Transportation Control Measure Removal Documentation

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Overview

Transportation Control Measures (TCMs) are transportation projects or programs codified into federal law through inclusion in Georgia's State Implementation Plan (SIP). ARC tracks the implementation of these projects through the Conformity Determination Report associated with regional transportation plan updates. A complete list of currently codified TCMs is included as Table 1 of this document. TCMs in the Atlanta SIP cover the gamut of transportation improvements from transit enhancements and commuter incentives to the HOV system and bridges associated with the Atlantic Station redevelopment.

Many TCMs were included in the SIP during the period of the middle 1990s to help advance attainment of the 1-hour ozone nonattainment area. In these cases, the State took off-travel model credit for their implementation in the SIP directly. Later in the 1990s and early 2000s, during the conformity lapse, several TCMs were added to allow for the continued advancement of certain key infrastructure project in a period when all non-exempt projects were frozen. Outside of these periods, no TCMs have been added to the Atlanta nonattainment area's transportation program.

TCMs inserted in the State's SIP do not have a sunset, unless specifically mentioned. Many are outdated, with new technologies or programs being implemented. In some cases, TCMs have affected land use decisions and can prevent the implementation of newer best practices in travel demand management or transit operations. Many TCMs have outlived their useful life and are due to be retired.

ARC staff have reviewed the methodologies and tools used to prepare the original TCM emission reports from the mid to late 1990s and recommend the following methods (Tables 2 and 3) to assess the emission impacts removing each TCM would have on the region's air quality. To advance this project, ARC staff will work with new and updated assumptions, tools and methodologies, where appropriate, to assess the impact the TCMs have on regional emissions.

The TCM calculations will fall in two broad methodological categories: Activity-Based Model (ABM) projects (Table 2) and off-model projects (Table 3). Those projects evaluated through the ABM will be coded and run through in one system-wide run. The resulting travel networks will be carried through full MOVES emission runs, similar to a conformity determination analysis run, to determine the amount of pollution offsets the projects require. The ABM method is preferred and all eligible projects will be evaluated using this methodology.

Projects evaluated using off-model methods cannot be run through the ABM. These projects will rely on updated methodologies based off those used in the 1990s. ARC staff will update inputs and assumptions, as applicable, to bring these techniques into the 21st century. The methodologies will focus on vehicle mile traveled (VMT) calculations to apply set MOVES-based emission factors to determine the amount of pollution offsets the projects require.

Table 1 – Status of Atlanta SIP TCMs

Description	ARC Project #	GDOT PI #	TIP	Status
HOV LANES Sponsor – GDOT I-85N from Chamblee-Tucker Rd to SR 316 (HOT Lanes), I-85 @ SR 316, Interchange Reconstruction	AR 073B	713760	98-00, 99-01	Implemented
	GW-AR 053A GW-AR 053B	110530	01-03 02-04 03-05 05-10	Implemented Implemented
ALTERNATIVE FUEL STATION Sponsor – Douglas County	DO-AR 211	771035	98-00 99-01 00-02 01-03 02-04	TCM removed from SIP on 11/28/2006 (71 FR 68740, November 28, 2006)
ATLANTIC STATION, 17th STREET BRIDGE Sponsor – City of Atlanta A – Bridge and Southbound off ramps C – Northside Dr over Norfolk Southern Railroad to Atlantic Station D – Northbound off ramp to 17th Street Bridge, Williams St Relocation	AT-AR 224A AT-AR 224C AT-AR 224D	714190 0001297 0001298	00-02 01-03 02-04 03-05 05-10	A – Implemented C – Implemented D – Implemented
CLEAN FUEL BUSES Sponsors – MARTA and CCT	M-AR 232	N/A	94-95	Implemented
EXPRESS BUS ROUTES Sponsor – MARTA	M-R 160 M-R 162	770632 770632	94-96	Implemented
IMPROVE / EXPAND BUS SERVICE Sponsor – MARTA	M-R 161	770633	96-98	Implemented
INTERSECTION UPGRADE, COORDINATION & COMPUTERIZATION Sponsor(s) – GDOT in partnership with local Jurisdictions	AT 089	04Y108	93-95	Implemented
	CL 094	770600	94-96	Implemented
	CO 249	770601	94-96	Implemented
	DK 118	770603	94-96	Implemented
	FN 086	770605	94-96	Implemented
	FS 068	770605	94-96	Implemented
	GW 135	170950	94-96	Implemented
	R 098	04418	93-95	Implemented
	R 098	770391	94-96	Implemented
ITS – ADVANCED TRAFFIC MANAGEMENT SYSTEM / INCIDENT MANAGEMENT PROGRAM Sponsor – GDOT I-75/I-85 within I-285, Northern portion of I-285 between I-75 and I-85	R 098	770391	94-96	Implemented
CLEAN FUELS REVOLVING LOAN PROGRAM Sponsor – GEFA	R 195	770790, 770795	96-98	Implemented

Description	ARC Project #	GDOT PI #	TIP	Status
HOV LANES Sponsor – GDOT I-75 and I-85 within I-285	R 174	320H94	94-96	Implemented
PARK & RIDE LOTS Sponsor(s) – Douglas & Rockdale Counties Douglas County – Chapel Hill @ I-20, Rockdale County – Sigman @ I-20	DO 211C		94-96	Implemented
REGIONAL COMMUTE OPTIONS & HOV MARKETING PROGRAMS Sponsor(s) – GDOT	R 159	770631	94-96	Implemented
SIGNAL PREEMPTION Sponsor – MARTA	M-R 164	770636	94-96	Implemented
TRANSIT INCENTIVES PROGRAM Sponsor - MARTA	M-AR 231A M-AR 231B	771031 771119	98-00 99-01 00-02	Implemented
TRANSPORTATION MANAGEMENT ASSOCIATIONS Sponsor – ARC	AR 221A AR 221B AR 221C AR 221E AR 221F	771033 771140 771141 0000570 0000571	98-00 99-01 00-02 01-03	Implemented
UNIVERSITY RIDESHARE PROGRAM Sponsor - ARC	AR 220A AR 220B AR 220C AR 220D AR 200E	771032 771113 0000351 0000567 0000568	98-00 99-01 00-02 01-03 02-04	Implemented

Table 2 – ABM-Based TCM Emission Offset Methodology

TCM Name	TCM Description	Brief Methodology Description
HOV Lanes	I-75 & I-85 ITP HOV lanes	Convert the HOV lanes to GP lanes in the model
HOT Lanes	I-85 HOT lanes	Convert the HOT lanes to GP lanes in the model
Atlantic Station	17th St bridge & ramps 17th St bridge over rail	Remove the bridges, ramps and transit
Express Bus Routes	#5, #6, #36, #125, XPPRESS #428 & #426	Remove the transit routes from the model
Improve/Expand Bus Service	#15, #114, #111	Remove the transit routes from the model
Park & Ride Lots	West Douglas P&R Sigman Rd @I-20	Remove the transit stops & associated routes from the model
Transit Signal Preemption	MARTA Routes #15 and #39	Remove the benefit of TSP from the model

Table 3 – Off-Model-Based TCM Emission Offset Methodologies

TCM Name	TCM Description	Brief Methodology Description
Clean Fuel Buses	200 CNG buses for MARTA & CCT	Prepare emission comparison for 200 CNG & diesel buses
Clean Fuels Revolving Loan Program	1,800 vehicle revolving clean fuel program	The emissions benefits of this TCM have phased out as Tier II and Tier III emissions standards and fuels have replaced Tier I and clean fuel fleet (CFFV) standards
Intersection Upgrade, Coordination & Computerization	Upgrades to 1,708 signals in Clayton, Cobb, DeKalb, Fulton and Gwinnett counties	Copy method used in 1990s with updates to planning assumptions
ATMS/Incident Management	I-75 & I-85 ITP & I-285 northern perimeter	Copy method used in 1990s with updates to planning assumptions
Regional Commute Options & HOV Marketing	Marketing and incentives to carpool & use transit	Copy method used in 1990s with updates to planning assumptions
Transit Incentives	Transit subsidies to employees in TMAs	Copy method used in 1990s with updates to planning assumptions
Transportation Management Associations (TMAs)	Formation and programs run by TMAs to encourage mode split	Copy method used in 1990s with updates to planning assumptions
University Rideshare Program	Carpooling and transit incentives program for university students/staff	Copy method used in 1990s with updates to planning assumptions

Clean Fuel Buses

This project reduced regional emissions by encouraging transit operators to convert from diesel to compressed natural gas (CNG) buses. CNG buses produce less emissions per mile than diesel buses.

Assumptions

- In total, the TCM allocated funds to convert 200 buses by the year 2010
- Average transit bus vehicle miles traveled per year = 57,000[1] (156.2 miles/day)

Calculations

Use emission rates by vehicle fuel type (ER_{CNG} and ER_{Diesel}) to determine the total emissions benefit of CNG buses for each model year. Emission rates are determined by using the speed and network model year for arterial roadways. Convert grams per year into short tons per day.[2]

(Eq. 1) $$E_{Bus} = Number\ of\ Buses * VMT * (ER_{Diesel} - ER_{CNG})$$

Table 4 – ABM Arterial Congested Speeds, VMT and Emission Rates by Model Year and Pollutant

Model Year	Arterial Congested Speed	VMT/day	NO_x		VOC	
			ER_{CNG}	ER_{Diesel}	ER_{CNG}	ER_{Diesel}
2020	30.8	156.2	1.96	2.88	0.356	0.313
2030	29.8	156.2	1.18	0.96	0.219	0.085
2040	28.8	156.2	1.16	0.92	0.217	0.081

Table 5 – E_{Bus} by Model Year and Pollutant

Model Year	E_{Bus} NO_x (tons/day)	E_{Bus} VOC (tons/day)
2020	0.032	-0.001
2030	-0.008	-0.005
2040	-0.008	-0.005

[1] MARTA, 2017

[2] Grams to short tons conversion factor = 907,184.74 g/ton

Improved Signalization

This project reduced intersection delay by upgrading technology and coordinating signals to smooth and increase speeds on major arterials in Clayton, Cobb, DeKalb, Fulton and Gwinnett counties. Reducing delay and smoothing speeds resulted in an emissions reduction along project corridors. TCM emissions were determined by calculating the change in emissions due to increased speed along upgraded arterials.

Assumptions

- 1,708 intersections were upgraded
- Improved signal timing and computerization resulted in a 10% increase in speed along deployed arterials
- Five intersections per mile were upgraded resulting in 341.6 miles of upgrades (1,708 signals/5 signals per mile)
- 40% of regional arterial traffic occurs during peak period and 60% occurs during non-peak periods

Calculations

Step 1 – Determine the Average Daily Traffic (ADT) on impacted arterials using GDOT's 445 Series VMT Reports for the year 2014 for urbanized principal arterials only. Where ADT = VMT/Mileage.

Table 6 – ADT Determination from GDOT 445 Series VMT Reports

Variable	Clayton	Cobb	DeKalb	Fulton	Gwinnett
VMT	1,209,229	2,994,543	1,786,179	3,913,532	3,985,808
Mileage	41	96	66	139	106
ADT	29,493	31,193	27,063	28,155	37,602

Step 2 – Determine the mileage weighted average ADT for the five-county area.

(Eq. 2) $$ADT_{avg} = \frac{\sum(ADT_{county} * Mileage_{county})}{\sum Mileage_{county}} \simeq 31{,}003$$

Step 3 – Convert the ADT_{avg} into total daily 2014 VMT on impacted roadways by multiplying by the ratio of signals to signals per mile.

(Eq. 3) $$VMT_{impacted} = ADT_{avg} * \frac{1{,}708\ signals\ upgraded}{5\ signals\ per\ mile} \simeq 10{,}590{,}584$$

Step 4 – Determine future impacted VMT for all model years by multiplying 2014 $VMT_{impacted}$ by the ratio of VMT growth in ARC's ABM. Then split the calculated $VMT_{impacted}$ by model year into peak and off-peak values using the assumption that 40% of arterial travel is during the peak period and 60% is during off-peak.

Table 7 – Impacted VMT Calculations for Five-County Area Regional Arterials by Time of Day Period

Model Year	ARC ABM-Based Data			Peak & Off-Peak Split	
	ARC's ABM Total Daily VMT	Percent Change in VMT from 2014	Calculated $VMT_{impacted}$	Peak Period $VMT_{impacted}$	Off-Peak $VMT_{impacted}$
2014 Index	155,393,575	-	10,590,584	4,236,234	6,354,351
2020	171,474,140	10.3%	11,686,528	4,674,611	7,011,917
2030	194,692,241	25.3%	13,268,918	5,307,567	7,961,351
2040	213,926,671	37.7%	14,579,808	5,831,923	8,747,885

Step 5 – Determine the change in speeds due to the implementation of the improved signalization using a 10% improvement assumption. Existing speeds (with improvements) are for principal arterials in the 5-county portion of the ARC ABM domain.

(Eq. 4) $$Speed_{noTCM} = \frac{Speed_{TCM}}{(1+\frac{1}{10})}$$

Table 8 – Arterial Speeds by Model Year with and without TCM Improvements

Model Year	Peak Period Arterial Speeds with Improvements (mph)	Calculated Peak Period Arterial Speeds without Improvements (mph)	Off-Peak Arterial Speeds with Improvements (mph)	Calculated Off-Peak Arterial Speeds without Improvements (mph)
2020	29.8	27.1	31.8	28.9
2030	28.6	26.0	31.0	28.2
2040	27.4	24.9	30.2	27.4

Step 6 – Use speed-based emission rates to determine the total emissions benefit of the Improved Signalization TCM for each model year and pollutant. Convert grams per year into short tons per day.[3]

(Eq. 5) $$E_{Signal} = \left[\left(ER_{pk}^{noTCM} * VMT_{pk}\right) + \left(ER_{offpk}^{noTCM} * VMT_{offpk}\right)\right] - \left[\left(ER_{pk}^{TCM} * VMT_{pk}\right) + \left(ER_{offpk}^{TCM} * VMT_{offpk}\right)\right]$$

Table 9 – Emission Rates by Model Year, Pollutant, TCM Status and Travel Time Period

[3] Grams to short tons conversion factor = 907,184.74 g/ton

Model Year	NO_x				VOC			
	ER_{pk}^{noTCM}	ER_{offpk}^{noTCM}	ER_{pk}^{TCM}	ER_{offpk}^{TCM}	ER_{pk}^{noTCM}	ER_{offpk}^{noTCM}	ER_{pk}^{TCM}	ER_{offpk}^{TCM}
2020	0.414	0.402	0.396	0.387	0.347	0.336	0.331	0.322
2030	0.142	0.139	0.138	0.135	0.184	0.178	0.177	0.171
2040	0.060	0.059	0.059	0.059	0.139	0.133	0.133	0.128

Table 10 – E_{signal} by Model Year and Pollutant

Model Year	E_{Signal} NO_x (tons/day)	E_{Signal} VOC (tons/day)
2020	0.209	0.191
2030	0.062	0.108
2040	0.010	0.090

ATMS/Incident Management Program

This project implemented a program to reduce incident duration on select high-volume freeways in metropolitan Atlanta by establishing technology and procedures to more quickly respond to incidents. Specifically, this TCM implemented video cameras and Advanced Traffic Management System (ATMS) strategies on I-75 and I-85 within I-285 and along the top-end of I-285 between I-75 and I-85.

Assumptions

- 50% of congestion is caused by incidents
- There is a 50% projected reduction in incident duration after the deployment of ATMS strategies

Calculations

Step 1 – Determine the percent reduction in incident delay. Where x = % reduction in incident duration.

(Eq. 6) $$Delay\ Reduced = 1 - (1 - x)^2 = 1 - (1 - 0.50)^2 = 75\%$$

Step 2 – Determine the change in average travel speeds due to the delay reduction associated with the implementation of ATMS and Incident Management strategies.

(Eq. 7) $$Speed\ Increased = \frac{\frac{1}{\left[\left(1-\frac{Y}{2}\right)*\left(\frac{1}{S}\right)+\left(\frac{Y}{2F}\right)\right]-S}}{S} = 10\%$$

Where: Y = Percent reduction in incident congestion
S = Average travel speed before incident management
F = Free flow Speed

Step 3 – Calculate the average freeway speeds after deployment of the TCM by reducing daily congested freeway speeds from the ABM by 10%. This is done using Equation 4 from the previous section. Existing speeds are for freeways determined by the ABM and weighted across time-periods.

Table 11 – ABM Freeway Speeds with and without ATMS/Incident Management by Model Year

Model Year	Daily Congested Freeway Speeds with ATMS/Incident Management	Daily Congested Freeway Speeds without ATMS/Incident Management
2020	48.7	44.3
2030	47.2	42.9
2040	45.5	41.3

Step 4 – Use speed-based emission rates to determine the total emissions benefit of the ATMS/Incident Management TCM for each model year. VMTs are taken from the ABM for facilities associated with the initial TCM (I-75 and I-85 within I-285 and along the top-end of I-285 between I-75 and I-85). Convert grams per day into short tons per day.[4]

(Eq. 8) $$E_{ATMS} = VMT * (ER_{noTCM} - ER_{TCM})$$

Table 12 – Emission Rates and VMT by Model Year, TCM Status and Pollutant

Model Year	NO_x		VOC		VMT
	ER_{noTCM}	ER_{TCM}	ER_{noTCM}	ER_{TCM}	
2020	0.356	0.364	0.285	0.276	9,980,538
2030	0.132	0.134	0.152	0.149	10,209,203
2040	0.060	0.061	0.114	0.111	10,640,439

Table 13 – E_{ATMS} by Model Year and Pollutant

Model Year	E_{ATMS} NO_x (tons/day)	E_{ATMS} VOC (tons/day)
2020	-0.088	0.099
2030	-0.019	0.041
2040	-0.018	0.035

[4] Grams to short tons conversion factor = 907,184.74 g/ton

Regional Commute Options & HOV Marketing

This project focused on lowering VMT and reducing single-occupancy vehicle trips by implementing a regional commute options program. The program encouraged carpooling, vanpooling and transit usage by marketing the benefits of these options. The program was broken into a rideshare program, an employer commute options program in major employment centers and employer transit incentives.

Assumptions

- 95% of peak period commuters received information about commute options resulting in a 5% increase in non-single-occupancy vehicle usage
- Ridesharing incentives offered to 80% of employees in major activity centers led to a 15% increase in non-single occupancy vehicle use
- Employer transit incentives (20% subsidy) offered to 80% of employees to obtain a 15% increase in non-single-occupancy vehicle usage
- Percent of new carpoolers that still make a trip after incentives are offered is 25%
- Two-thirds of commuting VMT occurs on freeways
- VMT calculations for each component of the Regional Commute Options and HOV Marketing TCM are handled separately and combined in the end

Calculations

Step 1 – Determine the reduction in VMT from the Rideshare Program.

Step 1a) Calculate the reduction in person trips using ABM data to determine key variables.

(Eq. 9) $$PT_{reduced} = (1 - T_{alone}) * (P_{notalone}) * (PT_{com}) * (P_{Aff}) * (P_{PK})$$

Where: $PT_{reduced}$ = Reduction in person trips
T_{alone} = Drive alone share of commute trips from ABM
$P_{notalone}$ = Percent increase in non-drive-alone modes
PT_{com} = Total commuter person trips from ABM
P_{Aff} = Percent of employees affected
P_{PK} = Percent of commute trips in the peak period from ABM

Table 14 – Variables and Reduction in Person Trips Calculations by Model Year

Model Year	T_{alone}	$P_{notalone}$	PT_{com}	P_{Aff}	P_{PK}	$PT_{reduced}$
2020	74.9%	5%	4,450,206	95%	74.7%	39,634
2030	72.1%	5%	4,965,150	95%	74.4%	48,956
2040	67.7%	5%	5,416,072	95%	74.1%	61,574

Step 1b) Calculate the reduction in total trips resulting from the change in person trips.

(Eq. 10) $$T_{red} = \left(1 - P_{newcarpool}\right) * \left(PT_{reduced}\right) - \frac{PT_{reduced}}{CPool}$$

Where: T_{red} = Reduction in trips
$P_{newcarpool}$ = Percent of new carpool riders
$PT_{reduced}$ = Reduction in person trips from Step 1a
CPool = Average size of a carpool from ABM

Table 15 – Variables and Reduction in Total Trips Calculations by Model Year

Model Year	$P_{newcarpool}$	$PT_{reduced}$	CPool	T_{red}
2020	25%	39,634	2.74	15,261
2030	25%	48,956	2.73	18,784
2040	25%	61,574	2.72	23,543

Step 1c) Calculate the resulting reduction in VMT due to the implementation of the rideshare program.

(Eq. 11) $$VMT_{red\_rideshare} = \left(T_{red}\right) * \left(D_{commute}\right) * \left(P_{maxVMT}\right)$$

Where: $VMT_{red\_rideshare}$ = Reduction in VMT
T_{red} = Reduction in trips from Step 1b
$D_{commute}$ = Average commute length from ABM
P_{maxVMT} = Percent of max VMT reduction realized due to access to ridesharing/transit

Table 16 – Variables and Reduction in VMT Calculations by Model Year

Model Year	T_{red}	$D_{commute}$	P_{maxVMT}	$VMT_{red\_rideshare}$
2020	15,261	12.97	95%	188,033
2030	18,784	12.97	95%	231,450
2040	23,543	12.97	95%	290,086

Step 2 – Determine the reduction in VMT from the Employer Commute Program in the Downtown, Midtown, Perimeter, Buckhead and Cumberland TMAs.

Step 2a) Calculate the reduction in person trips using ABM data for key variables.

(Eq. 12) $$PT_{reduced} = (1 - T_{alone}) * (P_{notalone}) * (PT_{com}) * (P_{Aff}) * (P_{PK})$$

Where: $PT_{reduced}$ = Reduction in person trips
T_{alone} = Drive alone share of commute trips from ABM
$P_{notalone}$ = Percent increase in non-drive-alone modes
PT_{com} = Total commuter person trips from ABM
P_{Aff} = Percent of employees affected from ABM
P_{PK} = Percent of commute trips in the peak period

Table 17 – Variables and Reduction in Person Trips Calculations by Model Year

Model Year	T_{alone}	$P_{notalone}$	PT_{com}	P_{Aff}	P_{PK}	$PT_{reduced}$
2020	62.1%	15%	993,522	80%	74.7%	33,753
2030	56.1%	15%	1,071,572	80%	74.4%	41,999
2040	46.7%	15%	1,160,354	80%	74.1%	54,994

Step 2b) Calculate the reduction in total trips resulting from the change in person trips.

(Eq. 13) $$T_{red} = \left(1 - P_{newcarpool}\right) * (PT_{reduced}) - \frac{PT_{reduced}}{CPool}$$

Where: T_{red} = Reduction in trips
$P_{newcarpool}$ = Percent of new carpool riders
$PT_{reduced}$ = Reduction in person trips from Step 2a
CPool = Average size of a carpool from ABM

Table 18 – Variables and Reduction in Total Trips Calculations by Model Year

Model Year	$P_{newcarpool}$	$PT_{reduced}$	CPool	T_{red}
2020	25%	33,753	2.74	12,996
2030	25%	41,999	2.73	16,115
2040	25%	54,994	2.72	21,027

Step 2c) Calculate the resulting reduction in VMT due to the implementation of the rideshare program.

(Eq. 14) $$VMT_{red\_commuteoptions} = (T_{red}) * (D_{commute}) * (P_{maxVMT})$$

Where: $VMT_{red\_commuteoptions}$ = Reduction in VMT
T_{red} = Reduction in trips from Step 2b

$D_{commute}$ = Average commute length from ABM
P_{maxVMT} = Percent of max VMT reduction realized due to access to ridesharing/transit

Table 19 - Variables and Reduction in VMT Calculations by Model Year

Model Year	T_{red}	$D_{commute}$	P_{maxVMT}	$VMT_{red\_commuteoptions}$
2020	12,996	12.97	95%	160,134
2030	16,115	12.97	95%	198,561
2040	21,027	12.97	95%	259,087

Step 3 – Determine the reduction in VMT from the Employer Transit Incentives in the Downtown, Midtown, Perimeter, Buckhead and Cumberland TMAs.

Step 3a) Calculate the reduction in the total trips using ABM data for key variables.

(Eq. 15) $$T_{red} = (PT_{com}) * (P_{PK}) * (P_{transit}) * (E) * (P_{subsidy}) * (P_{Aff}) * (P_{TR\_Red})$$

Where: T_{red} = Reduction in trips
PT_{com} = Total commuter person trips from ABM
P_{PK} = Percent of commute trips in peak period from ABM
$P_{transit}$ = Public transit share of commute trips from ABM
E = Price elasticity for transit
$P_{subsidy}$ = Percent of subsidy of cost of monthly transit pass
P_{Aff} = Percent of employees affected
P_{TR_Red} = Percent of transit ridership equal to the trip reduction

Table 20 – Variables and Reduction in Total Trips Calculations by Model Year

Model Year	PT_{com}	P_{PK}	$P_{transit}$	E	$P_{subsidy}$	P_{Aff}	P_{TR_Red}	T_{red}
2020	993,522	74.7%	16.8%	0.23	20%	80%	85%	3,776
2030	1,071,572	74.4%	16.6%	0.23	20%	80%	85%	4,073
2040	1,160,354	74.1%	17.5%	0.23	20%	80%	85%	4,410

Step 3b) Calculate the resulting reduction in VMT due to the implementation of transit incentives for each model year.

(Eq. 16) $$VMT_{red\_transit} = (T_{red}) * (D_{commute})$$

Where: $VMT_{red\_transit}$ = Reduction in VMT
T_{red} = Reduction in trips from Step 3a
$D_{commute}$ = Average commute length from ABM

Table 21 - Variables and Reduction in VMT Calculations by Model Year

Model Year	T_{red}	$D_{commute}$	$VMT_{red\_transit}$
2020	3,776	12.97	48,973
2030	4,073	12.97	52,821
2040	4,410	12.97	57,197

Step 4 – Use emission rates to determine the total emissions benefit of the regional commute options program TCM for each model year. Emission rates are determined by using the speed and roadway type. Convert grams per day into short tons per day.[5]

(Eq. 17)
$$E_{ComOpt} = \left(VMT_{red\_rideshare} + VMT_{red\_commuteoptions} + VMT_{transit}\right) * \left(\frac{2}{3}ER_{Freeway} + \frac{1}{3}ER_{Arterial}\right)$$

Table 22 – ABM Freeway & Arterial Congested Speeds by Model Year

Model Year	Freeway Congested Speed	Arterial Congested Speed
2020	48.7	29.8
2030	47.2	28.6
2040	45.5	27.4

Table 23 – Emission Rates and VMT by Model Year, Roadway Classification and Pollutant

Model Year	NO_x		VOC		ΣVMT[6]
	$ER_{Freeway}$	$ER_{Arterial}$	$ER_{Freeway}$	$ER_{Arterial}$	
2020	0.283	0.289	0.240	0.281	397,140
2030	0.093	0.092	0.118	0.137	482,833
2040	0.026	0.023	0.082	0.095	606,370

Table 24 – E_{ComOpt} by Model Year and Pollutant

Model Year	E_{ComOpt} NO_x (tons/day)	E_{ComOpt} VOC (tons/day)

[5] Grams to short tons conversion factor = 907,184.74 g/ton

[6] $\Sigma VMT = VMT_{red\_rideshare} + VMT_{red\_commuteoptions} + VMT_{transit}$

2020	0.125	0.111
2030	0.049	0.066
2040	0.017	0.058

MARTA Transit Incentives

This TCM covered an employer-based program through which employees were offered reduced-cost transit passes to encourage alternatives to driving alone. By incentivizing a switch to transit, this TCM aimed to reduce emissions by lowering VMT.

Assumptions

- 11,448 subsidized transit cards sold per month[7]
- 80% usage (10% non-use and 10% current riders at new companies)
- 100% of resulting trips are for commuting
- Two-thirds of commuting VMT occurs on freeways and one-third on arterials
- 1.26 average vehicle occupancy
- Average work trip length is 12.97 miles

Calculations

Step 1 – Calculate the number of new riders with incentivized transit cards.

(Eq. 18) $$New\ Riders\ with\ Cards = Transit\ Cards\ Sold * Use = (11{,}448) * (.80) = 9{,}158$$

Step 2 – Calculate the number of work trips offset.

(Eq. 19) $$Work\ Trips\ Offset = New\ Riders\ with\ Cards * Number\ of\ Trips\ in\ Commute = (9{,}158) * (2) = 18{,}317$$

Step 3 – Considering the vehicle occupancy rate, determine the number of trips reduced per day.

(Eq. 20) $$Trips\ Reduced\ per\ Day = \frac{Work\ Trips\ Offset}{Vehicle\ Occupancy\ Rate} = \frac{18{,}317}{1.26} = 14{,}537$$

Step 4 – Determine the VMT reduced per day.

(Eq. 21) $$VMT\ Reduced\ per\ Day = (Trips\ Reduced\ per\ Day) * (Average\ Trip\ Length) = (14{,}537) * (12.97) = 188{,}547$$

Step 5 – Use emission rates to determine the total emissions benefit of the MARTA transit incentives program for each model year and pollutant. Emission rates are determined by using the speed and roadway classification. Convert grams per day into short tons per day.[8]

(Eq. 22) $$E_{Transit} = (VMT\ Reduced\ per\ Day) * (\frac{2}{3} ER_{Freeway} + \frac{1}{3} ER_{Arterial})$$

[7] ARC, 2016

[8] Grams to short tons conversion factor = 907,184.74 g/ton

Table 25 – ABM Freeway & Arterial Congested Speeds by Model Year

Model Year	Freeway Congested Speed	Arterial Congested Speed
2020	48.7	29.8
2030	47.2	28.6
2040	45.5	27.4

Table 26 – Emission Rates and VMT by Model Year, Roadway Classification and Pollutant

Model Year	NO_x		VOC		VMT
	$ER_{Freeway}$	$ER_{Arterial}$	$ER_{Freeway}$	$ER_{Arterial}$	
2020	0.283	0.289	0.240	0.281	188,547
2030	0.093	0.092	0.118	0.137	188,547
2040	0.026	0.023	0.082	0.095	188,547

Table 27 – $E_{Transit}$ by Model Year and Pollutant

Model Year	$E_{Transit}$ NO_x (tons/day)	$E_{Transit}$ VOC (tons/day)
2020	0.059	0.053
2030	0.019	0.026
2040	0.005	0.018

Transportation Management Associations (TMAs)

TMAs in major activity centers encourage alternative commute modes and maximize the use of existing infrastructure in heavily congested areas through a variety of traffic demand management (TDM) strategies. This TCM seeded the creation of five TMAs and their commute alternative programs at Clifton Corridor, Perimeter Center, Buckhead, Midtown and Aerotropolis.

Assumptions

- 1.26 average vehicle occupancy
- TMAs will result in a 2% shift from single-occupancy vehicles
- Average round-trip work distance is 25.94 miles
- Average round-trip non-work trip distance is 12.98 miles
- 50% of TMA trips are off-peak (non-work) and 50% are during peak (work)
- The percent of single-occupancy home to work trips for TMAs is 73.9%

Calculations

Step 1 – Calculate the decrease in auto trips due to the TDM strategies implemented by the TMAs.

(Eq. 23) $$Reduction\ in\ Auto\ Round\ Trips = Employees * Percent\ SOV * TMA\ shift\ in\ SOV\ use = (370{,}264) * (0.739) * (0.02) = 5{,}473$$

Step 2 – Calculate the reduction in VMT from the trips reduced where $D_{roundtrip}^{work}$ is the round-trip distance to work and $D_{roundtrip}^{nonwork}$ is the round-trip non-work distance.

(Eq. 24) $$VMT\ Reduced\ per\ Day = Reduction\ in\ Auto\ Round\ Trips * \left(\frac{1}{2}D_{roundtrip}^{work} + \frac{1}{2}D_{roundtrip}^{nonwork}\right) = 5{,}473 * \frac{1}{2} * (25.94 + 12.98) = 106{,}495$$

Step 3 - Use emission rates to determine the total emissions benefit of the TMA strategies for each model year. Emission rates are determined by using the speed with 50% of travel off-peak and 50% during peak periods for arterials. Convert grams per day into short tons per day.[9]

(Eq. 25) $$E_{TMA} = (VMT\ Reduced\ per\ Day) * (\frac{1}{2}ER_{Peak} + \frac{1}{2}ER_{Offpeak})$$

Table 28 – ABM Arterial Peak and Off-Peak Congested Speeds by Model Year

Model Year	Arterial Peak Congested Speed	Arterial Off-Peak Congested Speed
2020	29.8	31.8
2030	28.6	31.0
2040	27.4	30.2

Table 29 – Emission Rates and VMT by Model Year, Time Period of Travel and Pollutant

[9] Grams to short tons conversion factor = 907,184.74 g/ton

Model Year	NO_x		VOC		VMT
	ER_{Peak}	$ER_{OffPeak}$	ER_{Peak}	$ER_{OffPeak}$	
2020	0.289	0.285	0.281	0.274	106,495
2030	0.092	0.090	0.137	0.133	106,495
2040	0.023	0.023	0.095	0.092	106,495

Table 30 – E_{TMA} by Model Year and Pollutant

Model Year	E_{TMA} NO_x (tons/day)	E_{TMA} VOC (tons/day)
2020	0.034	0.033
2030	0.011	0.016
2040	0.003	0.011

University Rideshare Program

This TCM provided a lump sum to all colleges and universities within the 10 county ARC area with the intent of providing startup funds for a student and staff based rideshare program. These programs encouraged car and vanpooling reducing the number of cars on the road and lowering VMT. The program was designed to work closely with ARC's rideshare program.

Assumptions

- 40,000 students and staff can participate in this program
- 2% usership from the 90% that currently don't carpool or use transit
- University student trip length to school = 13.37 miles[10] (50% of trips)
- Staff trip length to work = 12.97 (50% of trips)

Calculations

Step 1 – Calculate the number of trips reduced per day.

(Eq. 26) $$Reduction\ in\ Auto\ Round\ Trips = Participants * Percent\ SOV * Rideshare\ shift\ in\ SOV\ use = (40{,}000) * (0.90) * (0.02) = 720$$

Step 2 – Calculate the reduction in VMT from the trips reduced where $D_{roundtrip}^{student}$ is the round-trip student distance to university and $D_{roundtrip}^{staff}$ is the round-trip staff distance to work.

(Eq. 27) $$VMT\ Reduced\ per\ Day = Reduction\ in\ Auto\ Round\ Trips * \left(\frac{1}{2}D_{roundtrip}^{Student} + \frac{1}{2}D_{roundtrip}^{Staff}\right) = 720 * \frac{1}{2} * (26.74 + 25.94) = 18{,}965$$

Step 3 - Use emission rates to determine the total emissions benefit of the university rideshare program for each model year. Emission rates are determined by using the speed with 50% of travel off-peak and 50% during peak periods for arterials. Convert grams per day into short tons per day.[11]

(Eq. 28) $$E_{Univ} = (VMT\ Reduced\ per\ Day) * \left(\frac{1}{2}ER_{Peak} + \frac{1}{2}ER_{Offpeak}\right)$$

Table 31 – ABM Arterial Peak and Off-Peak Congested Speeds by Model Year

Model Year	Arterial Peak Congested Speed	Arterial Off-Peak Congested Speed
2020	29.8	31.75
2030	28.6	30.98
2040	27.4	30.15

Table 32 – Emission Rates and VMT by Model Year, Time Period of Travel and Pollutant

[10] This distance is substantially longer than that determined in the 1990s due to the ABMs ability to separate university students from primary school students who often have very short trips to school.
[11] Grams to short tons conversion factor = 907,184.74 g/ton

Model Year	NO_x		VOC		VMT
	ER_{Peak}	$ER_{OffPeak}$	ER_{Peak}	$ER_{OffPeak}$	
2020	0.289	0.285	0.281	0.274	18,965
2030	0.092	0.090	0.137	0.133	18,965
2040	0.023	0.023	0.095	0.092	18,965

Table 33 – E_{Univ} by Model Year and Pollutant

Model Year	E_{Univ} NO_x (tons/day)	E_{Univ} VOC (tons/day)
2020	0.0060	0.0058
2030	0.0019	0.0028
2040	0.0005	0.0020

Activity-Based Travel Model TCMs

Table 34 lists the TCM projects with emission benefits that were estimated through the regional activity-based travel demand model (ABM). This model uses the latest planning and travel assumptions to estimate trips by travel mode and vehicle speed. The output data is post-processed through ARC's existing modeling scripts and run through EPA's MOVES emissions model to assess emissions. This process is identical to ARC's transportation conformity process. Results between model runs without the TCMs and model runs created in the past with TCMs intact are directly comparable.

For this project, ARC relied on existing 2020, 2030 and 2040 travel networks with the TCM's present to compare against a series of newly coded networks that have the TCMs removed. The final emissions output by year and pollutant is called E_{ABM} and is added to the off-model values to produce the final emission benefit of the existing TCMs.

In several instances, bus routes that are part of TCMs were replaced by heavy-rail links as the MARTA system expanded in the late 1990s and early 2000s. In these situations, ARC did not remove heavy rail service to compensate due to deleterious effects that action would have on the total transit system, drastically overestimating the impacts of those TCMs. These TCMs were effectively absorbed into the heavy rail system permanently.

Table 34 – List of TCMs Incorporated into ARC's ABM Runs

TCM Name	TCM Description	Brief Methodology Description
HOV Lanes	I-75 & I-85 ITP HOV lanes	Convert the HOV lanes to GP lanes in the model
HOT Lanes	I-85 HOT lanes	Convert the HOT lanes to GP lanes in the model
Atlantic Station	17th St bridge & ramps 17th St bridge over rail	Remove the bridges, ramps and transit
Express Bus Routes[12]	#5, #6, #36, #125, XPPRESS #428 & #426	Remove the transit routes from the model
Improve/Expand Bus Service[12]	#15, #114, #111	Remove the transit routes from the model
Park & Ride Lots	West Douglas P&R Sigman Rd @I-20	Remove the transit stops & associated routes from the model
Transit Signal Preemption	MARTA Routes #15 and #39	Remove the benefit of TSP from the model

Table 35 – E_{ABM} by Model Year and Pollutant

[12] Due to the changing nature of transit serves since the 1990s, especially as new rail service was added, two bus routes were not present in the ABM to remove for this comparison. A bus route that connected H.E. Holmes Station to Perimeter Center and one that connected Flat Shoals Road to Kensington Station were both replaced by MARTA rail service and alternative routes. Through Interagency consultation it was determined that these routes were replaced and removing their equivalent was not necessary for this exercise.

Model Year	E_{ABM} NO_x (tons/day)	E_{ABM} VOC (tons/day)
2020	-0.055	0.003
2030	-0.027	0.008
2040	-0.010	0.003

Clean Fuels Revolving Loan Program

ARC to EPA: Are you ok with the assumption that the clean fuels revolving loan program TCM is producing no emissions benefit today since the implementation of Tier 2 and Tier 3 fuels and would be ok to resolve with zero offsets?

EPA Reply: Yes, that assumption is fine. However, EPD needs to include some language on the implementation of Tier 3 in addition to using the same rationale used to remove the GA Clean Fuels Fleet Program from the SIP.

Total TCM Emissions

Step 1 – To determine the total emissions of the off-travel model TCMs sum the emission benefits of each individual TCM. $E_{off\text{-}model}$ should be evaluated for each model year and pollutant.

(Eq. 29) $$E_{off-model} = E_{Bus} + E_{signal} + E_{ATMS} + E_{ComOpt} + E_{Transit} + E_{TMA} + E_{Univ.}$$

Table 36 – Off-Model NO_x Emissions by Model Year in Tons per Day

Model Year	E_{Bus}	E_{Signal}	E_{ATMS}	E_{ComOpt}	$E_{Transit}$	E_{TMA}	E_{Univ}	$E_{Off\text{-}model}$
2020	0.0317	0.21	-0.088	0.125	0.059	0.034	0.0060	0.38
2030	-0.0076	0.06	-0.019	0.049	0.019	0.011	0.0019	0.11
2040	-0.0083	0.01	-0.018	0.017	0.005	0.003	0.0005	0.01

Table 37 – Off-Model VOC Emissions by Model Year in Tons per Day

Model Year	E_{Bus}	E_{Signal}	E_{ATMS}	E_{ComOpt}	$E_{Transit}$	E_{TMA}	E_{Univ}	$E_{Off\text{-}model}$
2020	-0.0015	0.19	0.099	0.111	0.053	0.033	0.006	0.49
2030	-0.0046	0.11	0.041	0.066	0.026	0.016	0.003	0.26
2040	-0.0047	0.09	0.035	0.058	0.018	0.011	0.002	0.21

Step 2 – The value of $E_{off\text{-}model}$ should be combined with the number calculated from the TCMs evaluated through ARC's ABM to determine a final value for the total amount of emissions to be offset as part of the TCM removal process.

(Eq. 30) $$E_{total} = E_{off-model} + E_{ABM}$$

Table 38 – Emissions by Model Year and Pollutant in Tons per Day

Model Year	NO_x (tons/day)			VOC (tons/day)		
	$E_{Off\text{-}model}$	E_{ABM}	E_{total}	$E_{Off\text{-}model}$	E_{ABM}	E_{total}
2020	0.378	-0.055	0.32	0.491	0.004	0.49
2030	0.114	-0.027	0.09	0.257	0.008	0.27
2040	0.009	-0.010	0.00	0.209	0.003	0.21

Total TCM Emissions – Supplemental

There is a slight decrease in bus VMT from the removal of transit based TCMs in the ABM. This is the result of the removal of buses, bus routes, park and ride lots, and associated transit services. The removal of these ABM TCMs reduces the number of miles covered by transit. While overall VMTs might slightly increase from the removal of these TCMs, bus VMTs decrease slightly in the region.

The slight decrease in overall VMT due to the removal of TCMs from the ABM is due to the impact of removing the Atlantic Station TCM. Traditional TCMs such as HOV lanes, assume a decrease in VMT when added to a SIP and an increase in VMT if removed from a SIP. However, the Atlantic Station TCM is a non-traditional TCM that did not strictly analyze VMT before and after the project.

Instead, the Atlantic Station TCM was evaluated as a smart-growth project. This evaluation considered VMT with the project tied to TCM requirements (such as connection to transit, limited VMT per resident, and other TCM requirements) compared to a traditional project without TCM requirements. The evaluation also considered if the project was developed elsewhere in the region with typical VMT and mobile split behavior with typical growth.

Because the Atlantic Station TCM and its associated 17th Street bridge, ramps, and transit add activity (vehicle VMT, vehicle populations, starts, etc.) to the area, there is an overall reduction in VMT when the project is removed. When the Atlantic Station TCM is removed, the model does not create a different, new development in its place, it just adjusts the speeds and miles traveled through the network as a result of the addition or removal of a project. This is similar to what is done with conformity determinations.

In addition, this TCM has become an attraction for people all around the city who might forego an activity at home and travel quite a distance to Midtown Atlanta to enjoy the amenities Atlantic Station has to offer. Because of these factors, the sum of all these impacts results in an overall slight VMT decrease in the 13-county region from the TCM removals from the ABM.