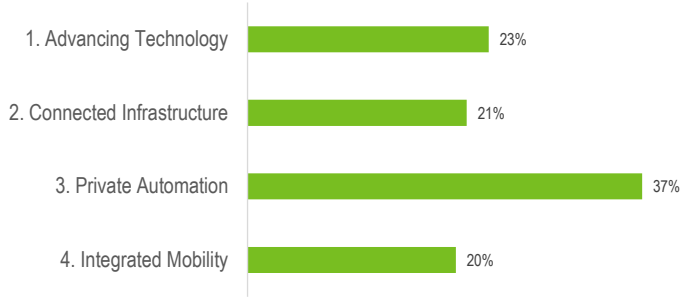
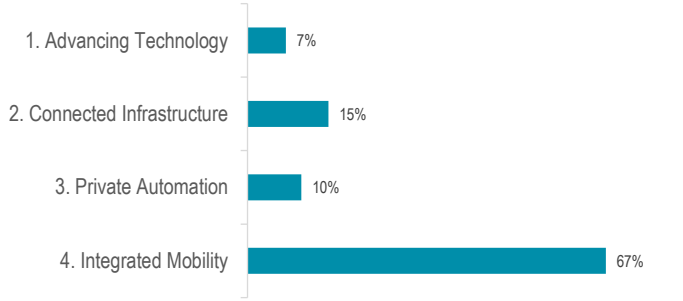


Which scenario do you most want to happen?

Greater Minnesota



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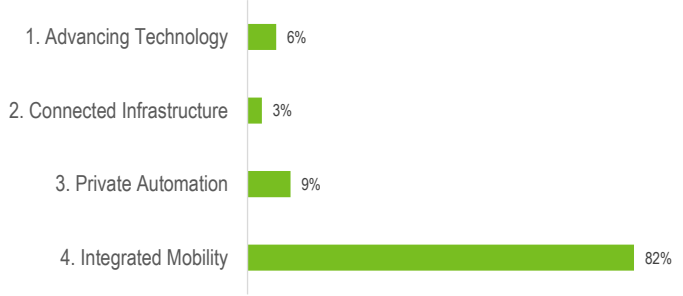

Planning Considerations

MnDOT sets the transportation vision for the state and has a role in the formation of policy that may determine how CAV technology rolls out in Minnesota. MnDOT's plans deal with all modes of transportation, including freight, transit, biking, and walking. Cities and counties work with Minnesota residents at local scales and have critical knowledge in how transportation differs across contexts, and how CAVs may roll out differently.

The following recommendations offer ideas for how local, regional, and state planners can think about CAV technology in the coming years.

- Engage different audiences when planning for CAV (geographic, ability, etc.), because issues related to CAV may be broadly shared, but many are context sensitive.
- Address equity explicitly, but be cautious to promise benefits without having the tools to ensure they're realized.
- Use scenario planning in both transportation and land use planning, rather than using a single planning approach.
- Work to clarify potential costs and identify who would be responsible.
- Address data security.
- Use robust and targeted communication strategies to reach a wide variety of audiences who may be interested in or affected by CAV development, and to ensure your message is easily understood and available.
- Consider that Scenario 2 and Scenario 4 both include a more active role for the public sector than Scenario 3 and these preferences may reflect a combination of perceived need or desire for that active public role.

Current Policies

After talking through the future implications of their scenarios, participants were asked for their thoughts on MnDOT's current policy direction. They had the opportunity to indicate whether they thought each current policy item would become more important, stay the same in importance, or be less important if their scenario was the future. The charts below show the top three policies that participants said should remain in effect or increase in importance under each scenario. More information about how participants ranked the importance of each policy can be found in Appendix E.

Policy should be just as important as now

Policy should be more important than now

Scenario 1

Ensure transportation data is up-to-date, usable and easily accessible.

Support a system that provides equitable access to goods, services, opportunities and destinations.

Overcoming physical barriers and eliminating critical system gaps for people walking, rolling or bicycling

Scenario 2

Ensure transportation data is up-to-date, usable and easily accessible.

Giving priority to stand-alone investments for pedestrian infrastructure projects that are connected to transit service or regional job concentrations.

Provide ongoing training to transportation professionals.

Scenario 3

Supporting travel demand management strategies including implementing carpools/vanpools, staggered work hours, telework and compressed work weeks.

Support a system that provides equitable access to goods, services, opportunities and destinations.

Overcoming physical barriers and eliminating critical system gaps for people walking, rolling or bicycling

Scenario 4

Support a system that provides equitable access to goods, services, opportunities and destinations.

Overcoming physical barriers and eliminating critical system gaps for people walking, rolling or bicycling

Conduct regular inspections of infrastructure, facilities and equipment.

Next steps

MnDOT's scenario planning effort is part of a larger discussion around CAV technologies. The depth and breadth of conversations at the workshops proves that this is a far-ranging, pressing topic. No matter which version of the future unfolds, there will be more meetings, debates, and plans about CAV down the road. It's impossible to consider all possibilities in one go, and so planning for CAV must remain broad and flexible, able to both anticipate and respond to developments.

There will also be ongoing efforts to figure out how to properly communicate about the technology. Everyone will need to learn how to think about their transportation needs differently, and how to interact with new types of vehicles as a passenger and an operator. This scenario planning effort is an early step in MnDOT planning for and communicating about CAV. We are grateful to all of our workshop participants for their time and insight.

Appendix A: Definitions

DEPARTMENT OF TRANSPORTATION

CONNECTED AND AUTOMATED VEHICLE

DEFINITIONS

Connected and Automated Vehicle Strategic Plan

MnDOT is working with stakeholders around the state to plan for the connected and automated vehicles in Minnesota. This includes a **scenario planning process** to imagine a range of possible futures and consider how we can best minimize the risks and maximize the benefits for all Minnesotans, regardless of how the future unfolds. For more information, see www.dot.state.mn.us/automated.

Levels of Automation

0	1	2	3	4	5
NO AUTOMATION	**DRIVER ASSISTANCE**	**PARTIAL AUTOMATION**	**CONDITIONAL AUTOMATION**	**HIGH AUTOMATION**	**FULL AUTOMATION**
Zero autonomy; the driver performs all driving tasks	Vehicle is controlled by the driver, but some driving assist features may be included in the design	Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.	Driver is a necessity, but not required to monitor the environment. The driver must be ready to take control of the vehicle at all times without notice.	The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.	The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

Other Acronyms and Definitions

Automation. Degree to which vehicles are automated and driver is in control or is needed. Levels of automation typically described between Level 0 (no automation) and Level 5 (full automation). See detailed definitions above.

AV. Automated Vehicle. General term for a vehicle that has some degree of automation. Also used to describe the broader field of connected and automated vehicles.

CAV. Connected and Automated Vehicles. Umbrella term used to describe vehicles with connectivity and automation. Also used to describe the broader field of connected and automated vehicles.

Connectivity. Degree to which vehicles can communicate with other vehicles (vehicle to vehicle or V2V), infrastructure (vehicle to infrastructure or V2I), other devices (vehicle to other or V2X).

Cooperation. Used to describe the degree of data sharing and integration of services to achieve public and user benefit. Lack of cooperation would include individual providers not sharing data or allowing transportation services to be integrated with other public and/or private services.

CV. Connected Vehicle. A vehicle with some form of wireless communications service that allows it to connect with other devices inside or outside the vehicle.

Electrification. Growth in electric vehicles and charging and other infrastructure to support their use. While not necessary for automation, future automated fleets are typically assumed to be electric.

EV. Electric vehicles.

On Demand Shared Services. See *Mobility on Demand*.

Platooning. A method of grouping vehicles together, primarily to increase road capacity. Would decrease the distance between vehicles and allow them to accelerate or brake simultaneously.

Shared Mobility. Shared mobility refers to the shared use of a vehicle, bicycle, scooter or other transportation mode. The intent of shared mobility is to allow users to access transportation on an as-needed basis and without necessarily needing to own it.

Mobility on Demand. Mobility on demand (MOD) describes the integration of multiple modes of travel such that a user is directed toward the optimal mobility service to meet their transportation needs. The user interface is typically envisioned to be an app that allows access to, integration of, and payment for services.

V2V, V2I, V2X. See *Connectivity*.

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Appendix B: Scenario Fact Sheets

DEPARTMENT OF TRANSPORTATION

1

Connected and Automated Vehicle Strategic Plan

MnDOT is working with stakeholders around the state to plan for connected and automated vehicles in Minnesota. This includes a **scenario planning process** to imagine a range of possible futures and consider how we can best minimize the risks and maximize the benefits for all Minnesotans, regardless of how the future unfolds. For more information, see www.dot.state.mn.us/automated.

SCENARIO:

ADVANCING TECHNOLOGY

Today's technology gets incrementally better and becomes more common

SUMMARY

Moderate advances and wider adoption of CAV technologies that were available or in advanced stages of testing in 2019.

KEY ASSUMPTIONS

- Continued progress and innovation in CAV, but connected and Level 4 highly automated vehicles not common
- Highly automated shuttles can operate in limited approved areas

INDICATORS

Connectivity	Automation	Electrification	Sharing
LOW	LOW	LOW	LOW

A DAY IN THE LIFE

Parker is traveling in the early morning from the farm outside Fergus Falls to visit her father at his suburban assisted living community. She loves that her father can get around within the small community on his own, using the wheelchair-accessible automated shuttle. While the car dealers say affordable Level 4 AVs are coming soon, she is happy to have all the latest safety features on the pickup she recently bought. The automatic braking and lane keeping make her trip safer as she passes another long platoon of trucks on the highway.

WHAT'S DIFFERENT FROM TODAY?

TECHNOLOGY INDICATORS		
Connectivity	**LOW**	– 15% of vehicles can communicate with other connected vehicles, roadside infrastructure (e.g., traffic signals) and devices (e.g., smart phones) – Truck platooning on rural expressways and interstates is common
Automation	**LOW**	– 15% of vehicles are highly automated – Highly automated shuttles only in approved zones
Electrification	**LOW**	– 5% of vehicles are electric (up to 15% in urban areas), still a an increase from today – Shuttles in approved zones are electric
Sharing	**LOW**	– Public agencies and private entities are only beginning to work cooperatively – Shared mobility fleets (e.g., Uber, Lyft) and public transit work together in many cities – 5-10% of travel done using mobility-on-demand (up to 20% in cities), usually as non-shared rides

DISTRIBUTION OF BENEFITS	
Users	– Where in use, connected and automated technology applies primarily to motor vehicles (i.e., cars, trucks, transit) – People walking, rolling and bicycling benefit from motor vehicle safety devices – Individuals with limited mobility benefit from automated shuttles in approved zones
Locations	– Connected and automated vehicle safety features are not limited to any specific geography in the state – Automated zones could be anywhere but more likely in areas with greater density – urban cores, campuses (college, medical, corporate), etc.

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Scenario 1E: Improving Safety for Vulnerable Users

GEORGE

April
2019

George is 78 years old and is retired. Until last year, he drove most places. Looking back, he can see his reflexes weren't what they once were but he never considered himself unfit to drive. Then the accident happened when another driver ran a red light and hit him broadside as he entered the intersection. With his car totaled and his confidence badly shaken, he decided to stop driving. Now he walks and takes the bus most places. But as someone who doesn't see that well and walks slowly, he worries every day that he won't be seen by the cars, buses and trucks on the busy street he crosses at least twice a day. After a number of near misses as a pedestrian and long waits on the curb, he is starting to spend more time at home, socializing less and relying on family and friends to get his needs met.

April
2039

George is 78 years old and is retired. At his recent physical, the doctor said some of his reflexes had slowed and his vision had decreased. Noting this, his son bought him a new car with cutting-edge safety features, including lane-keeping and adaptive cruise control. Thanks to these features, George is safer behind the wheel and he feels more comfortable driving to meet his needs. Knowing that more cars, trucks and buses include similar features makes him feel more comfortable as a pedestrian too. While these technologies are not everywhere, they are starting to make transportation safer for everyone.

DEPARTMENT OF TRANSPORTATION

Connected and Automated Vehicle Strategic Plan

MnDOT is working with stakeholders around the state to plan for connected and automated vehicles in Minnesota. This includes a **scenario planning process** to imagine a range of possible futures and consider how we can best minimize the risks and maximize the benefits for all Minnesotans, regardless of how the future unfolds. For more information, see www.dot.state.mn.us/automated.

2

SCENARIO:

CONNECTED INFRASTRUCTURE

Connected vehicles and devices improve safety and efficiency

SUMMARY

The public sector makes significant investment in connected infrastructure to encourage CAV adoption, which has lagged due to slower than expected development of automated vehicle technologies.

KEY ASSUMPTIONS

- Level 2 and 3 AV technology is common but requires supportive connected infrastructure to achieve benefits
- Public agencies invest in connected technologies to make AVs more functional

INDICATORS

Connectivity	Automation	Electrification	Sharing
HIGH	MED	MED	LOW

A DAY IN THE LIFE

Shandra leaves her Apple Valley home at the peak of rush hour. Ever since I-35W became the region's premier connected corridor, driving has become safer and more efficient. At the freeway on-ramp, Shandra's car warns her of a crossing pedestrian she hadn't seen in the dusk. She easily slides into traffic and settles into a platoon of other connected cars, trucks, and buses. Messaging signs display the travel speed and travel times to various points, and the smoother flow of traffic has improved fuel efficiency. Once downtown, a display on the dashboard shows the optimal speed to avoid stopping at red lights. The connected signals and parking information devices make it easy to find a parking spot.

WHAT'S DIFFERENT FROM TODAY?

TECHNOLOGY INDICATORS		
Connectivity	**HIGH**	– 75% of vehicles can communicate with other connected vehicles, roadside infrastructure (e.g., traffic signals) and other devices (e.g., smart phones) – Truck platoons are common on expressways and freeways
Automation	**MED**	– 50% of vehicles are Level 3 AV – Freight vehicles and services are highly automated
Electrification	**MED**	– 15% of vehicles are electric (50% in urban settings)
Sharing	**LOW**	– Public agencies and private entities share data for the purpose of making connected applications work – There are multiple providers and platforms, which are not integrated across locations – 5-10% of travel done using mobility-on-demand (up to 20% in cities), usually as non-shared rides

DISTRIBUTION OF BENEFITS	
Users	– Wide use of connected technology creates safety and mobility benefits for motor vehicle users vehicles (i.e., cars, trucks, transit) – People walking, rolling and bicycling benefit from motor vehicle safety devices – Individuals with limited mobility do not see many improvements because level 4 AV technology is not widely available and is expensive
Locations	– Connected and automated vehicle safety features are not limited to any specific geography in the state – Connected infrastructure is more prevalent in urban areas and along key corridors

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Scenario 2E: Improving Safety for Vulnerable Users

BEN

April
2019

Ben is 78 years old and is retired. Until last year, he drove most places. Looking back, he can see his reflexes weren't what they once were but he never considered himself unfit to drive. Then the accident happened when another driver ran a red light and hit him broadside as he entered the intersection. With his car totaled and his confidence badly shaken, he decided to stop driving. Now he walks and takes the bus most places. But as someone who doesn't see that well and walks slowly, he worries every day that he won't be seen by the cars, buses and trucks on the busy street he crosses at least twice a day. After a number of near misses as a pedestrian and long waits on the curb, he is starting to spend more time at home, socializing less and relying on family and friends to get his needs met.

April
2039

Ben is 78 years old and is retired. At his recent physical, the doctor noted some of his reflexes had slowed and his vision had decreased. But thanks to the advanced technology now in vehicles and on the roadside, Ben is still safe behind the wheel. He feels comfortable driving knowing the smart signals are communicating with his car and every other car, making intersections much safer than they used to be. (With more and more self-driving cars on the road too, he expects to switch to one of those before too long, if he can afford it.) Even though he doesn't see well and moves slowly, he still finds walking in his neighborhood safe and enjoyable. He makes sure to carry his small safety transponder which alerts vehicles of all types – cars, buses and trucks, both automated and conventional – to the presence of pedestrians, bicyclists and other non-motorized users. Of all his worries, getting around safely and independently is not one of them.

DEPARTMENT OF TRANSPORTATION

Connected and Automated Vehicle Strategic Plan

MnDOT is working with stakeholders around the state to plan for connected and automated vehicles in Minnesota. This includes a **scenario planning process** to imagine a range of possible futures and consider how we can best minimize the risks and maximize the benefits for all Minnesotans, regardless of how the future unfolds. For more information, see www.dot.state.mn.us/automated.

3

SCENARIO:

PRIVATE AUTOMATION

Automated vehicles are here, for better and for worse

SUMMARY

AVs proliferate with a mix of privately owned vehicles and competing mobility-on-demand providers. Congestion is common in urban areas.

KEY ASSUMPTIONS

- Level 4 highly automated vehicles are available at prices affordable to many households
- Outdated pricing, policy and lack of coordination results in most trips being in single occupant vehicles

INDICATORS

Connectivity	Automation	Electrification	Sharing
MED	HIGH	MED	MED

A DAY IN THE LIFE

Marketa leaves her St. Paul office and requests a ride on her phone. Within seconds, an electric AV pulls up in a nearby pickup lane, where many cars are taking in passengers. After wading through the waiting vehicles, she gets in for her ride out to Lake Elmo. She takes out her book and begins to read – it could be a long ride, as congestion has made what was once a 30-minute commute into almost an hour. Many of Marketa's friends and relatives have their own automated vehicles and use them for everything from commuting to errands to transporting children and other family members. However, they too are frustrated with the increased congestion.

WHAT'S DIFFERENT FROM TODAY?

TECHNOLOGY INDICATORS		
Connectivity	**MED**	– 50% of vehicles can communicate with other connected vehicles, roadside infrastructure (e.g., traffic signals) and other devices (e.g., smart phones) – Truck platooning is common on rural expressways and interstates
Automation	**HIGH**	– 75% of vehicles are highly automated – Shared mobility fleets (e.g., Uber, Lyft) are highly automated – Freight vehicles and services are highly automated
Electrification	**MED**	– 15% of vehicles are electric (50% in urban settings) – All shared mobility fleets are electric
Sharing	**MED**	– Shared mobility fleets (e.g., Uber, Lyft) and public transit compete in many cities – Most data is still proprietary, which results in competition for space, congestion, fewer efficiencies – 50% of travel is done using mobility-on-demand, usually as non-shared rides

DISTRIBUTION OF BENEFITS	
Users	– Private ownership of highly automated vehicles is common – Lower levels of connectivity and cooperation limit benefits to transit and other modes of transportation – Individuals with limited mobility benefit from the new highly automated vehicles
Locations	– Connected and automated vehicle safety features are not limited to any specific geography in the state – Lack of cooperation favors mobility-on-demand trips that are more profitable for private operators, generally in urban areas and regional centers

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Scenario 3E: Disrupting the DWI/DUI Cycle

SANDRA

April
2019

Sandra is 23 years old, working full time and taking college classes as she can, hoping to earn a degree although it will take many years. She has struggled with alcohol addiction since she was in high school. While she is mostly recovered today, she has occasional relapses. Recently, she was at a party where she started drinking and got drunk. That night, she was arrested for driving under the influence and, because of past offenses, lost her license. Losing her license quickly created a crisis in her life: without access to a car, she must rely on transit, expensive taxi or rideshare trips or rides from others to get to work. As a result, she has been missing work. Getting to her weekly evening college class is out of the question. Next week she has a mandated court appointment that is not only during the work day but will probably require her to take off the whole day just to deal with the transportation. Her supervisor has given her a warning that if she is late again or misses another day she will be moved to the on-call worker pool which she knows she can't live on.

April
2039

Sandra is 23 years old, working full time and taking college classes as she can, hoping to earn a degree although it will take many years. She has struggled with alcohol addiction since she was in high school. While she is mostly recovered today, she has occasional relapses. Recently, she was at a party where she started drinking and got drunk. While this was a big setback on her path to sobriety, it didn't present a transportation issue: to get home that night, she just ordered up a low-cost automated shuttle as usual and got home without incident. Her attendance record at work hasn't been perfect and coming in hungover won't help. But the availability of the low-cost automated shuttle at the LRT station means she gets to and from her suburban job more easily. Her transportation costs are low and she has been able to save some money as a result. The shuttle service also has opened up new housing options. Sandra has been considering moving to a new apartment outside the city that is safer and more spacious. Although not on a transit line, it is still within the shuttle service area.

DEPARTMENT OF TRANSPORTATION

Connected and Automated Vehicle Strategic Plan

MnDOT is working with stakeholders around the state to plan for connected and automated vehicles in Minnesota. This includes a **scenario planning process** to imagine a range of possible futures and consider how we can best minimize the risks and maximize the benefits for all Minnesotans, regardless of how the future unfolds. For more information, see www.dot.state.mn.us/automated.

4

SCENARIO:

INTEGRATED MOBILITY

Connected and automated transportation is widely available and serves everyone

SUMMARY

On-demand CAV ride-hailing and transit services expand and integrate with other modes of transportation through data sharing, policy, and connected infrastructure.

KEY ASSUMPTIONS

- Level 4 highly automated vehicles are available at prices affordable to average income households
- Integrated, coordinated mobility-as-a-service is common
- Car ownership rates drop, especially in cities

INDICATORS

Connectivity	Automation	Electrification	Sharing
HIGH	VERY HIGH	HIGH	HIGH

A DAY IN THE LIFE

Chin is working from home in Hinckley when he gets a message that his favorite author is giving a talk in Duluth, 75 miles away. He has a report due that afternoon, but knows that he will be able to work while traveling. He opens the city's mobility app to request a shared AV for the trip. However, there is an incident on Interstate 35, and the train fare has been substantially reduced to discourage travelers from using the interstate. He books his trip and takes an automated rideshare service to the train station. After a comfortable, high-speed trip, he submits his report, walks out of the station, and steps into a waiting shared electric AV. After the talk, Chin jumps into a waiting AV for a ride back to Hinckley. He is the only passenger, but the vehicle also has packages to be delivered at stops along the way.

WHAT'S DIFFERENT FROM TODAY?

TECHNOLOGY INDICATORS		
Connectivity	**HIGH**	– 75% of vehicles can communicate with other connected vehicles, roadside infrastructure (e.g., traffic signals) and other devices (e.g., smart phones)
Automation	**VERY HIGH**	– 75% of vehicles are highly automated – Shared mobility fleets (e.g., Uber, Lyft) are highly automated – Freight vehicles and services are highly automated
Electrification	**HIGH**	– 75% of vehicles are electric – All shared mobility fleets are electric
Sharing	**HIGH**	– Data sharing allows for an efficient, integrated system of private vehicles, shared mobility fleets, transit and freight – 75% of travel done using mobility-on-demand, often as shared rides – Private ownership of fully automated vehicles is uncommon, particularly in urban areas and regional centers

DISTRIBUTION OF BENEFITS	
Users	– Technology, sharing and coordinated policies spread benefits across all users, including non-motorized modes and people with limited mobility
Locations	– Connected and automated vehicle safety features are not limited to any specific geography in the state – Mobility-on-demand options are available almost everywhere in the state

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Scenario 4E: Reducing Barriers, Improving Health

EMILIO

April
2019

Emilio is 43 years old and has regular appointments at the county clinic and other medical facilities. Because he doesn't have a car and uses a wheelchair, he usually arranges a ride through Metro Mobility or contacts the county to arrange a ride for him through one of their contracted providers. These services work but they require him to schedule a day in advance. Because of scheduling constraints, the entire trip includes a lot of time waiting for the ride. It is not uncommon to miss appointments if he doesn't plan ahead, and even then "appointment days" means he can't do much else that day. When he was more mobile, he used to take the bus - but with at least one transfer in each direction, this too was a hassle and took a lot of time. From the county perspective, providing these trips are a critically important part of providing health services – but the trips are very expensive and the costs are increasing every year.

April
2039

Emilio uses a device reminiscent of the smartphones of the past to order an automated shuttle just when he needs it for both the trip to and from the clinic (similar to ordering an Uber/Lyft vehicle today). If he needs an attendant in the vehicle to help him, he can indicate that in his order (at a higher price). Because he qualifies for the county's medical transportation program, this trip is billed to the county through the app. Compared to today, the trip is more convenient and more efficient while still providing him the personal safety and security he needs to feel comfortable making the trip. If demand is high, the trip may be shared with others but the advanced routing algorithm keeps it efficient. While he misses talking to the driver, he has gotten used to the conversation with the AI Attendant he interacts with while on board. When he needs a prescription, he can choose to use the shuttle or just have it delivered by one of the low-cost automated delivery services. For the county, this new service has greatly reduced costs (fewer drivers and more efficient routing), greatly reduced people missing appointments for transportation reasons, and improved overall patient outcomes as a result.

Appendix C: Workshop Materials

Worksheet 1: Potential Impacts (Individual Brainstorm)

1 ADVANCING TECHNOLOGY

Date: _____

Please identify opportunities and challenges of your scenario. Then indicate which 3 are most important.

Potential CAV Impacts of Your Scenario	Opportunity?	Challenge?	Top 3?

Worksheet 2: Changes to MnDOT Current Direction

1 ADVANCING TECHNOLOGY

Date: _____

What MnDOT is currently focusing on	MORE Important	LESS Important	NEUTRAL	Don't Know	Why?
PLANNING					
Using a 20 year planning horizon in long-range plan development					
Identifying roadway construction projects ten years in advance					
ROADWAYS					
Spending the majority of state road construction funding on maintaining the existing state highway system					
Investing in operational traffic improvements (e.g. signal timing, intersection improvements, access management)					
Building out the MnPASS system in the Twin Cities					
Investing in low-cost safety projects focused on reducing fatal and serious injury crashes (e.g. rumble strips, high tension cables, intersection and crosswalk improvements, access closures, lighting)					
Creating more separation between bicycles and motor vehicle traffic					
Prioritizing maintaining state highways and bridges on the National Highway System to a greater extent than other state highways					
TRANSIT					
Building out the transitway system in the Twin Cities					
Consolidating transit providers in Greater Minnesota					
Implementing consistent hours and days of transit service across similar communities in Greater Minnesota					
Increasing hours and frequency of transit service in Greater Minnesota					

What MnDOT is currently focusing on	MORE Important	LESS Important	NEUTRAL	Don't Know	Why?
FREIGHT					
Improving freight operations and connections between modes					
Developing/supporting programs in cooperation with community colleges and private sector to ensure freight workforce is available for industry needs (e.g. truck drivers)					
Harmonizing truck weight/size restrictions with neighboring states					
Increasing truck parking					
PASSENGER RAIL					
Advancing phase I passenger rail corridors toward construction and implementation (e.g. Twin Cities to Chicago, NLX to Duluth)					
POLICY					
Ensuring transportation data is up-to-date, usable and easily accessible					
Implementing Complete Streets, performance-based practical design (i.e. design flexibility) and Context Sensitive Solutions					
Prioritizing low-cost, short-term solutions when large-scale solutions cannot be implemented/funded in the near-term					
Enhancing and maintaining statewide radio communications for emergency response					
Supporting a system that provides equitable access to goods, services, opportunities and destinations					
Maximizing the useful life of existing transportation assets					
Assessing risks to transportation infrastructure and services (e.g. flash flooding, excessive heat, cybersecurity)					
Providing ongoing training to transportation professionals					
Conducting regular safety and condition inspections of transportation infrastructure, facilities and equipment					
OTHER - ADD YOUR OWN:					

Worksheet 2: Changes to MnDOT and Met Council Current Direction

1 ADVANCING TECHNOLOGY

Date: _____

Please rate the elements of MnDOT's/Met Council's current direction as more or less important given the future described in your scenario. Statements of current direction are based on the MnDOT Family of Plans and the region's 2040 Transportation Policy Plan (TPP).

What MnDOT and Met Council are currently focusing on	MORE Important	LESS Important	NEUTRAL	Don't Know	Why?
PLANNING					
Using a 20 year planning horizon in long-range plan development					
Identifying roadway construction projects ten years in advance					
ROADWAYS					
Spending the majority of state road construction funding on maintaining the existing state highway system					
Prioritizing maintaining state highways and bridges on the National Highway System to a greater extent than other state highways					
Using the following priorities to address mobility issues: 1. traffic management technologies (e.g., retiming traffic signals and comprehensive incident response) 2. lower cost spot mobility improvements at specific locations to maximize the return-on-investment 3. MnPASS lanes 4. strategic capacity enhancements (namely interchanges and general-purpose lanes)—when priorities 1-3 cannot improve travel conditions for people and freight					
Investing in lower-cost safety projects focused on reducing fatal and serious injury crashes (e.g. rumble strips, high tension cables, intersection and crosswalk improvements, access closures, lighting)					

What MnDOT and Met Council are currently focusing on	MORE Important	LESS Important	NEUTRAL	Don't Know	Why?
TRANSIT					
Building out the transitway system, including rail and bus rapid transit (BRT) corridors					
Growing/expanding the base bus system					
Developing new services for first mile/last mile connections					
Electrifying the bus fleet					
BICYCLE AND PEDESTRIAN					
Creating more separation between bicycles and motor vehicle traffic					
Implementing the Regional Bicycle Transportation Network					
Achieving substantial compliance with the Americans with Disabilities Act requirements on the state highway system by 2037 (end of current 20-year investment plan)					
Overcoming physical barriers and eliminating critical system gaps for people walking, rolling or bicycling					
Giving priority to stand-alone investments for pedestrian infrastructure that are connected to transit service or regional job concentrations					
FREIGHT					
Improving freight operations and connections between modes (e.g. truck, rail, barge, etc.)					
Harmonizing truck weight/size restrictions with neighboring states					
Increasing truck parking					
PASSENGER RAIL					
Advancing phase I passenger rail corridors toward construction and implementation (e.g. Twin Cities to Chicago, NLX to Duluth)					

What MnDOT and Met Council are currently focusing on	MORE Important	LESS Important	NEUTRAL	Don't Know	Why?
POLICY					
Performance-Based Practical Design					
Ensuring transportation data is up-to-date, usable and easily accessible					
Implementing Complete Streets, performance-based practical design (i.e. design flexibility) and Context Sensitive Solutions					
Prioritizing low-cost, short-term solutions when large-scale solutions cannot be implemented/funded in the near-term					
Supporting travel demand management strategies including implementing carpools/vanpools, staggered work hours, telework, and compressed work weeks					
Supporting a system that provides equitable access to goods, services, opportunities and destinations					
Assessing risks to transportation infrastructure and services (e.g. flash flooding, excessive heat, cybersecurity)					
Conducting regular safety and condition inspections of transportation infrastructure, facilities and equipment					
OTHER - ADD YOUR OWN:					

Appendix D: Discussion & Analysis

Appendix D: Facilitated Group Discussion Summary and Themes

In the breakout sessions, participants filled out Worksheet 1, which asked them to create a list of both the opportunities and challenges they saw in their scenario. After individuals completed Worksheet 1 on their own, each small group discussed the opportunities and challenges for their respective scenario during the brainstorming session. During the discussion, staff worked as facilitators to identify common opportunities and challenges and discuss them further.

General themes were identified for opportunities and challenges. The facilitator notes reinforce the general themes identified for Worksheet 1 and Worksheet 2. Themes identified during the discussions were applicable to all four scenarios and not necessarily unique to any one scenario.

During the facilitator discussions, the top two opportunity themes identified were Safety and Equity.

- **Safety**: Opportunities for Safety focus on reducing human error, driver distraction, and crash severity. Many conversations also highlighted the opportunities for improving bicycle and pedestrian safety.
- **Equity**: Among Equity discussions, these opportunities highlighted increasing mobility for persons with disabilities, senior citizens, the urban and rural divide, and persons in low socio-economic classes.

The top two themes identified among challenge discussions were Equity and CAV Implementation.

- **Equity**: Most of the conversations identified Equity both as an opportunity and a challenge. Equity challenges raised concern regarding accessibility of CAV for lower socio-economic individuals, individuals living in rural communities, as well as making new vehicles and infrastructure ADA compliant. Equity related challenges also identified the loss of driving jobs within public transit and freight.
- **CAV Implementation**: CAV Implementation included topics related to the funding and cost of new infrastructure. Participants further discussed the challenges of adopting new CAV-related policies and standards.

With each scenario, there were certain themes or common topics that emerged. The following sections provide an overview of the topics specific to each scenario.

Summary Observations from Greater Minnesota Worksheet 1

Opportunities

- Participants responded positively to safety, truck platooning, efficiency, and environmental benefits from CAV; at the same time, they generally understand and have questions about the downside risks
- From the written comments, all four scenarios were seen as potentially viable (none received strong negative reactions as whole); that said, components of each scenario raised both positive interest and concerns

Challenges

- People got hung up on rollout of electric vehicles, in particular the need for charging infrastructure and who was going to pay
- Viability of CAV in rural areas was a consistent concern for reasons of infrastructure, affordability and practicality
- In particular for Scenario 2 but also for others, participants assumed infrastructure costs would go up and be an added burden to public agencies and/or the public

Other

- Participant comments for Scenarios 2, 3, and 4 generally reflected back at least some of the key elements of the scenarios; Scenario 1 comments were more general
- Equity was a consistent comment theme – both opportunity and challenge – regardless of how or whether it was raised in the scenario
- As CAV advances, there are opportunities to dive deeper into a number of the issues (concerns) identified and potentially isolate unknowns from true concerns (see specific recommendations below)
- There were relatively few written comments expressing concern over control or restrictions on personal freedom; however, as this is a common statement with CAV on one that came up in discussion, it may be assumed to be underreported in the written comments

This information should be contrasted with reactions from the Twin Cities Metro Area to identify any differences that may inform MnDOT direction.

Summary Observations from Twin Cities Metro Worksheet 1

Opportunities

- Participants responded positively to safety benefits, efficiency, and mobility for people who have limitations today
- People respond to efficiency benefits of connected infrastructure

Challenges

- Comments across scenarios seem to reflect a general assumption that benefits will not be equitably available (income, geography)
- With heavy public infrastructure role in Scenario 2, many people are skeptical of both the ability to pay for the infrastructure and the reliability of the technology
- Taking comments cumulatively, technology skepticism offsets perceived safety benefits in most scenarios

Other

- There are numerous examples of partial misunderstanding where better information or first hand experience would help (e.g., concerns about mixed fleets, costly infrastructure, technology)

- For Scenario 3 (private automation), comments reflect an understanding of this scenario but not strong enthusiasm for it
- Many comments reflect opportunities to clarify issues of funding and what infrastructure is needed – this could reduce concerns about issues that are less likely to materialize
- Issues of insurance and liability consistently comes up even though not called out in scenarios – this is an opportunity to provide more information
- Despite the promise of (and apparent support for) Scenario 4 (Integrated Mobility), there are major underlying issues that come out: equity, affordability, reliability of the tech, safety (related to reliability), liability

Key to Facilitated Discussion Analysis

Summary:

- A high level summary of the trends and observations that facilitators captured in their group discussion notes

Details:

- A more fine-grained outline of the key observations and synthesis of the detailed comments, including identified opportunities and challenges

Recommendations:

- Recommendations to MnDOT that came out of the group discussion (if any)

Scenario 1: Advancing Technology

Overview

- Scenario 1 was not used in Bemidji, East Grand Forks or Rochester due to smaller group sizes
- Because this scenario was not that different from today, many of the discussions focused on the challenges of this scenario
- Many of the discussions considered the impacts of the slow adoption and integration of CAVs with this Scenario
- Because the Scenario is set for 2040, multiple workshops discussed the shortcomings of this Scenario, particularly in terms of electric vehicles and infrastructure
    - One discussion considered only 5 percent of all vehicles being electric in 20 years as a "massive failure," particularly from a policy and regulation perspective

Congestion/VMT/Efficiency

Summary:

- Congestion/VMT more likely to be identified as a challenge
- Efficiency more likely to be identified as an opportunity

Details:

- Discussion considered the slow adoption rate of CAVs will likely result in increased congestion
- VMT considered most likely continue to increase in this scenario
- Connected and automated vehicles will likely be more efficient, resulting in environmental and energy benefits
- Some discussions identified that the energy benefits would not be enough

Recommendations:

- Realize that many see the efficiency and energy benefits of CAV but have concerns about VMT and congestion

Freight

Summary:

- Comments focused on platooning (platooning is the only freight issue identified in scenario)

Details:

- Discussion considered the benefits of platooning
- Opportunities were identified with platooning that may impact land use, particularly in downtowns
- Discussion on how platooning may increase efficiency
- Concerns about freight trucking efficiency impacts on rail freight

Recommendations:

- Seek opportunities to reinforce/communicate the benefits of platooning

Funding/Cost

Summary:

- Most of the discussion focused on the challenges of funding

Details:

- Many workshops discussed the changes in transportation revenue, including how gas tax funds will be impacted by connected, automated, and electric vehicles
- Many discussions considered it difficult to fund new infrastructure while maintaining old infrastructure
- Several discussions identified that the personal cost of automated or connected vehicles will likely be not accessible to people of lower socio-economic status

Recommendations:

- Seek to clarify likely public costs and potential options to pay for them

Scenario 2: Connected Infrastructure

Overview

- Scenario 2 discussions included far more challenges than opportunities

- Because this scenario anticipates the lagging advancement of automated technology, many conversations focused on the challenges of relying on connected infrastructure and technology
- Most opportunities discussed highlighted safety and congestion/VMT/efficiency related opportunities, the challenges discussed covered a variety of topics

Congestion/VMT/Efficiency

Summary:

- Similar levels of opportunities and challenges identified, though more opportunities in total

Details:

- Opportunities focused on the increased efficiency of connected vehicles
- Many discussions highlighted the ease of parking in this Scenario
- Challenge discussions indicated that this Scenario may increase VMT and congestion
- This Scenario is considered to increase congestion due to the gradual adoption of connected vehicles with traditional vehicles

Recommendations:

- None

Funding

Summary:

- Funding was primarily discussed as a challenge with this Scenario

Details:

- Many workshops discussed how this Scenario requires new infrastructure to meet the demands of connected vehicles
- There were a few discussions focusing how will this new infrastructure be funded

Recommendations:

- Clarify funding – what is the need, what are the options, is it a constraint?

Infrastructure

Summary:

- Infrastructure was primarily discussed as a challenge with this Scenario

Details:

- Infrastructure discussion challenges focused on gradual adoption
- Many discussions focused on the intersection between new infrastructure and traditional infrastructure
- Discussions considered the costs of the new infrastructure

Recommendations:

- None

Technology/Data/Communications

Summary:

- Greatest number of challenges discussed in Scenario 2 with this topic
- Most discussions focused on challenges of technology and data (especially V2V communications)

Details:

- Opportunities discussed the benefits of connected vehicles communicating with one another
- Most technology challenges focused on the possible gaps in standardization of the technology
- Several discussions considered internet access and connection a possible challenge in rural areas
- Many groups discussed the challenges of data availability, particularly in terms of data privacy and hacking.

Recommendations:

- Seek opportunities to explore/demonstrate rural communications technologies

Scenario 3: Private Automation

Overview

- Each workshop included one group to discuss Scenario 3, with the exception of the Twin Cities Metro #2 workshop, which had two small groups to discuss Scenario 3
- Overall, there were more opportunities identified with this workshop than challenges
- Equity was by far the greatest opportunity discussed
    - Equity opportunities with this Scenario focused on increased mobility for seniors and people with disabilities
    - Equity challenges considered the limited automated technology access for low income individuals

Congestion/VMT/Efficiency

Summary:

- Congestion/VMT/Efficiency was the most common challenge identified in this Scenario
- Opportunities and challenges discussed were similar topics, but considered from different perspectives

Details:

- Congestion
    - Opportunity discussions considered automated vehicles would benefit traffic flow and travel time

    - Many conversations identified that automated vehicles may likely result in an increase in single occupancy, or empty, vehicles, which will increase congestion
- Efficiency
    - Opportunity discussion identified that automated vehicles will result in efficient traffic flow
    - Several groups also discussed that automated vehicles are more likely to be energy and fuel efficient
    - Multiple groups discussed that automated vehicles integrated with traditional vehicles will decrease efficiency, and may result in congestion or traffic conflicts

Recommendations:

- None

Land Use

Summary:

- Land use was discussed in groups as both an opportunity and challenge

Details:

- Several discussions considered the implications of parking in this Scenario
- Multiple conversations identified that parking needs will decrease with this Scenario
- Most conversations identified shift in parking need as an opportunity
- Other discussions identified that curbside use is an opportunity that will influence land use

Recommendations:

- None

Technology/Data/Communication

Summary:

- As this Scenario highlights advanced technology, the automated technology was identified widely as an opportunity
- Most challenges considered the transition period the greatest challenge

Details:

- Opportunities outlined the benefits of the technology advancements
- Many discussions considered data availability as a result of this Scenario
    - Data availability and use was identified as both an opportunity and challenge
- Several discussions identified that job demand would change as a result of advancing automation
    - This was identified as both an opportunity and a challenge
- In general, challenges discussed considered the transition from traditional to automated vehicles

Recommendations:

- Seek to clarify how technology and mixed fleets would work – what are some steps? What are real vs. perceived issues?

Scenario 4: Integrated Mobility

Overview

- If workshops had greater number of participants, Scenario 4 was the scenario most likely to be added as an additional breakout group
- The following workshops had two groups to discuss Scenario 4: Twin Cities Metro #1 and Twin Cities Metro #2 workshops
- More challenges were identified than opportunities
- There was a lot of discussions focusing on equity, particularly regarding the access for seniors, youths, people with disabilities and rural communities
    - Challenges with equity included lack of access for low-income populations as well as rural communities
- Most safety discussions considered the benefits of Scenario 4; most of the safety challenges were weather related

Congestion/VMT/Efficiency

Summary:

- Congestion/VMT/Efficiency was identified similarly as opportunities and challenges
- There were some mixed discussions regarding whether VMT and efficiency would increase or decrease

Details:

- Efficiency
    - Several groups discussed how high levels of connected and automated vehicles will increase efficiency
    - Other groups considered that this level of connected and automated vehicles will increase VMT, which may impact efficiency
- There were also several comments that discussed the challenges of increased VMT, particularly with empty vehicles
- There were also many discussions regarding how if congestion increases, people will not be negatively impacted, because they can work while commuting

Recommendations:

- None

Land Use

Summary:

- Many conversations identified that this scenario will shift land use needs
- These conversations were more often opportunities than challenges

Details:

- Opportunity discussions highlighted that land use needs will change
- Changes in land use were identified as parking, lanes, and even vehicles
- The challenges identified considered the transition to connected and automated vehicles

Recommendations:

- None

Multimodal/Sharing

Summary:

- Overall, multimodal/sharing was more likely discussed as an opportunity
- Most of the discussions involving sharing considered the opportunities to expand sharing

Details:

- Several workshops discussed that this Scenario will increase ride sharing by coordinating service
- Many groups discussed that this Scenario has the opportunity to increase transit, particularly by resolving the first/last mile issue
- There were some discussions in groups that considered that this Scenario may be a challenge by potentially decreasing transit use

Recommendations:

- None

Technology/Data/Communications

Summary:

- Technology was identified during discussions primarily as a challenge

Details:

- Many groups believed technology to be a challenge, considering the event when the technology does not work
- Several discussions identified weather as a challenge to technology working
- Many groups also discussed how the technology will impact jobs
    - Shifting jobs demand was considered a challenge by some groups

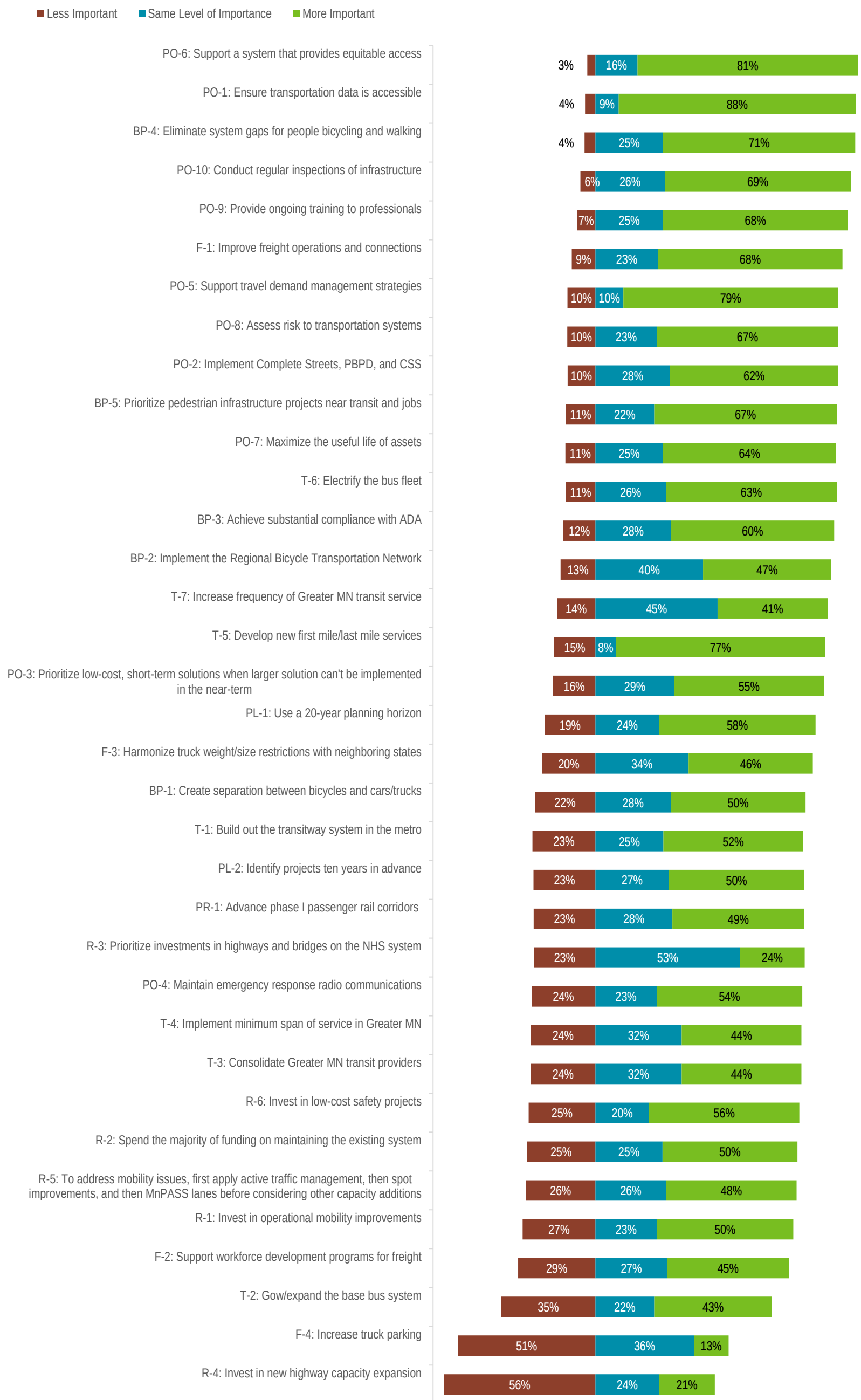
Recommendations:

- While acknowledging the challenges, seek to educate in more detail how the technology works, including current examples/applications

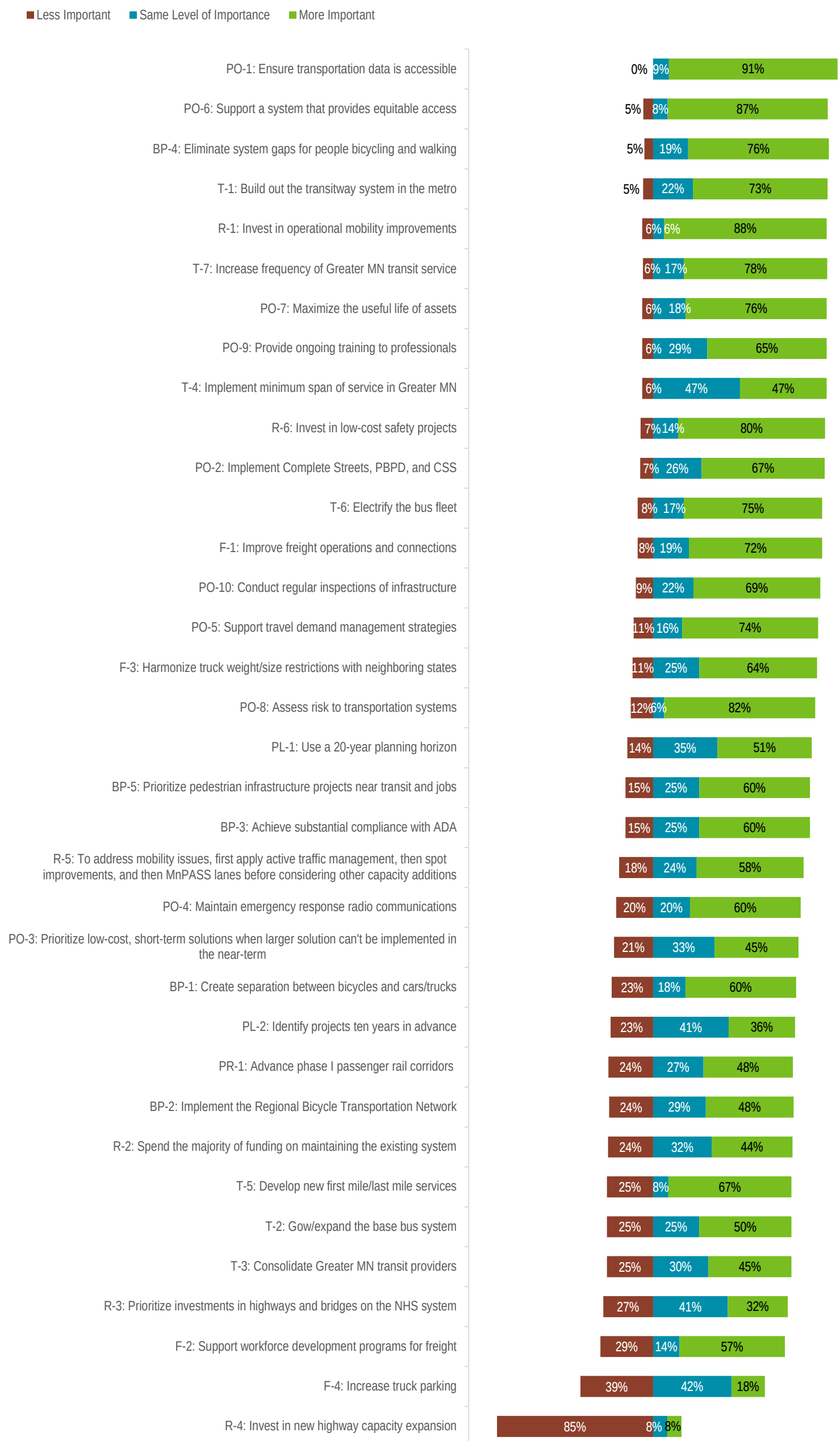
Appendix E: Analysis Tables

Current Policy	Code	Short Description
Using a 20 year planning horizon in long-range plan development	PL-1	PL-1: Use a 20-year planning horizon
Identifying roadway construction projects ten years in advance	PL-2	PL-2: Identify projects ten years in advance
Investing in operational mobility improvements (e.g. signal timing, intersection improvements, access management)	R-1	R-1: Invest in operational mobility improvements
Spending the majority of funding on maintaining the existing state highway system	R-2	R-2: Spend the majority of funding on maintaining the existing system
Prioritizing maintaining state highways and bridges on the National Highway System to a greater extent than other state highways	R-3	R-3: Prioritize investments in highways and bridges on the NHS system
Investing in capital mobility improvements (e.g. roadway expansion, interchange conversion)	R-4	R-4: Invest in new highway capacity expansion
Using the following priorities to address mobility issues: 1. traffic management technologies (eg: retiming traffic signals and comprehensive incident response) 2. Lower cost spot mobility improvements at specific locations to maximize the return-on-investment 3. MnPASS lanes 4. Strategic capacity enhancements (namely interchanges and general-purpose lanes) - when priorities 1-3 cannot improve travel conditions for people and freight	R-5	R-5: To address mobility issues, first apply active traffic management, then spot improvements, and then MnPASS lanes before considering other capacity additions
Investing in low-cost safety projects focused on fatal and serious injury crashes (e.g. rumble strips, high tension cables, intersection and crosswalk improvements, access closures, lighting)	R-6	R-6: Invest in low-cost safety projects
Building out the transitway system, including rail and bus rapid transit (BRT) corridors	T-1	T-1: Build out the transitway system in the metro
Growing/expanding the base bus system	T-2	T-2: Grow/expand the base bus system
Consolidating transit providers in Greater Minnesota	T-3	T-3: Consolidate Greater MN transit providers
Implementing minimum span of service for transit in Greater Minnesota	T-4	T-4: Implement minimum span of service in Greater MN
Developing new services for first mile/last mile	T-5	T-5: Develop new first mile/last mile services
Electrifying the bus fleet	T-6	T-6: Electrify the bus fleet
Increasing hours and frequency of transit service in Greater Minnesota	T-7	T-7: Increase frequency of Greater MN transit service
Creating more separation between bicycles and motor vehicle traffic	BP-1	BP-1: Create separation between bicycles and cars/trucks
Implementing the Regional Bicycle Transportation Network	BP-2	BP-2: Implement the Regional Bicycle Transportation Network
Achieving substantial compliance with the Americans with Disabilities Act requirements on the state highway system by 2037 (end of current 20-year investment plan)	BP-3	BP-3: Achieve substantial compliance with ADA
Overcoming physical barriers and eliminating critical system gaps for people walking, rolling, or bicycling	BP-4	BP-4: Eliminate system gaps for people bicycling and walking
Giving priority to stand-alone investments for pedestrian infrastructure that are connected to transit service or regional job concentrations	BP-5	BP-5: Prioritize pedestrian infrastructure projects near transit and jobs
Improving freight operations and connections between modes (e.g. truck, rail, barge, etc.)	F-1	F-1: Improve freight operations and connections
Developing/supporting programs in cooperation with community colleges and private sector to ensure freight workforce is available for industry needs (e.g. truck drivers)	F-2	F-2: Support workforce development programs for freight
Harmonizing truck weight/size restrictions with neighboring states	F-3	F-3: Harmonize truck weight/size restrictions with neighboring states
Increasing truck parking	F-4	F-4: Increase truck parking
Advancing phase I passenger rail corridors (e.g. Twin Cities to Chicago, NLX to Duluth)	PR-1	PR-1: Advance phase I passenger rail corridors
Ensuring transportation data is up-to-date, usable and easily accessible	PO-1	PO-1: Ensure transportation data is accessible
Implementing Complete Streets, performance-based practical design (i.e. deisgn flexibility) and Context Sensitive Solutions	PO-2	PO-2: Implement Complete Streets, PBPD, and CSS
Prioritizing low-cost, short-term solutions when large-scale solutions cannot be implemented in the near-term	PO-3	PO-3: Prioritize low-cost, short-term solutions when larger solution can't be implemented in the near-term
Enhancing and maintaining statewide radio communications for emergency response	PO-4	PO-4: Maintain emergency response radio communications
Supporting travel demand management strategies including implementing carpools/vanpools, staggered work hours, telework, and compressed work weeks	PO-5	PO-5: Support travel demand management strategies
Supporting a system that provides equitable access to goods, service, opportunities and destinations	PO-6	PO-6: Support a system that provides equitable access
Maximizing the useful life of transportation assets	PO-7	PO-7: Maximize the useful life of assets
Assessing risk to transportation infrastructure and services (e.g. flash flooding, excessive heat, cybersecurity)	PO-8	PO-8: Assess risk to transportation systems
Providing ongoing training to transportation professionals	PO-9	PO-9: Provide ongoing training to professionals
Conducting regular inspections of transportation infrastructure, facilities and equipment	PO-10	PO-10: Conduct regular inspections of infrastructure

Policy Direction Worksheet: Response Summary and Comparison
Greater MN & Metro Combined, All Scenarios

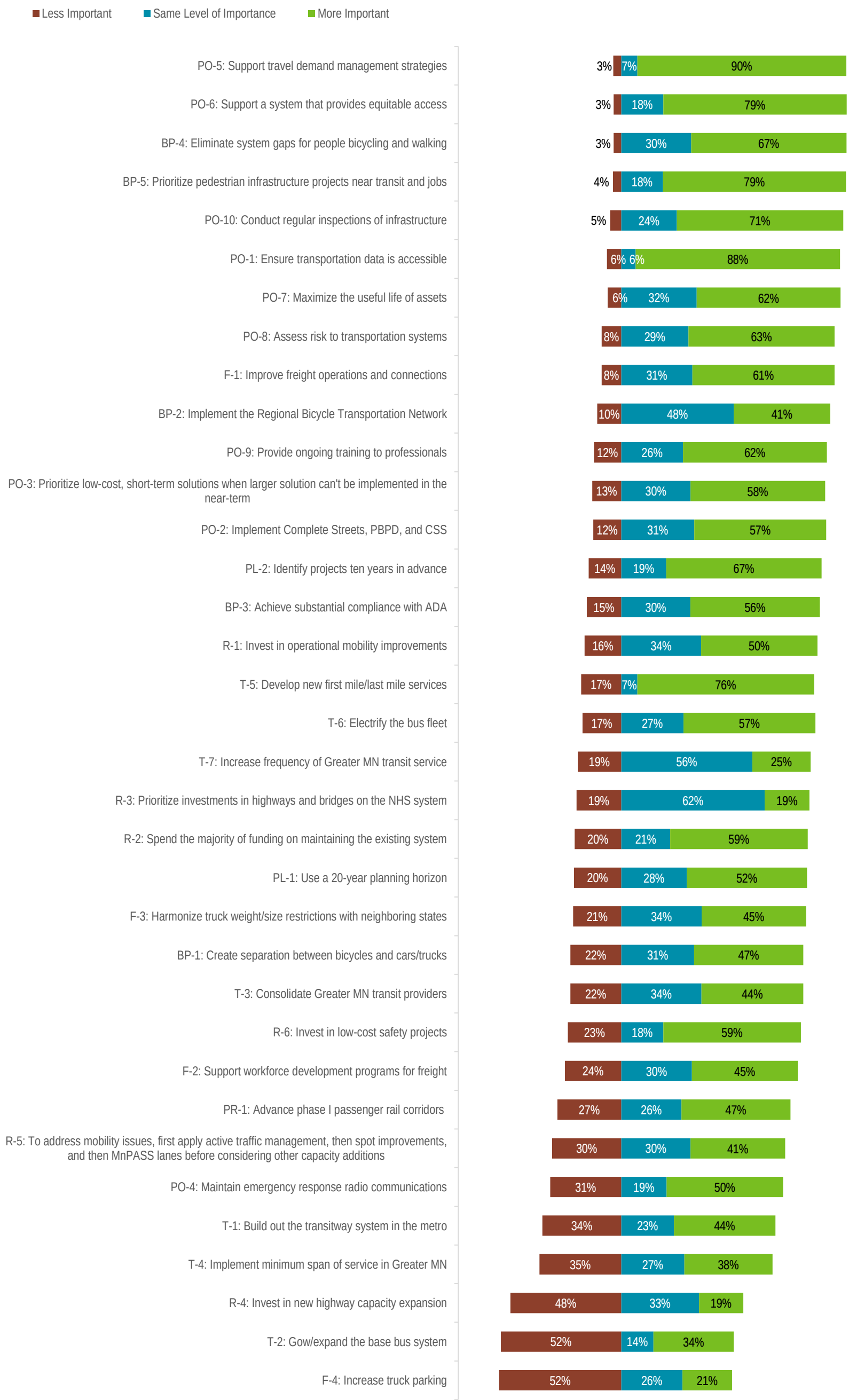


Policy Direction Worksheet: Response Summary and Comparison
Greater MN & Metro Combined, Scenario 1

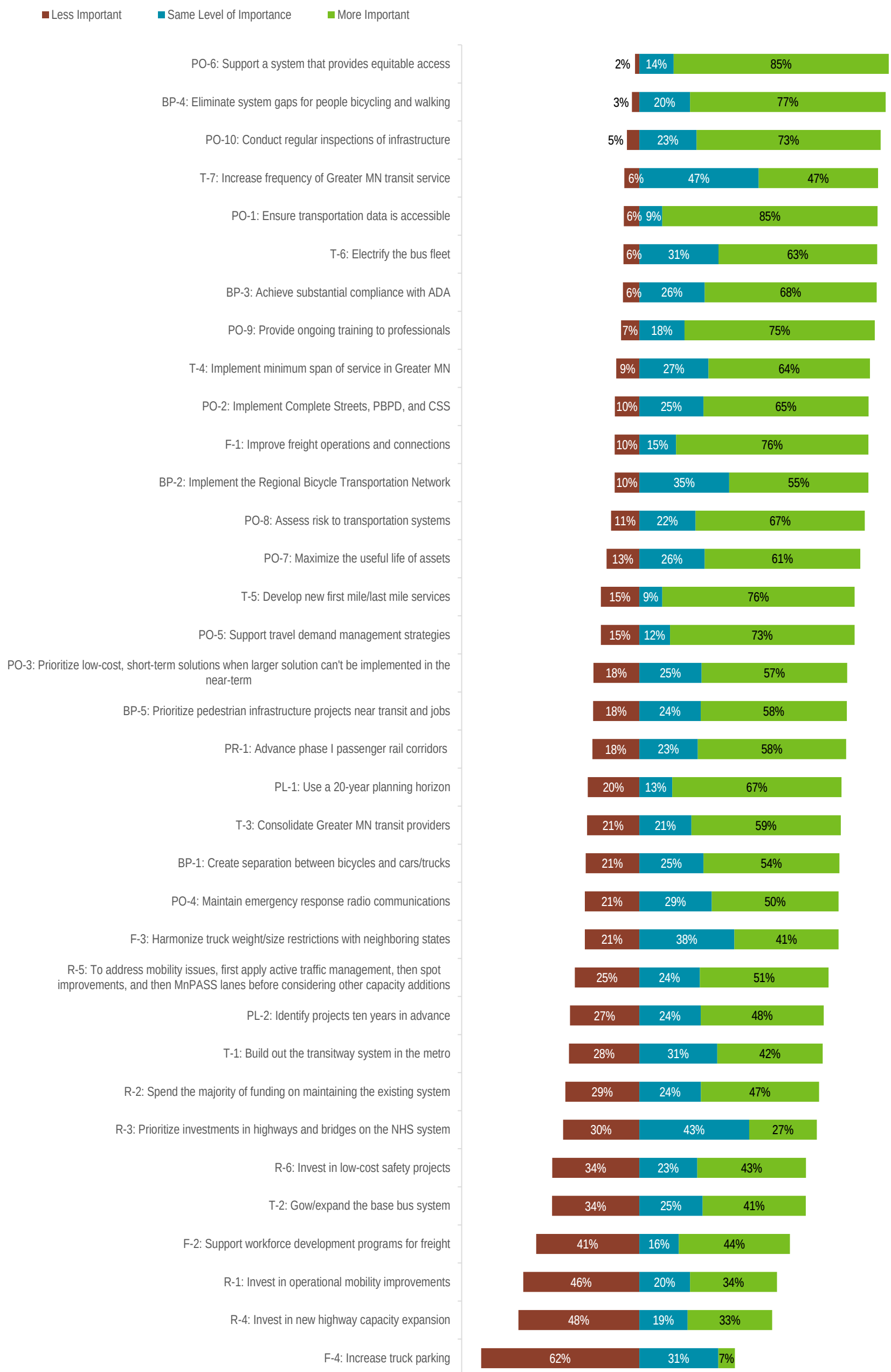


Policy Direction Worksheet: Response Summary and Comparison
Greater MN & Metro Combined, Scenario 2

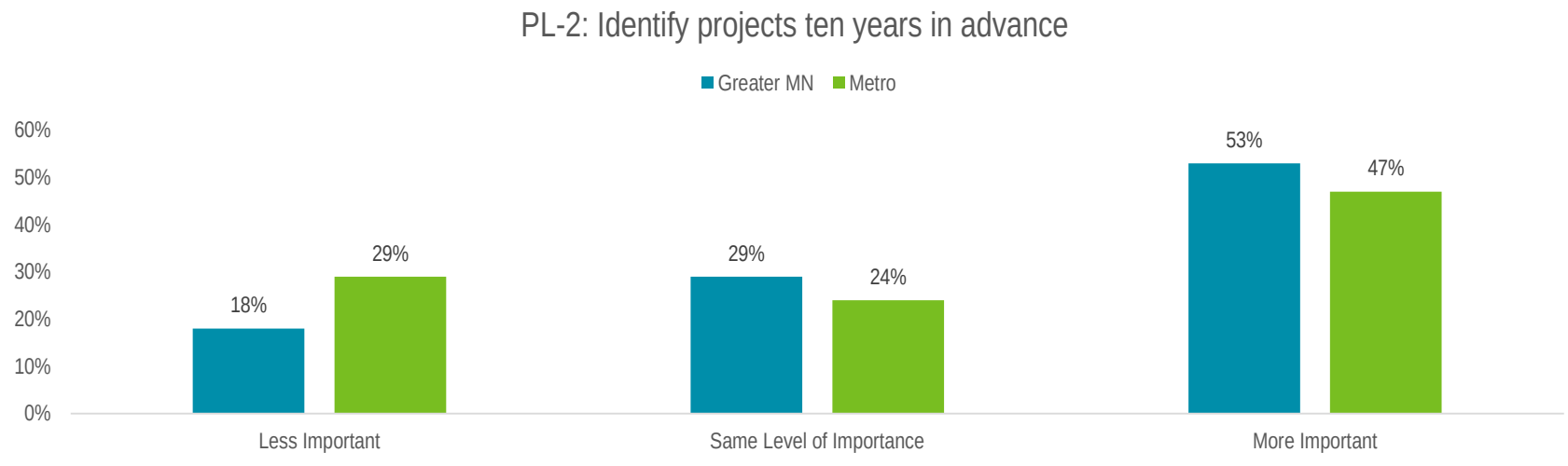
Policy Direction Worksheet: Response Summary and Comparison
Greater MN & Metro Combined, Scenario 3

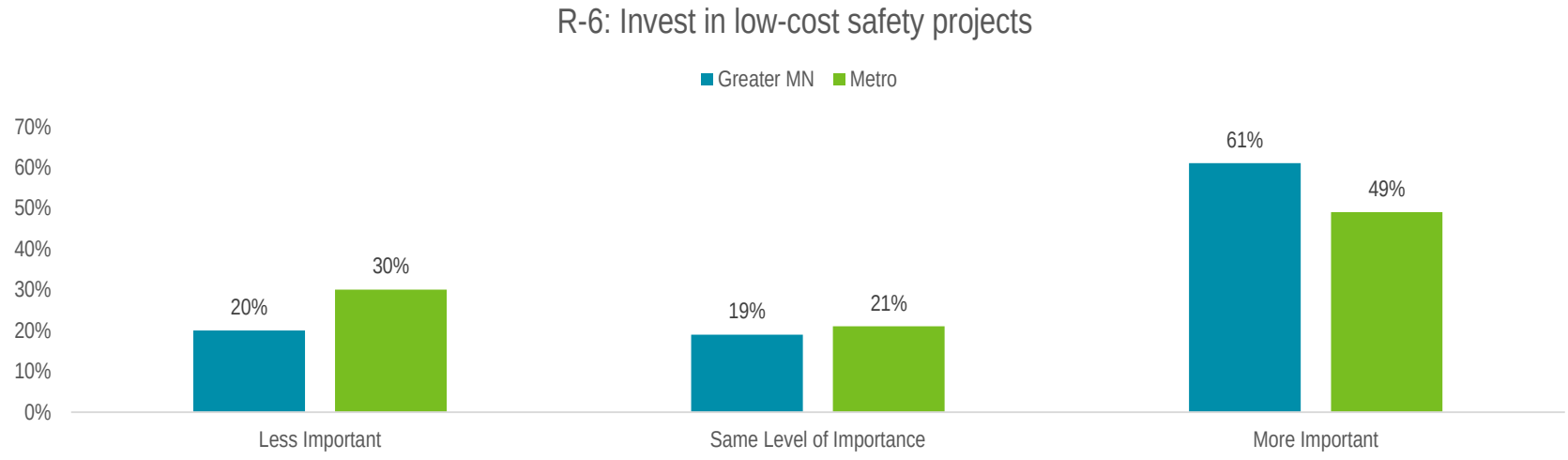


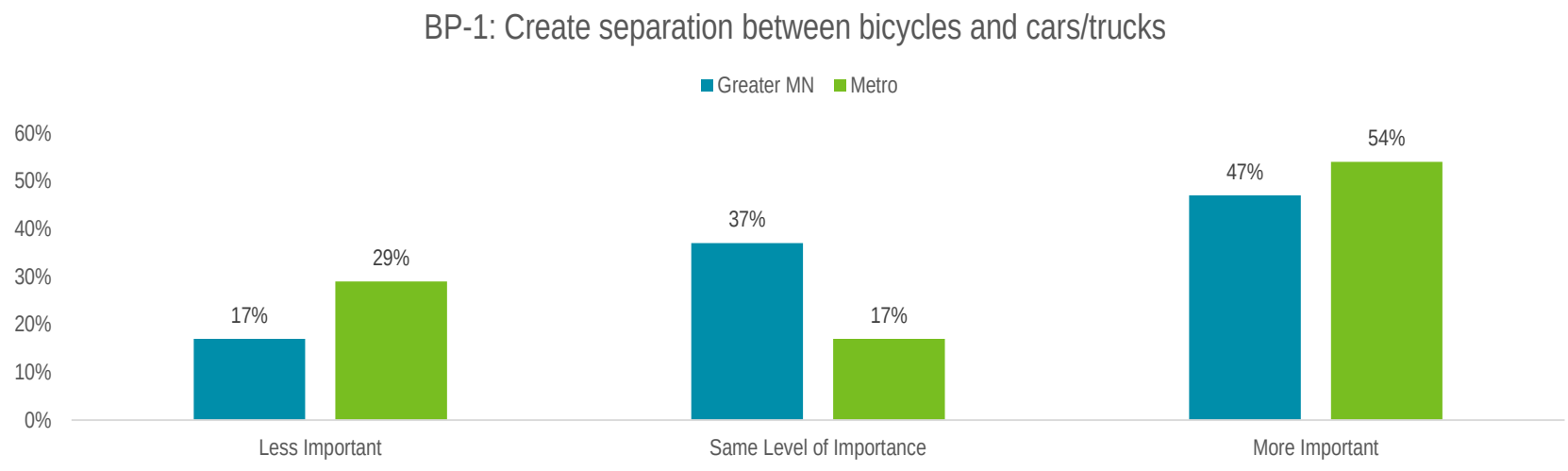
Policy Direction Worksheet: Response Summary and Comparison
Greater MN & Metro Combined, Scenario 4

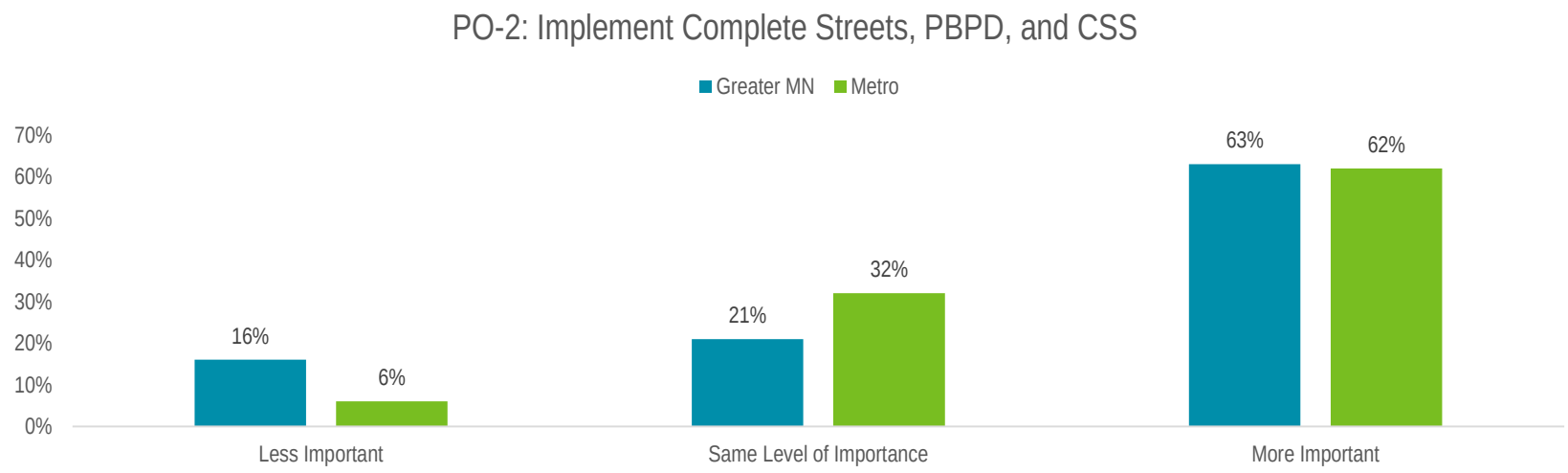


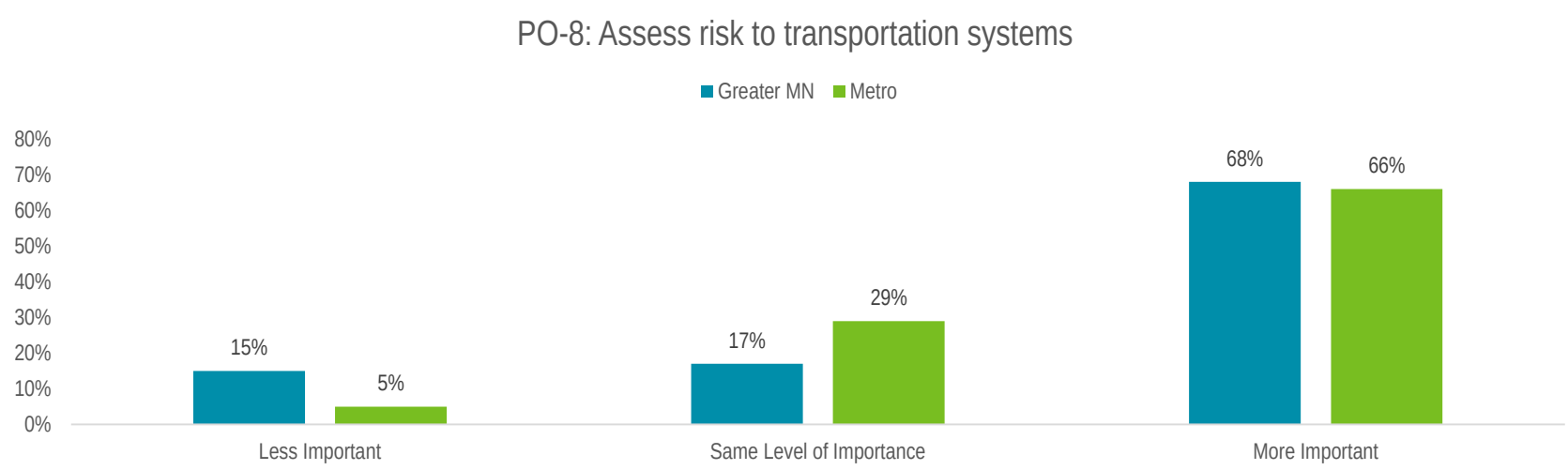
Greater Minnesota and the Metro Area were generally aligned in their assessment of the policies. There were five policies where their opinions differed by more than 10 percent.







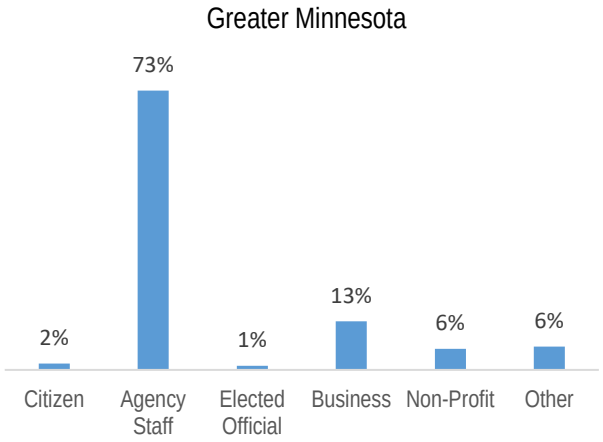


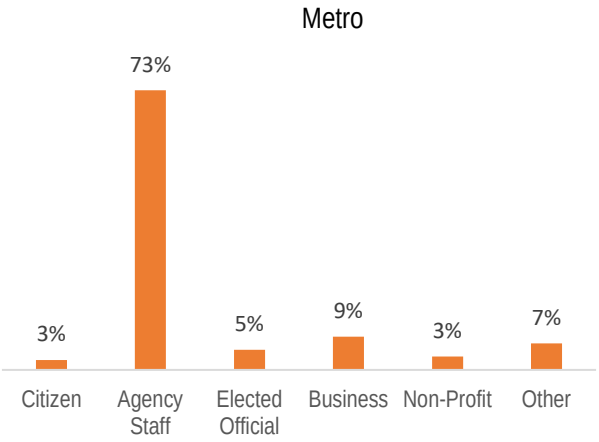


Appendix F: Participant Information

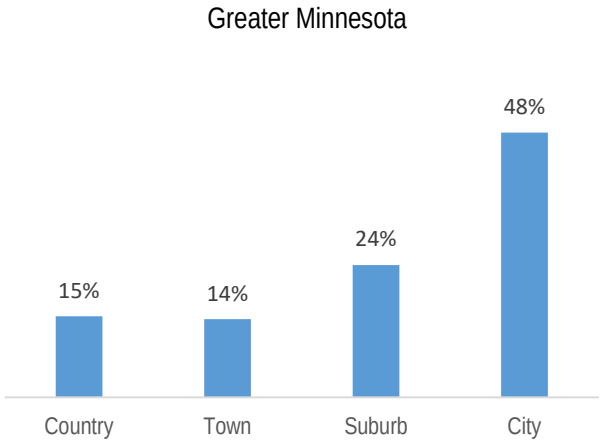
Live Polling Results – Participant Information

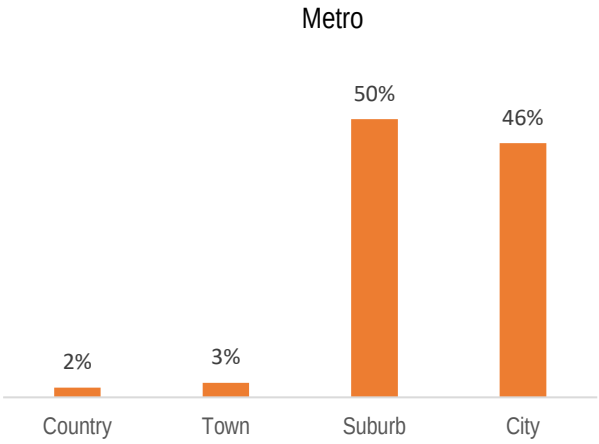
Which best describes your role today?





Where do you live?

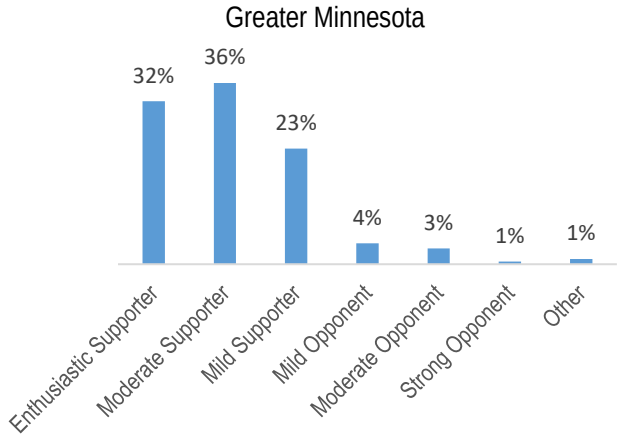


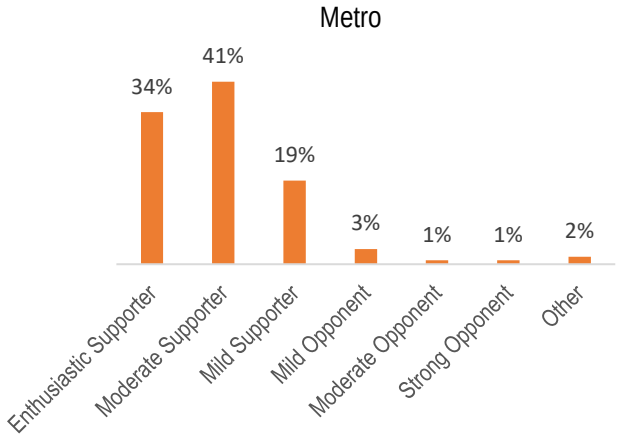


Appendix G: Scenario Impressions

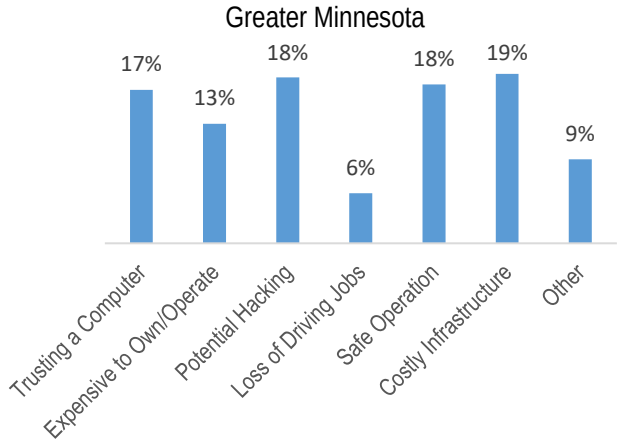
Live Polling Results – Scenario Impressions

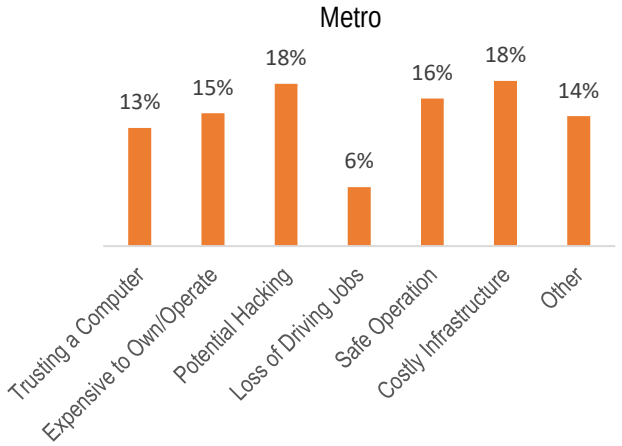
How do you feel about CAVs being allowed and/or used in Minnesota?



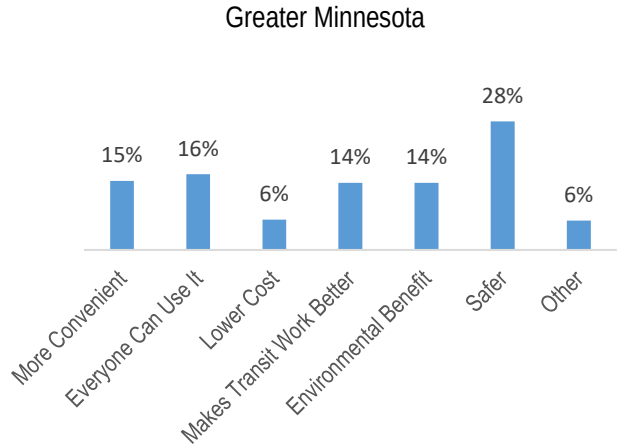


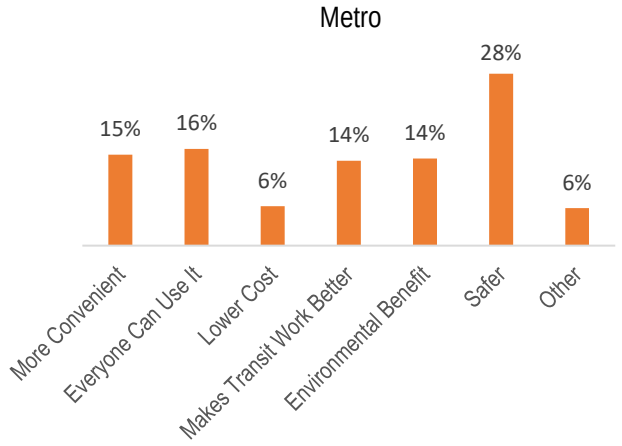
Which potential issues with CAV are of the greatest concern to you? (Choose up to 3)



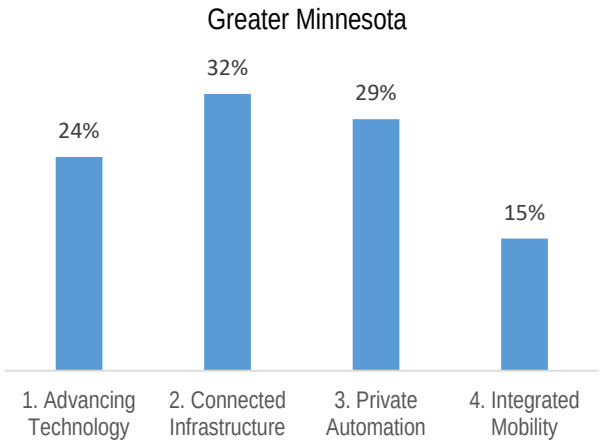


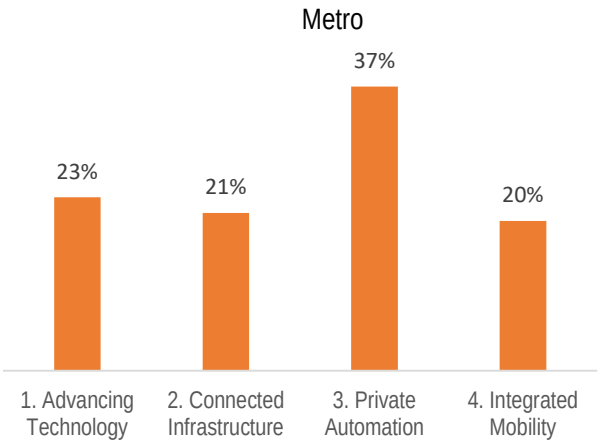
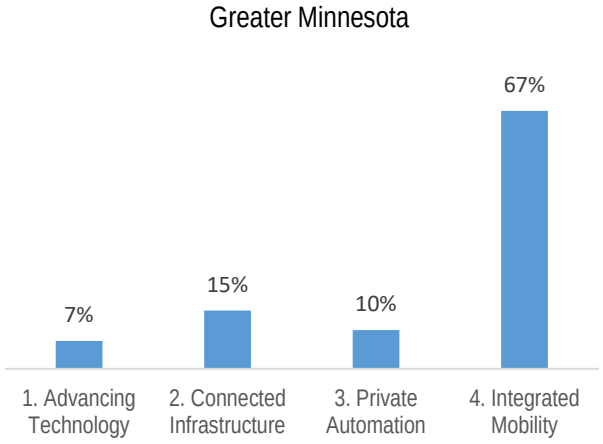
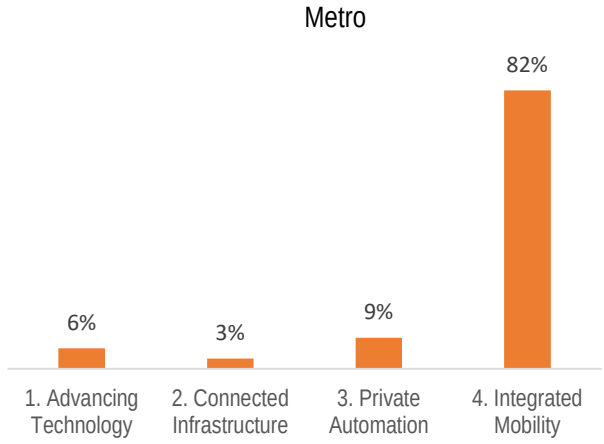
Which potential benefits of CAV are most important to you? (Choose up to 3)





Which scenario do you think is most likely to happen?





Which scenario do you most want to happen?