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MICHIANA AREA COUNCIL OF GOVERNMENTS

SCENARIO TESTING FOR MOD/MAAS AND CAV

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PREPARED FOR:
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1.0 DEFINITION, DESIGN, AND TESTING OF MAAS/CAV SCENARIOS

RSG coordinated with Michiana Council of Governments (MACOG) staff to refine three Mobility as a Service (MaaS) and Connected/Autonomous Vehicle (CAV) scenarios to be evaluated for the Long Range Transportation Plan (LRTP). The scenarios represented best and worst case CAV scenarios in 2045 and a MaaS/shared-CAV scenario for an interim year, 2035.

This section documents the scenario definitions, dimensions of uncertainty to be addressed, and the assumptions for each scenario regarding induced trip-making, mode shares, trip-length/willingness-to-travel, time-of-day for long-distance travel, deadheading trips, and capacity effects.

Scenario Definitions

Three CAV / MaaS scenarios were designed to help understand the range of uncertainty around the potential disruptions CAV and/or MaaS could have to the transportation system in the future.

Two scenarios were set in year 2045 and assumed the vehicle fleet has largely or completely been replaced with CAVs. One of these two scenarios was designed to make the “best” assumptions for congestion minimizing potential (“Best CAV Scenario”), while the other was designed to make the “worst” assumptions for congestion minimizing potential (“Worst CAV Scenario”).

The third scenario was set in year 2035 and assumed that fully autonomous vehicles have only been achieved for freeway driving and that only half of the vehicle fleet has this technology (“Interim CAV Scenario”).

The tables below document the detailed assumptions defining the three scenarios, as follows:

- Fleet composition and short-distance demand assumptions (Table 1);
- Long distance demand and supply assumptions (Table 2); and
- Zero-occupant vehicle (ZOV) trip assumptions (Table 3).

TABLE 1. FLEET COMPOSITION AND SHORT DISTANCE DEMAND ASSUMPTIONS

	BEST CAV SCENARIO (2045)	WORST CAV SCENARIO (2045)	INTERIM CAV SCENARIO (2035)
Scenario objective	Least congested scenario	Most congested scenario	Fully autonomous on freeway only
Fleet assumptions	75% of auto is CAV SAE Level 5[1]	75% of auto is CAV SAE Level 5	50% of auto is CAV SAE Level 3 – 4[2]
CAV fleet compositions	40% private owned, 60% MaaS fleets	90% private owned, 10% MaaS fleets	95% private own / 5% MaaS fleets
Short Distance Passenger Trips			
Induced trip-making	5%	50%	0%
Destination choice (Discount on travel time disutility)	5%	30%	5%
Short Distance Trucks			
CAV mode share	75%	75%	50%
Induced short distance truck demand (II)[3]	5%	50%	0%

[1] Society of Automotive Engineers (SAE) Level 5 = Full Automation
[2] SAE Level 3-4 = Conditional Automation to High Automation
[3] II = Internal-Internal trips (i.e., within MACOG region)

TABLE 2. LONG DISTANCE DEMAND AND SUPPLY ASSUMPTIONS

	BEST CAV SCENARIO (2045)	WORST CAV SCENARIO (2045)	INTERIM CAV SCENARIO (2035)
Long Distance Passenger Trips			
CAV mode share	71%	97%	60%
Induced trip-making	20%	75%	10%
Time of day shift	AM/PM Cut by 35%, NT increase by 35%	AM/PM Cut by 35%, NT increase by 35%	AM/PM Cut by 20%, NT increase by 20%
Long Distance Multiple-Unit (MU) Truck CAV			
CAV mode share	100%	90%	50%
Induced long distance MU truck demand (EI/IE/EE)[4]	20%	75%	15%
Induced long distance MU truck demand (II)	5%	50%	0%
Assignment			
Value of time discount	5%	30%	5%
Freeway usage and capacity	1) only CAV use 2) 50% capacity increase	1) only CAV use 2) 50% capacity increase	No change
CAV passenger car equivalent (PCE) factor	1.0[5]	1.1	1.05
Intersections	No change[6]	No change	No change

[4] EI/IE/EE = External-Internal/Internal-External/External-External trips (i.e., trips into/out of/or through the MACOG region)
[5] This should not be reduced below 1.0 until all vehicles are CAVs.
[6] No appreciable change is likely until very close to 100% of vehicles have new technology.

TABLE 3. ZERO-OCCUPANT VEHICLE TRIP ASSUMPTIONS

	BEST CAV SCENARIO (2045)	WORST CAV SCENARIO (2045)	INTERIM CAV SCENARIO (2035)
Type 1 ZOV Trips: Car-sharing among members of the same household may result in ZOV trips if a CAV drops one household member off at a destination and subsequently travels to some other location to pick up another household member.			
Percentage HBW Trips	20%	40%	0%
Percentage HBOWT Trips	15%	35%	0%
Percentage HBOST Trips	0%	0%	0%
Percentage HBOLT Trips	10%	20%	0%
Type 2 ZOV Trips: A CAV may return to its home location to avoid paid parking.			
None, due to enough parking spots and low parking cost			
Type 3 ZOV Trips: A CAV may travel to other remote (non-home) location to avoid paid parking.			
None, due to enough parking spots and low parking cost			
Type 4 ZOV Trips: CAVs may circulate after dropping off an occupant for a short-duration activity.			
Percentage HBOWT, HBOST	Zero	Zero (except for CBD TAZ, 20%)	Zero
Type 5 ZOV Trips: After dropping off a passenger, MaaS need to deadhead to a different location to pick up the next passenger. MaaS deadheading was incorporated into the modeling framework by inverting all passenger origins and destinations and feeding the result into a gravity model.			
MaaS trip ends as Origin and MaaS trip origins as Destination			
Type 6 ZOV Trips: MaaS CAV will need to return to centralized depots intermittently, either to recharge or when demand is low.			
	Neighboring TAZs parking capacity increase to 1,000,000	Neighboring TAZs parking capacity increase to 1,000,000	Zero

Methodology

The methodology for testing the scenarios involved both manual processing and leveraging of existing modeling tools, including both the Michigan Department of Transportation (MDOT) statewide model and the MACOG regional model.

RSG utilized and adjusted MACOG regional model datasets, including increasing trips to represent induced trip-making, shifting trips to reflect the scenario mode shares, redistributing trips to reflect greater willingness-to-travel, shifting the time-of-day for external trips, developing deadheading trip tables, and adjusting assignment parameters such as passenger car equivalencies. Once the scenario demand was developed, it was converted to allow application to the MACOG model area with adjustments to the assignment procedure to reflect the supply side assumptions documented for each scenario. Subarea extraction was used to pull the resulting vehicle trip matrix for the MACOG region as well as the assignment output.

The MDOT statewide model and its CAV functionality was used to obtain long distance and external travel as well as control totals for ZOV trips. The MDOT statewide model also provided the basis for VMT and volume performance measures, although these were calculated via a pivot methodology which leveraged the richer detail and associated metrics in the MACOG regional model. That is, for the VMT and volume performance measures we report herein, the measures are the result of factoring the MACOG 2045 no-build run measures using the MDOT statewide model scenario results, as shown in the formula below:

$$Reported\ Scenario\ Measurement = \frac{MDOT\ Scenario\ Subarea\ extraction}{MDOT\ Baseline\ Subarea\ extraction} \times MACOG\ Model\ Baseline$$

Where:

Reported Scenario measurement: Scenario specific VMT or traffic volumes discussed in this section;

MDOT Scenario Subarea extraction: Actual VMT or traffic volumes reported from MDOT model sub-area extraction from specific scenario;

MDOT Baseline Subarea extraction: Actual VMT or traffic volumes reported from MDOT model sub-area extraction from baseline scenario;

MACOG Model Baseline: Actual VMT or traffic volumes reported from MACOG model baseline scenario.

Table 4 shows the example of how this pivoting works. For the I-80/I-90 toll road through traffic, the MACOG baseline (2045 no-build) scenario suggested a total of 771 auto trips (labeled “A”). The MDOT baseline subarea extraction suggested a total of 519 auto trips (labeled “B”). The MDOT Best CAV scenario subarea extraction suggested a total of 268 auto trips (labeled “C”).

The final reported MDOT Best CAV scenario for the I-80/I-90 toll road through auto trips are 398 according to the formula (labeled “D”). The reported ZOV volume (labeled “G”), CAV volume (labeled “H”), and conventional auto (labeled “J”) are based on the volume distribution from MDOT Best CAV scenario subarea extraction (values labeled “E”, “F”, and “I”, respectively) and pivoted total auto volume (labeled “D”). The same calculation was applied to single-unit (SU) trucks and multiple-unit (MU) trucks.

TABLE 4 SCENARIO MEASUREMENT PIVOTING EXAMPLE

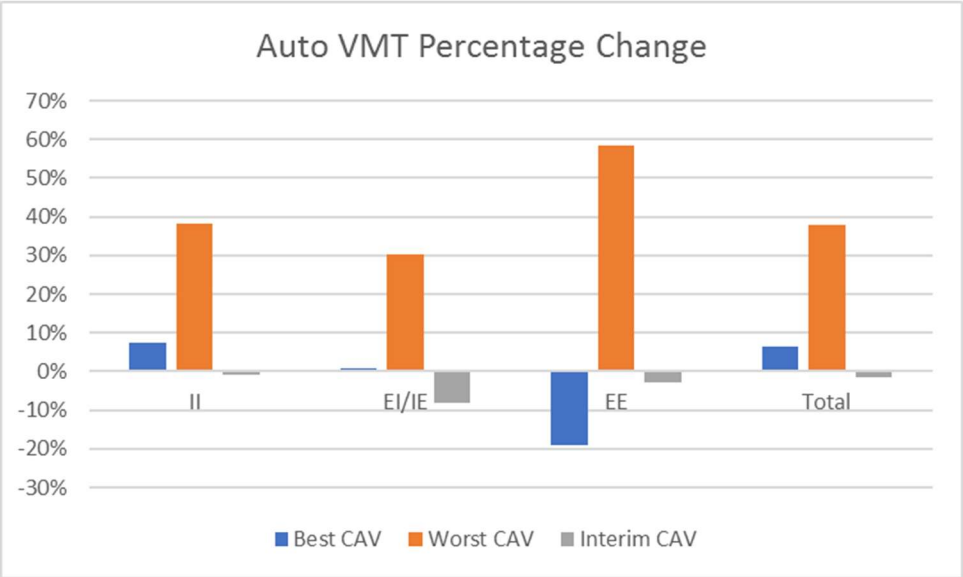
I80/I90 TOLL ROAD THROUGH TRIPS AM PERIOD		MACOG MODEL BASELINE	MDOT BASELINE SUB-AREA	MDOT BEST CAV SCENARIO SUB-AREA	MDOT BEST CAV REPORTED MEASUREMENT
Auto	Total	(A) 772	(B) 520	(C) 268	(D) 398
	ZOV	-	-	(E) 0	(G) 0
	CAV Auto	-	-	(F) 268	(H) 398
	Conventional Auto	772	520	(I) -	(J) -
SU Trucks	Total	70	-	-	88
	CAV Truck	-	-	-	88
	Conventional Truck	70	-	-	-
MU Trucks	Total	990	332	417	1,243
	CAV Truck	-	-	417	1,243
	Conventional Truck	990	332	-	-

2.0 SCENARIO RESULTS

Auto VMT

Figure 1 shows the percentage change of automobile VMT for the three scenarios compared against baseline scenario. In total, auto VMT increased the Best and Worst CAV scenarios, but decreased for the Interim CAV scenario. The Worst CAV scenario showed dramatically higher auto VMT.

FIGURE 1 PERCENTAGE CHANGE IN AUTO VMT



These results follow from the scenario assumptions, of which several factors would be expected to affect the VMT:

- Fleet composition
- Induced trip making
- Discount on travel time penalty
- Additional ZOV trips
- Route

The detail scenario assumptions and corresponding impact on VMT is listed in Table 5. In the table, “+” means positive impact and “-“ means negative impact. “++” or “- -“ indicates stronger impact.

The percentage of MaaS Fleet has a negative impact on VMT. A higher percentage of MaaS fleet would result in a higher percentage of shared rides, which causes a decrease of vehicle trips given personal trips remaining the same.

The induced trip-making has a positive impact on VMT. Short distance trips were increased by 50% due to induced trips in the Worst CAV scenario. This had a strong positive impact on VMT.

The discount on travel time disutility allows longer travel distances for short distance trips. Under this assumption, the Worst CAV scenario had a stronger positive impact on VMT as compared to the other two scenarios.

TABLE 5 SCENARIO ASSUMPTIONS IMPACT ON AUTO VMT

	BEST CAV SCENARIO	WORST CAV SCENARIO	INTERIM CAV
CAV fleet compositions	40% PRIVATE OWNED, 60% MAAS FLEETS	90% PRIVATE OWNED, 10% MAAS FLEETS	95% PRIVATE OWN, 5% MAAS FLEETS
Effect on VMT	--	-	-
Short Distance trips Induced trip-making	0.05	0.5	0
Effect on VMT	+	++	no impact
Destination Choice (Discount on travel time disutility)	0.05	0.3	0.05
Effect on VMT	+	++	+
ZOV assumptions	+	++	+

Zero occupancy vehicle trips also increased total auto VMT. Table 6 shows the actual VMT and percentage distribution made by conventional auto, CAV, and ZOV for all of the scenarios. In the Best CAV scenario, ZOV contributes 11% of VMT. In the Worst CAV scenario, ZOV contributes 6% of VMT. In the Interim scenario, ZOV contributes 1% of VMT. The reason that the Best CAV scenario has the highest ZOV VMT is due to the Best CAV scenario having the highest percentage of MaaS fleet and highest VMT from Type 5 ZOV trips.

TABLE 6 VMT DISTRIBUTION WITHIN AUTO MODE

	CONVENTIONAL AUTO	CAV	ZOV	CONVENTIONAL AUTO	CAV	ZOV
Baseline	13,719,382	0	0	100%	0%	0%
Best CAV Scenario	3,077,446	11,780,560	1,879,202	18%	70%	11%
Worst CAV Scenario	3,619,362	17,164,773	1,216,751	16%	78%	6%
Interim CAV Scenario	6,485,010	6,920,968	88,398	48%	51%	1%

In additional to these just-discussed factors that affect demand, origin and destination pattern changes and highway assignment differences also affect VMT (e.g., Best CAV and Worst CAV scenarios allow only CAVs to use the freeways). Table 7 shows the VMT by origin and destination. For internal demand, VMT increased for both Best CAV and Worst CAV scenarios but decreased for Interim CAV scenario (which is due to mode shifting). Although mode shifting also exists in the Best CAV and Worst CAV scenarios, other factors like induced demand compensated that.

For traffic between internal and external zones, VMT increased for both the Best CAV and the Worst CAV scenarios but decreased for the Interim CAV scenario. The reason might have to do with differences in the destination choice assumptions.

For through traffic, VMT decreased for the Best CAV scenario which is partially due to the assumptions that only CAV traffic can use the freeways and some conventional auto traffic therefore bypasses the region. The same assumption also exists under the Worst CAV scenario, but there is much higher induced demand under this scenario, offsetting the effect.

TABLE 7 AUTO VMT BY OD PATTERNS

TOTAL VMT	BASELINE	BEST CAV	WORST CAV	INTERIM CAV
Internal to Internal	12,043,356	12,944,197	16,663,126	11,952,458
External to Internal/Internal to External	1,412,852	1,424,247	1,841,619	1,297,180
External to External	263,174	213,445	416,991	256,140
Total	13,719,382	14,581,889	18,921,736	13,505,778
Difference	**Baseline**	**Best CAV**	**Worst CAV**	**Interim CAV**
Internal to Internal		900,840	4,619,770	-90,899
External to Internal/Internal to External		11,395	428,767	-115,672
External to External		-49,729	153,817	-7,034
Total		862,507	5,202,354	-213,604

In summary, the Worst CAV scenario has the highest auto VMT increase, largely contributed by CAV VMT. The Best CAV scenario has a 6% increase of auto VMT. The Interim CAV scenario has VMT slightly deceased (by 2%), which is due to mode shifting from drive alone to shared ride.

Single-Unit Truck VMT Change

Figure 2 shows the percentage change of VMT for single-unit (SU) trucks. The overall SU truck VMT change pattern is similar to the automobile VMT change pattern: the largest VMT increase occurred in the Worst CAV scenario, followed by the Best CAV scenario. The VMT change for the Interim CAV scenario is small.

FIGURE 2 SU TRUCK VMT PERCENTAGE CHANGE

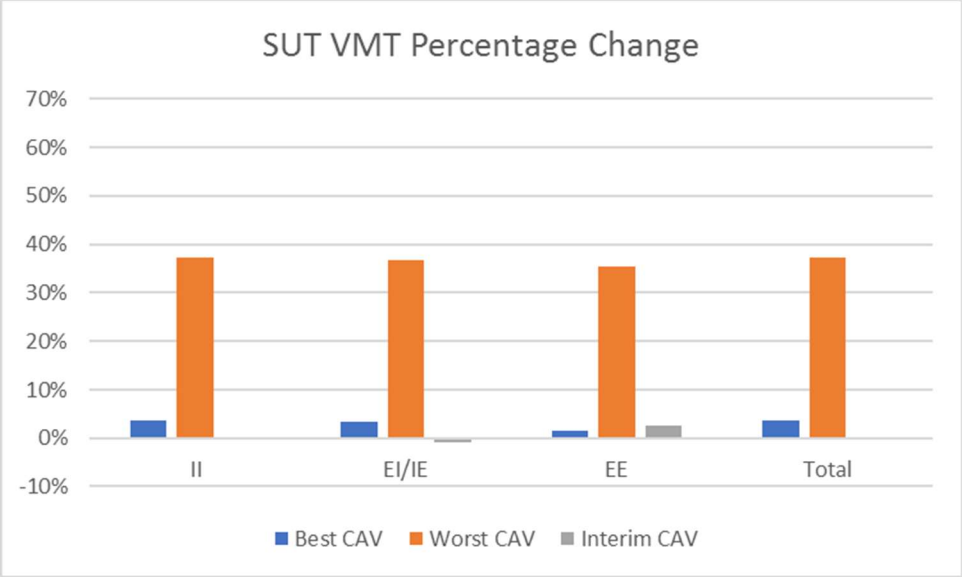


Table 8 shows the scenario assumptions and effect on SU truck demand, which is consistent with the findings for the SU truck VMT change.

TABLE 8 SCENARIO ASSUMPTIONS IMPACT ON SU TRUCK VMT

	BEST CAV SCENARIO	WORST CAV SCENARIO	INTERIM CAV
Induced short distance truck demand (II)	0.05	0.5	0
Effect on VMT	+	++	no impact

Table 9 shows SU truck VMT by origin and destination. VMT increases in both the Best CAV and the Worst CAV scenarios were mostly contributed by internal SU truck trips.

TABLE 9 SU TRUCK VMT BY OD PATTERNS

TOTAL VMT	BASELINE	BEST CAV	WORST CAV	INTERIM CAV
Internal to Internal	1,144,423	1,186,258	1,572,190	1,142,624
External to Internal/Internal to External	158,347	163,772	216,714	157,044
External to External	50,972	51,730	68,966	52,322
Total	1,353,742	1,401,761	1,857,871	1,351,991
Difference	**Baseline**	**Best CAV**	**Worst CAV**	**Interim CAV**
Internal to Internal		41,835	427,767	-1,799
External to Internal/Internal to External		5,425	58,367	-1,303
External to External		758	17,995	1,350
Total		48,019	504,129	-1,751

Multiple-Unit Truck VMT Change

Figure 3 shows the percentage change of VMT for MU trucks. For both internal demand and internal and external traffic, there is a small increase of VMT for the Best CAV scenario and a significant increase of VMT for the Worst CAV scenario. There is barely any change of VMT for the Interim CAV scenario. For through traffic, all three scenarios exhibit a significant drop in VMT. In both the Best CAV and Interim CAV scenarios, MU trucks experienced a decrease in VMT and in the Worst CAV scenario, MU trucks had an increase in VMT.

FIGURE 3 MU TRUCK VMT PERCENTAGE CHANGE

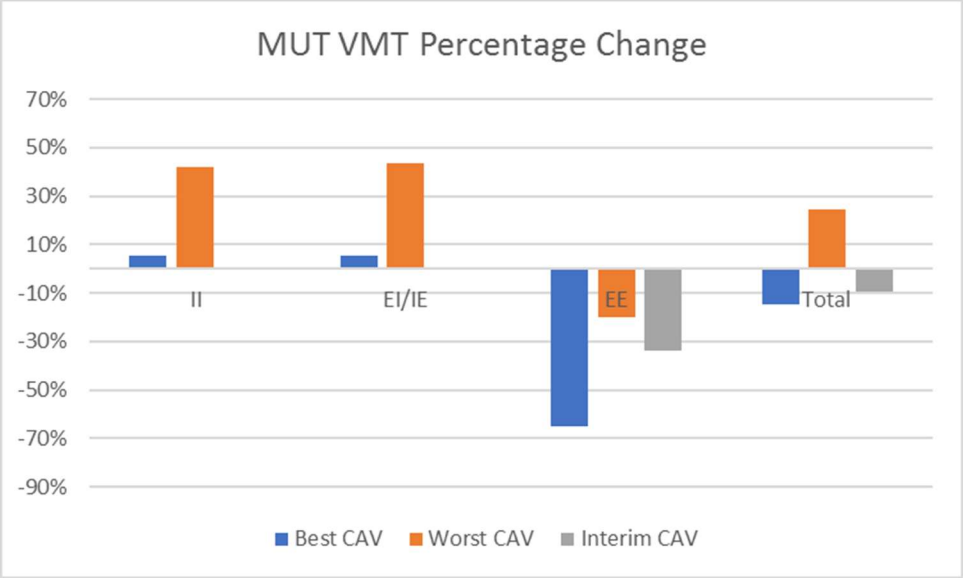


Table 10 shows the MU truck VMT by origin and destination. In all scenarios, the VMT decreased for through traffic. The Best CAV scenario has the largest VMT decrease for through traffic, followed by the Interim CAV scenario.

TABLE 10 MU TRUCK VMT BY OD PATTERNS

TOTAL VMT	BASELINE	BEST CAV	WORST CAV	INTERIM CAV
Internal to Internal	1,174,523	1,236,433	1,665,877	1,172,359
External to Internal/Internal to External	262,891	277,063	377,026	263,150
External to External	564,530	196,291	452,054	373,737
Total	2,001,944	1,709,787	2,494,957	1,809,245
Difference	**Baseline**	**Best CAV**	**Worst CAV**	**Interim CAV**
Internal to Internal		61,910	491,354	-2,164
External to Internal/Internal to External		14,172	114,135	258
External to External		-368,238	-112,475	-190,793
Total		-292,157	493,013	-192,699

The decrease of MU truck through traffic VMT in the three scenarios is largely due to changes in MU truck routing choices from the baseline. Figure 4 to Figure 6 show the difference of MU truck traffic loaded to freeway links, comparing against the baseline. The red color indicates links on which MU truck volume increased while the green color indicates links on which MU truck volume decreased. In all three scenarios, MU truck volume decreased on I-80/I-90 but increased on I-94.

FIGURE 4 FREEWAY MU TRUCK TRAFFIC BEST CAV VS. BASE

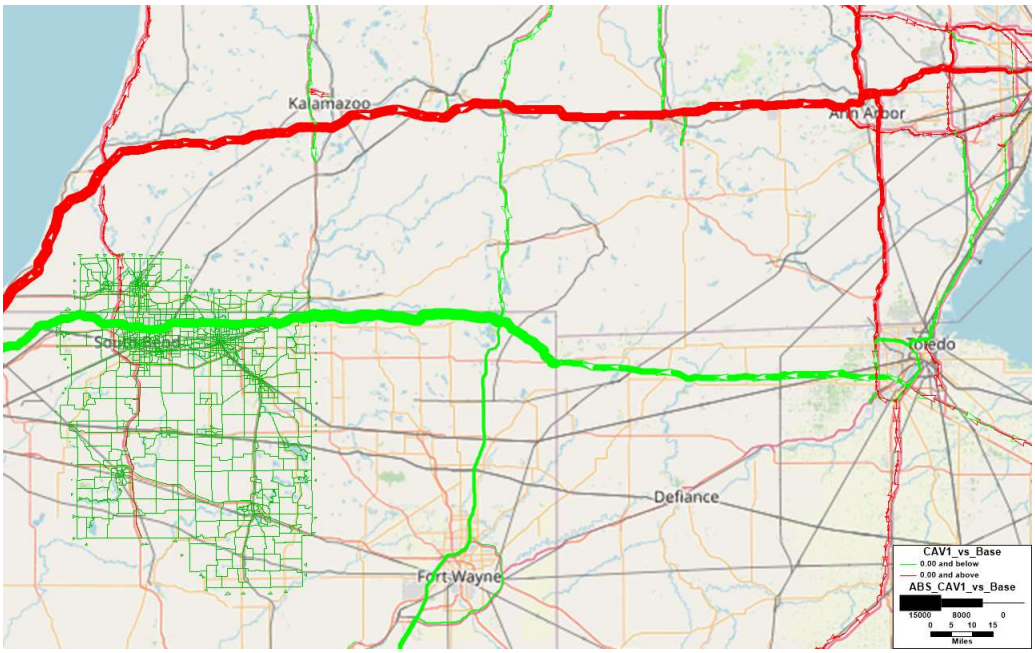


FIGURE 5 FREEWAY MU TRUCK TRAFFIC WORST CAV VS. BASE

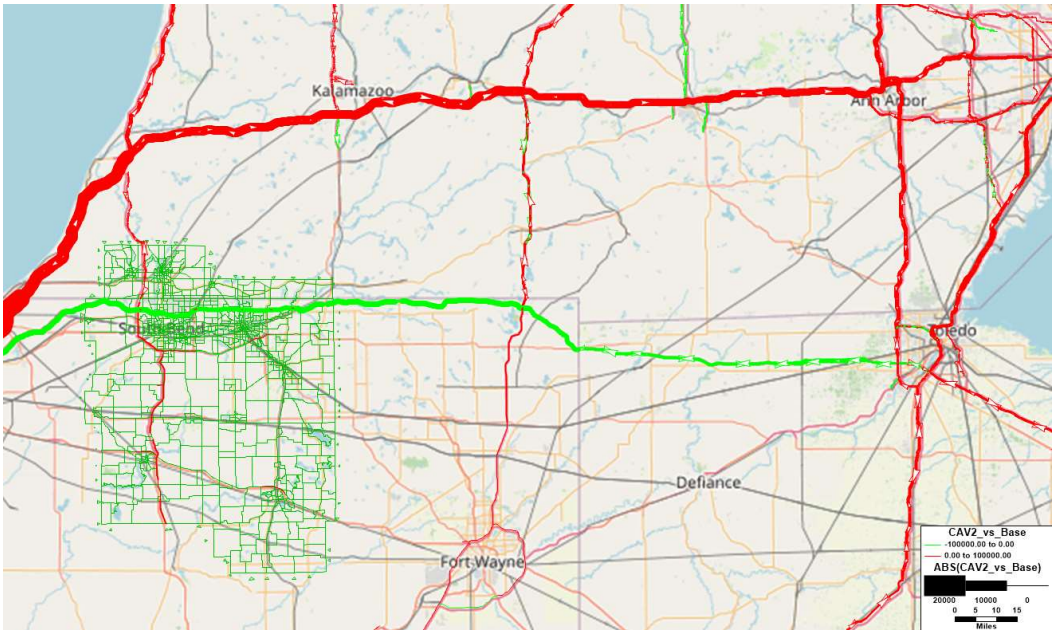
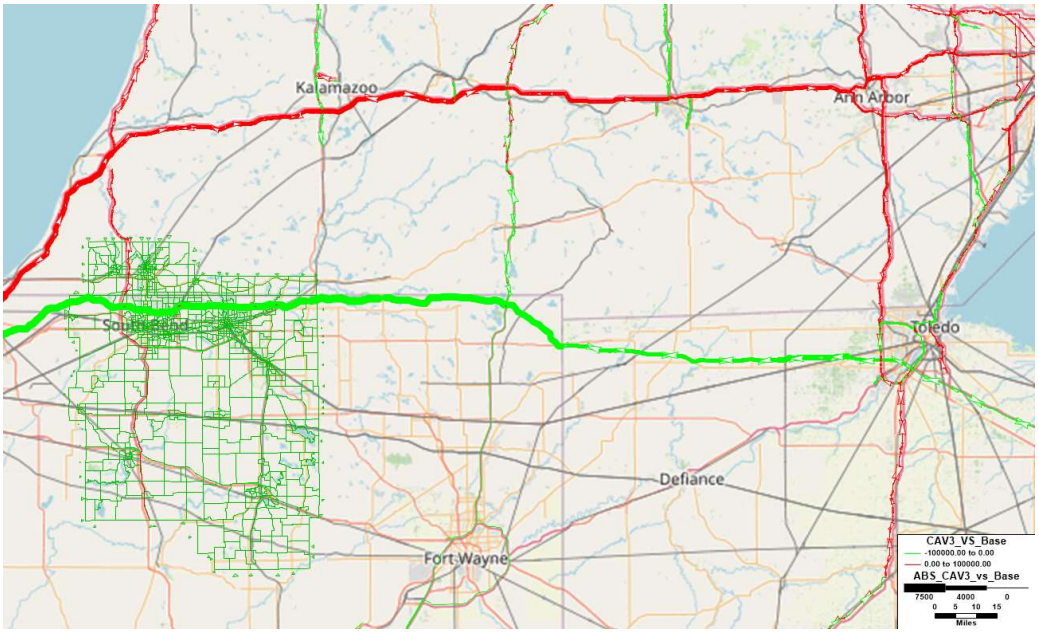


FIGURE 6 FREEWAY MU TRUCK TRAFFIC INTERIM CAV VS. BASE



I-80/I-90 Toll Road Through Traffic

Table 11 shows daily through traffic using the I-80/I-90 toll road. In the baseline scenario, there are 4.5K daily auto trips traveling through the region, all of which are conventional auto. In the Best CAV scenario, this number dropped to 1.9K, all of which are CAV. In the Worst CAV scenario, this number increased to 5.4K, most of which are CAV. In Interim CAV scenario, this number decreased to 3.5K, with two third of them being CAV auto. ZOV contributed a very small fraction of through traffic. Note that across all vehicle types, in both the Best CAV and the Worst CAV scenarios, we assumed that only CAV can use freeway, which is the reason that there is no conventional traffic reported on the I-80/I-90 toll road in the Best CAV and Worst CAV scenarios.

In the baseline scenario, there are 580 daily SU truck trips traveling through the region, all of which are conventional trucks. In the Best CAV scenario, this number dropped to 107, all of which are CAV SU trucks. In the Worst CAV scenario, this number dropped to 319, all of which are CAV SU trucks. In the Interim CAV scenario, this number decreased to 272, with one half of them being CAV SU trucks.

In the baseline scenario, there are 6.9K daily MU truck trips traveling through the region, all of which are conventional truck. In the Best CAV scenario, this number dropped to 2.1K, all of which are CAV MU trucks. In the Worst CAV scenario, this number dropped to 6.0K, all of which are CAV MU trucks. In the Interim CAV scenario, MU truck volume decreased to 4.8K, with about 55% of them being CAV trucks.

TABLE 11 I80/I90 TOLL ROAD DAILY THROUGH TRIPS

		BASELINE	BEST CAV	WORST CAV	INTERIM CAV
Auto	Total	4,532	1,929	5,379	3,454
	ZOV	-	-	3	98
	CAV Auto	-	1,928	5,376	2,057
	Conventional Auto	4,532	-	-	1,299
SU Truck	Total	580	107	319	272
	CAV Truck	-	107	319	137
	Conventional Truck	580	-	-	135
MU Truck	Total	6,873	2,116	5,982	4,772
	CAV Truck	-	2,116	5,982	2,696
	Conventional Truck	6,873	-	-	2,077

Other Through Traffic

Table 12 shows daily through traffic not using I-80 and I-90. In the baseline scenario, there were 24K daily auto trips traveling through the region not using I-80 and I-90. In the Best CAV scenario, this number dropped to 19K, with the majority being CAV auto and one fourth being conventional auto. In the Worst CAV scenario, through auto traffic not using I-80 and I-90 increased to 34K, with the majority being CAV auto and about 11% being conventional auto. In the Interim CAV scenario, through auto traffic not using I-80 and I-90 decreased to 23K, mostly contributed by CAV auto. In all three CAV scenarios, ZOV contributed a small fraction of through traffic.

In the baseline scenario, there were 2.5K daily SU truck trips traveling through the region not using I-80 and I-90. In the Best CAV scenario, this number remained almost the same, with 2.0K CAV truck trips and 0.6K conventional truck trips. In the Worst CAV scenario, the through SU truck traffic not using I-80 and I-90 increased to 3.4K, with 2.8K CAV truck trips and 0.6K conventional truck trips. In the Interim CAV scenario, the through traffic volume not using I-80 and I-90 is similar to the baseline scenario, with 1.5K CAV truck trips and 1.1K conventional truck trips.

In the baseline scenario, there were 7.2K daily MU truck trips traveling through the region not using I-80 and I-90. In the Best CAV scenario, this number dropped to 4.5K, with the majority being CAV MU truck trips. In the Worst CAV scenario, the through MU truck traffic not using I-80 and I-90 increased to 9.0K, with the majority being CAV MU truck trips. In the Interim CAV scenario, the through traffic not using I-80 and I-90 slightly decreased to 6.8K, with 3.6K CAV truck trips and 3.3K conventional truck trips.

TABLE 12 OTHER DAILY THROUGH TRAFFIC

		BASELINE	BEST CAV	WORST CAV	INTERIM CAV
Auto	Total	24,051	19,351	34,450	22,617
	ZOV	-	414	711	43
	CAV Auto	-	13,954	30,011	12,608
	Conventional Auto	24,051	4,983	3,728	9,966
SU Trucks	Total	2,539	2,582	3,441	2,607
	CAV Truck	-	1,978	2,822	1,485
	Conventional Truck	2,539	604	620	1,122
MU Trucks	Total	7,234	4,460	9,062	6,824
	CAV Truck	-	4,457	8,716	3,560
	Conventional Truck	7,234	3	346	3,264

Inbound and Outbound Trips

Table 13 shows the sum of inbound (external to internal) and outbound (internal to external) trips by vehicle class. In the baseline scenario, there were 199K daily inbound and outbound trips, all of which are conventional. In the Best CAV scenario, this number dropped slightly to 190K, with the majority being CAV. ZOV contributed about 15% of inbound and outbound trips. In the Worst CAV scenario, inbound and outbound auto traffic increased to 250K, with the majority being CAV auto and 16% being conventional auto. ZOV contributed 4% of inbound and outbound trips. In the Interim CAV scenario, inbound and outbound auto traffic decreased to 184K, equally contributed by CAV and conventional auto. ZOV only contributed a small fraction of inbound and outbound trips.

In the baseline scenario, there were 13K daily inbound and outbound SU truck trips. In the Best CAV scenario, this number increased slightly to 13K, with 10K CAV truck trips and 3K conventional truck trips. In the Worst CAV scenario, the inbound and outbound SU truck traffic increased to 17K, with 14K as CAV truck trips and 3K as conventional truck trips. In the Interim CAV scenario, the inbound and outbound SU truck traffic is similar to baseline, equally contributed by CAV and conventional truck.

In the baseline scenario, there were 30K daily inbound and outbound MU truck trips. In the Best CAV scenario, this number increased 32K, with the majority being CAV MU truck trips. In the Worst CAV scenario, the daily inbound and outbound MU truck traffic increased to 44K, with the majority being CAV MU truck trips. In the Interim CAV scenario, the inbound and outbound MU truck volume is similar to the baseline scenario, equally contributed by CAV and conventional MU trucks.

TABLE 13 INBOUND AND OUTBOUND TRIPS

		BASELINE	BEST CAV	WORST CAV	INTERIM CAV
Auto	Total	199,484	189,636	249,956	183,661
	ZOV	-	27,682	10,483	2,571
	CAV Auto	-	125,716	198,466	90,426
	Conventional Auto	199,484	36,237	41,006	92,442
SU Trucks	Total	12,597	13,054	17,259	12,492
	CAV Truck	-	9,916	14,142	6,246
	Conventional Truck	12,597	3,138	3,117	6,246
MU Trucks	Total	30,215	32,166	43,747	30,397
	CAV Truck	-	31,953	41,239	15,305
	Conventional Truck	30,215	213	2,508	15,093

Internal Traffic

Table 14 shows internal traffic by vehicle class. In the baseline scenario, there were 2.4 million internal auto trips, all of which were conventional auto. In the Best CAV scenario, the internal auto trips increased to 2.67 million, with almost 1.5 million being CAV auto, 450 thousand being conventional auto, and 718 thousand being ZOV trips. In the Worst CAV scenario, the internal auto trips increased to 3.44 million, with almost 2.3 million being CAV auto, 606 thousand being conventional auto, and 540 thousand being ZOV trips. In the Interim CAV scenario, the internal auto trips slightly decreased to 2.39 million, equally contributed by CAV and conventional auto. ZOV only contributed a small fraction of total auto demand.

In the baseline scenario, there were 130K internal SU truck trips, all of which are conventional trucks. In the Best CAV scenario, the demand is almost the same as in the baseline scenario, with 102K being CAV trucks and 32K being conventional trucks. In the Worst CAV scenario, the internal SU truck demand increased to 179K, with 146K being CAV trucks and 33K being conventional trucks. In the Interim CAC scenario, the internal SU truck demand is almost the same as in the baseline scenario, equally contributed by CAV trucks and conventional trucks.

In the baseline scenario, there were 55K internal MU truck trips, all of which were conventional trucks. In the Best CAV scenario, the demand slightly increased, with 37K being CAV trucks and 18K being conventional trucks. In the Worst CAV scenario, the internal MU truck demand increased to 74K, with 63K being CAV trucks and 11K being conventional trucks. In the Interim CAV scenario, the internal MU truck demand is almost the same as in the baseline scenario, equally contributed by CAV trucks and conventional trucks.

TABLE 14 INTERNAL TRIPS

		BASELINE	BEST CAV	WORST CAV	INTERIM CAV
Auto	Total	2,429,191	2,672,022	3,435,800	2,391,997
	ZOV	-	718,572	540,691	41,505
	CAV Auto	-	1,499,407	2,288,240	1,175,284
	Conventional Auto	2,429,191	454,043	606,869	1,175,208
SU Trucks	Total	130,056	135,175	179,049	130,015
	CAV Truck	-	102,603	146,525	65,008
	Conventional Truck	130,056	32,572	32,524	65,008
MU Trucks	Total	54,506	55,077	74,221	53,410
	CAV Truck	-	37,074	62,952	26,204
	Conventional Truck	54,506	18,003	11,268	27,205

3.0 CONCLUSIONS AND RECOMMENDATIONS

In evaluating the three MaaS/CAV scenarios considered in this study, we found that:

- As expected, some CAV effects contribute to increased VMT while other effects contribute to decreased VMT. As we compiled assumptions about these effects to form the scenarios we tested, our Worst CAV scenario proved out with the highest auto and SU truck VMT increases (i.e., it was worse than our Best CAV scenario in terms of congestion measures).
- The scenario rules we used for freeways led to MU truck routing choices which yielded a decrease in through traffic MU truck VMT under all three scenarios.
- CAVs contribute a large fraction of the total auto VMT experienced under both the Worst CAV and the Best CAV scenarios.
- Zero occupancy vehicle (ZOV) trips represent a significant portion of the regional travel for internal trips, but contribute very little to internal-external, external-internal, or through traffic.

Some limitations in the analysis included:

- The assumptions used to develop the scenarios consist of assertions and what-ifs and of course the actual future conditions and constraints may vary; they are intended to create an idea about the range of potential outcomes which is useful for planning purposes.
- The analysis relied on the MDOT statewide model CAV functionality to generate the demand matrix. The CAV parameters used in MDOT model are of course not calibrated due to lack of observed data; actual results may vary.
- Subarea extraction was used to create the VMT and demand matrix for the MACOG region. We used a pivoting approach to investigate VMT and traffic measurements at an aggregate level. However, the MDOT model portion covering the MACOG region has relatively sparse zones and network structure and internal traffic VMT growth might not be reflected to full extent.
- The MACOG region is part of the halo zones in the MDOT model and is viewed as part of the external zones instead of as part of the internal zones in the MDOT MU truck model. Therefore, certain MU truck assumptions are not fully able to be applied.

This work serves as an exploratory study about potential CAV impacts on MACOG regional travel. As decision-support needs evolve for the region, the need to develop functionality into the MACOG regional model to directly explore future CAV impacts and address some of the above limitations may become more important.

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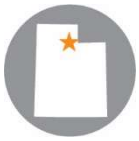
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