Using Municipal Vehicles as Sensor Platforms to Monitor the Health and Performance of the Traffic Control System

PIs: Mark McCord, Rabi Mishalani,
Benjamin Coifman
The Ohio State University

Project Overview
via Teleconference

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Objective

Develop, demonstrate, and promote approach for obtaining traffic flow estimates across extensive urban roadway networks from video data collected from transit buses

Motivation

Traditional traffic studies obtain data over long time periods but at limited locations

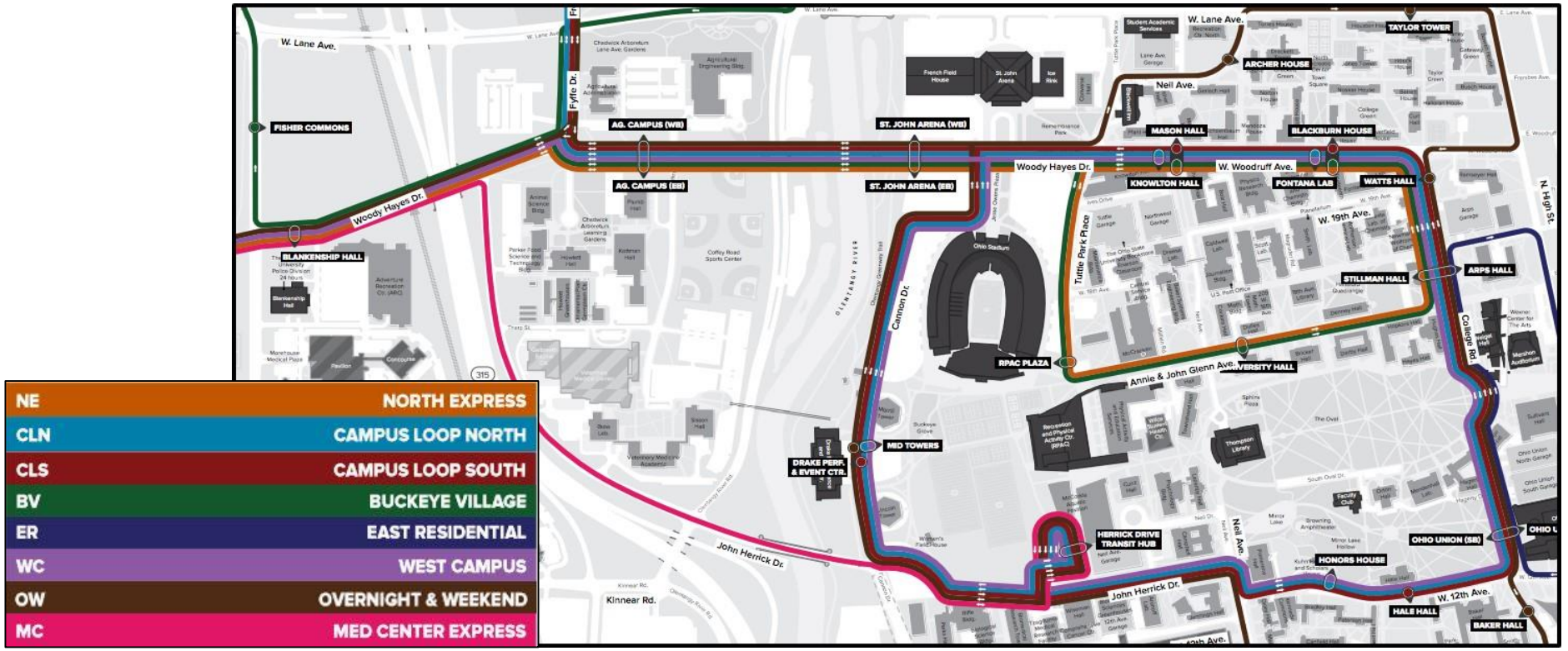
Manual Counting

Road Tubes

Motivation, cont.

Transit buses cover major roadways across the urban network on a regular repeated basis

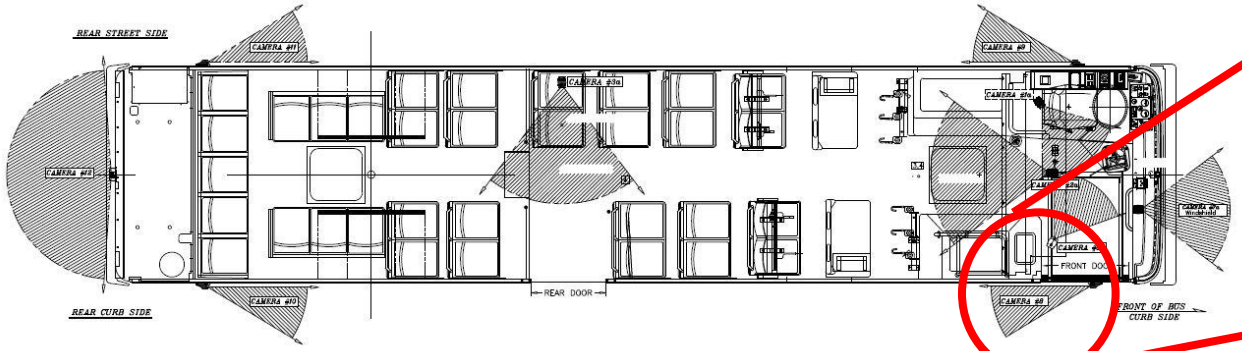
Part of OSU Campus Area Bus Service (CABS) Route Map



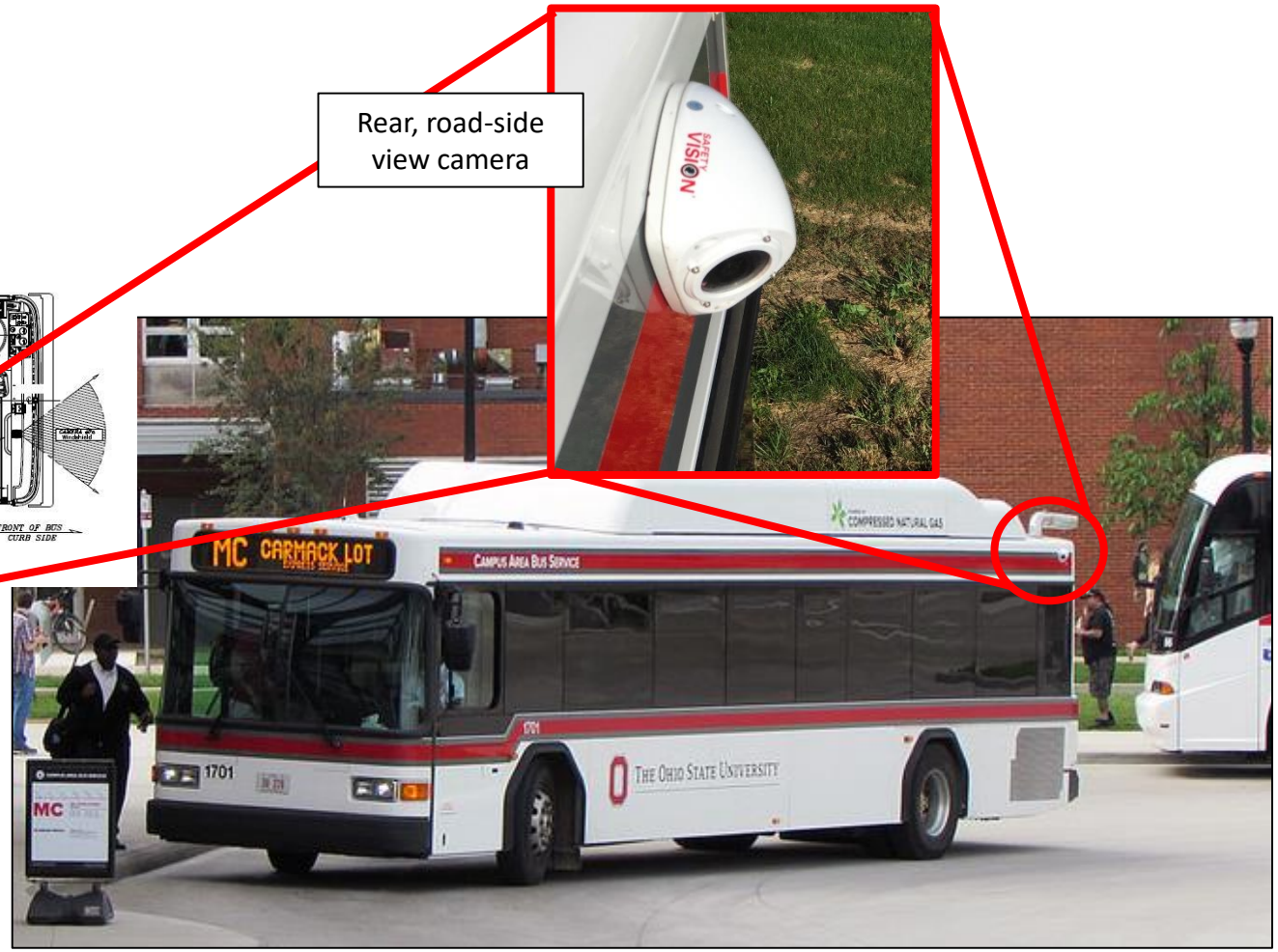
Motivation, cont.

Transit buses are increasingly being equipped with video cameras for other purposes

CABS buses



Rear, road-side view camera



Project team worked with CABS on selection and specifications for new cameras (2017)

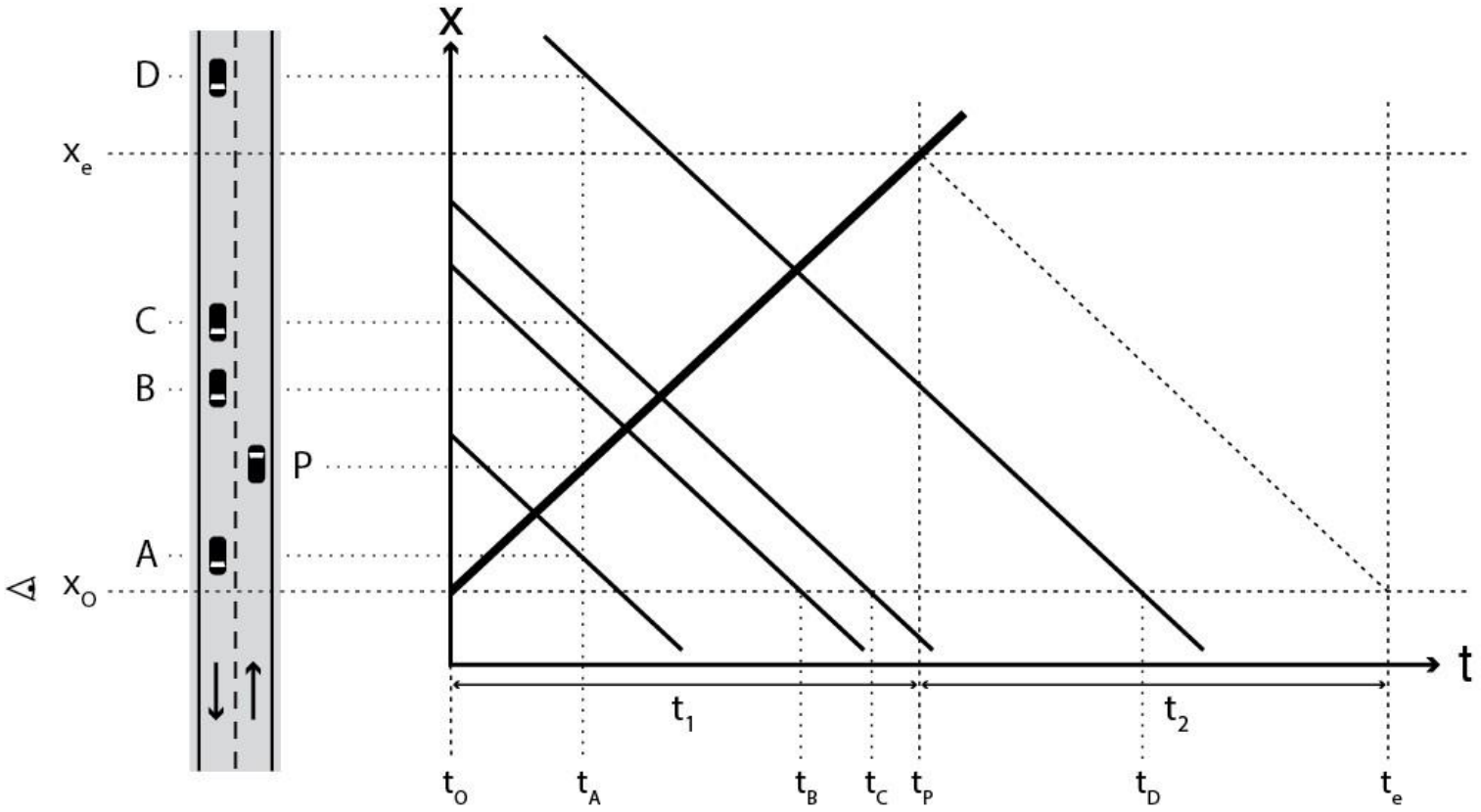
Concept

Take advantage of existing video to obtain repeated observations of traffic and convert to useful planning level measures of traffic flows

Methodological Development

Modify the “textbook” Moving Observer method for “one-way” observations

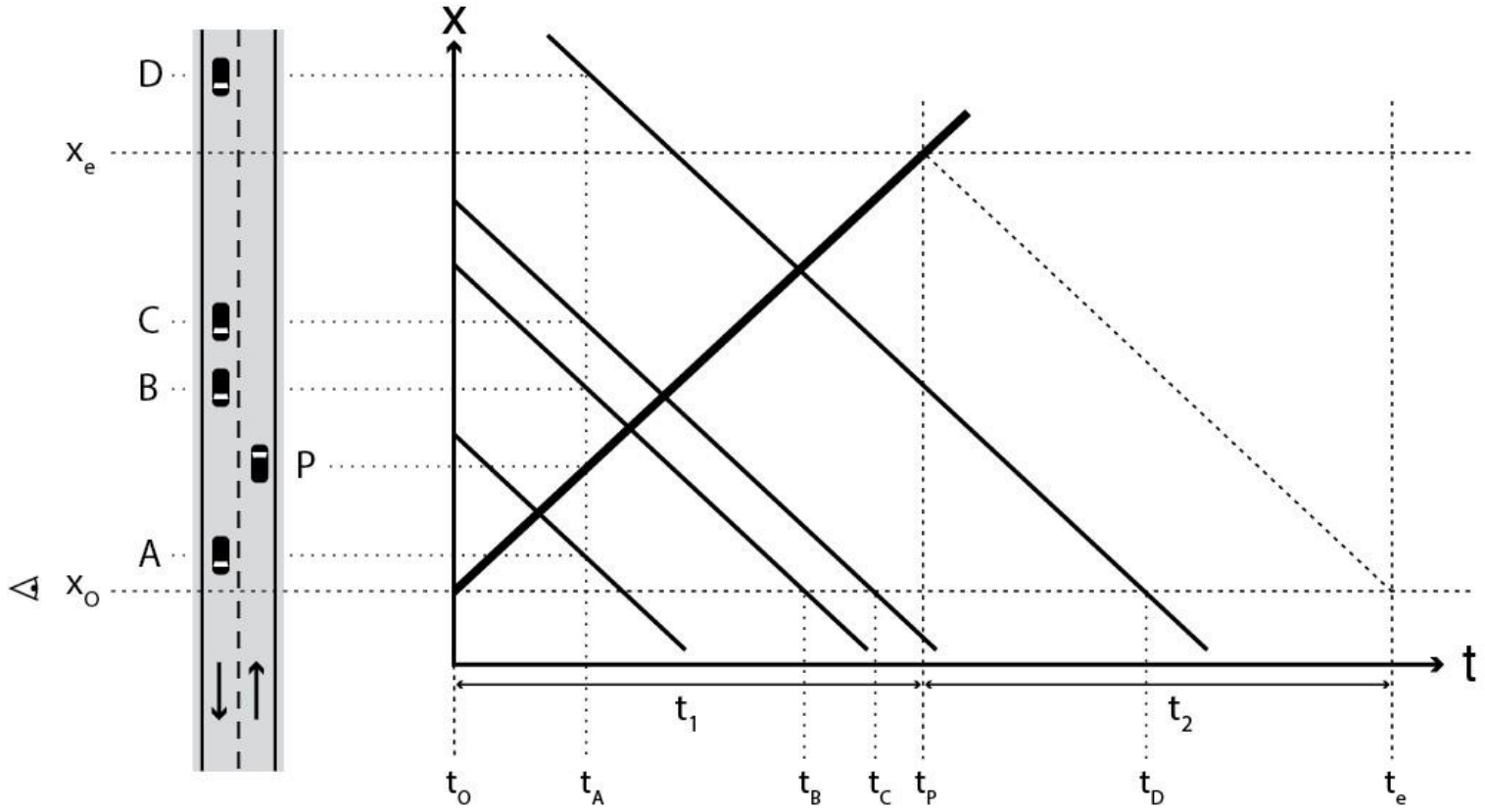
- Modified moving observer method used to estimate traffic flow from a mobile platform traveling in only one direction
- $q = n^{veh}/(t_1 + t_2)$



Methodological Development, cont.

Modified Moving Observer method: Difficulty

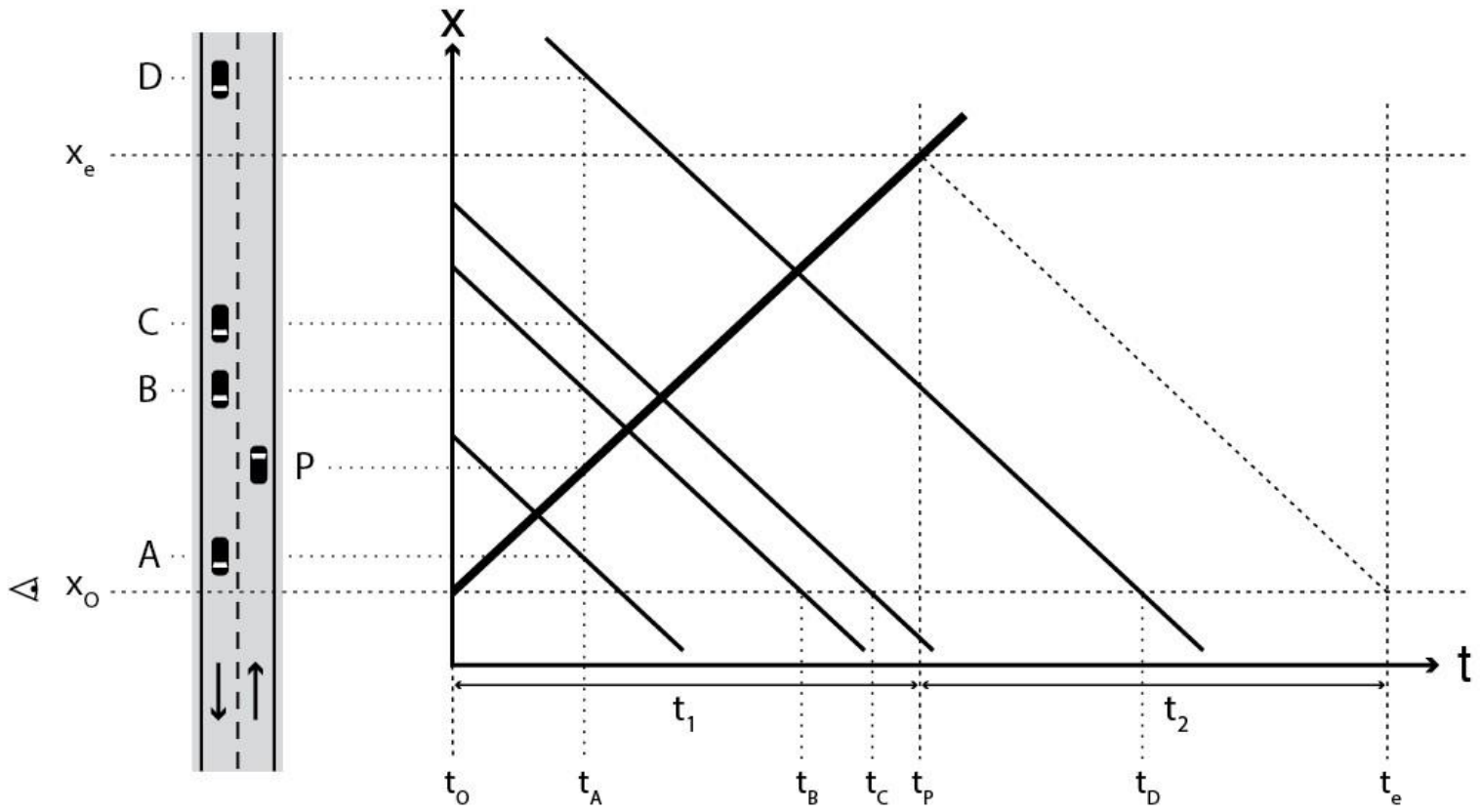
- Modified moving observer method provides very short duration observations
- Parameter t_2 in $q = n^{veh}/(t_1 + t_2)$ is "tricky"



Methodological Development, cont.

Use of transit buses: Advantages

- Transit buses provide many independent observations that can be aggregated
- Buses (platform) and cameras (sensor) are already in operation: No deployment cost
- Buses cover large portions of urban network



Activities

- Collect video imagery from OSU Campus Area Bus Service (CABS) vehicles in regular service along with other data for comparison purposes
- Process (semi-manually) into traffic volume estimates
- Investigate quality and usefulness of empirical volume estimates
- Use estimates in outreach function
- Develop improved estimation

Updates since November 2018 Presentation

- Collected and collecting video imagery from OSU CABS vehicles in regular service, along with other data for comparison purposes
- Processed and processing (semi-manually) video data into traffic volume estimates
- Investigated and investigating quality and usefulness of empirical volume estimates
- Used and using estimates in outreach function
- Investigated and investigating improvement in estimation

Additional Data Collection and Processing

- Collected, processed (semi-manually), and investigated performance of additional CABS video imagery on a few days throughout the year

Additional Data Collection and Processing, cont.

- Planned, collected, and processed concurrent data sets for Vehicle Miles Traveled Studies
  - CABS video imagery
  - Student manual traffic counts
  - Mid-Ohio Regional Planning Commission (MORPC) road tube data

Vehicle Miles Traveled (VMT) Study

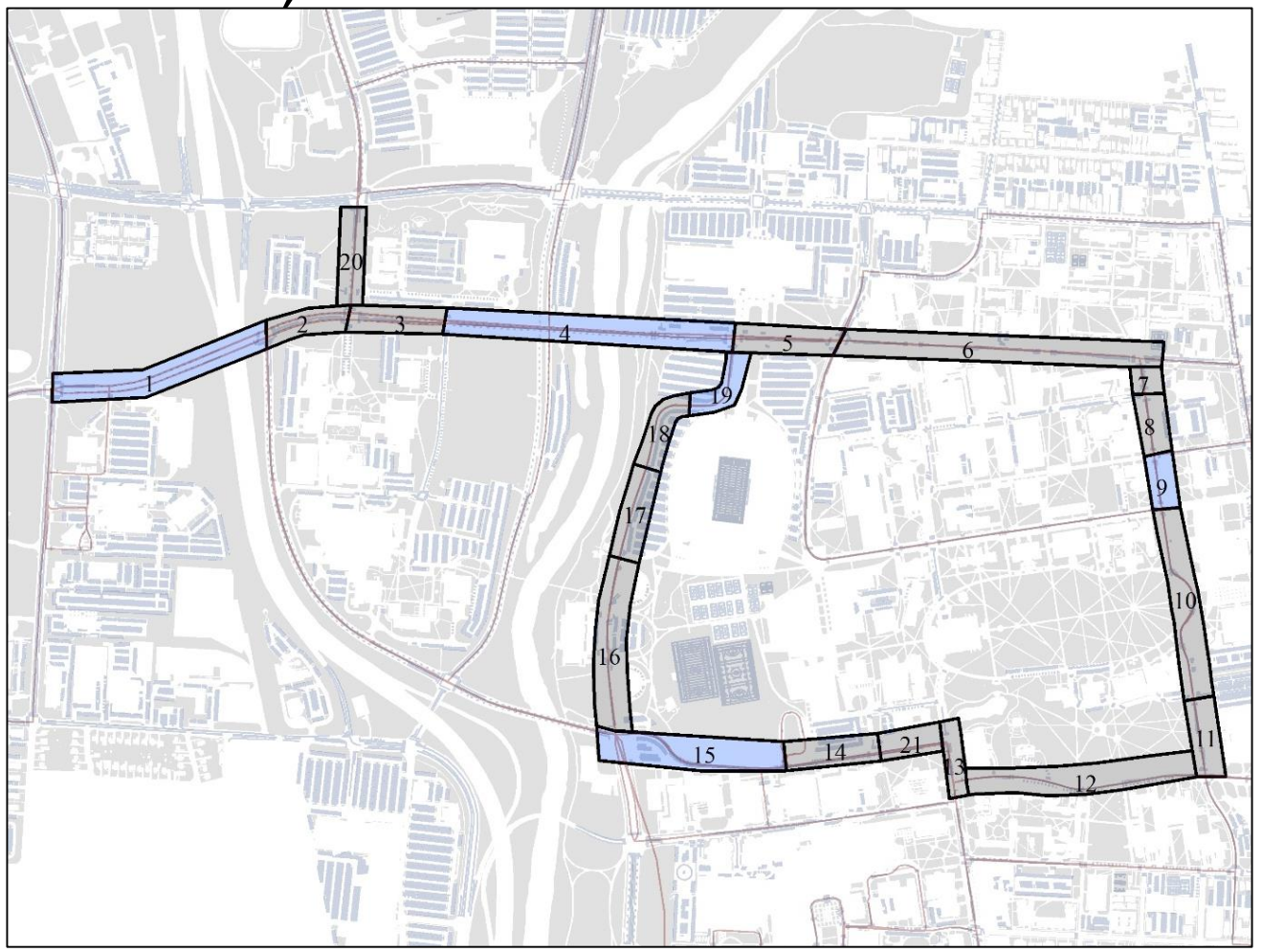
- Estimating VMT (basic measure of network travel) on OSU's campus using conventional and project-based methods
- Large-scale data collection with concurrent video, manual, and road tube data on Thursday, October 25, 2018; repeated Thursday, October 24, 2019
- Multiple objectives
  - Research: Data are used to validate and investigate performance of video-based estimates using concurrent road tube and manual data
  - Education: The effort forms a class term project, which involved 30 (2018) and 32 (2020) engineering students (undergraduate and graduate)
  - Outreach: We provide OSU with VMT estimates, which they do not otherwise have

2018 VMT Study

6.26 directional road miles

7 am to 7 pm, Thursday, 25 October 2018

23,916 vehicle miles traveled

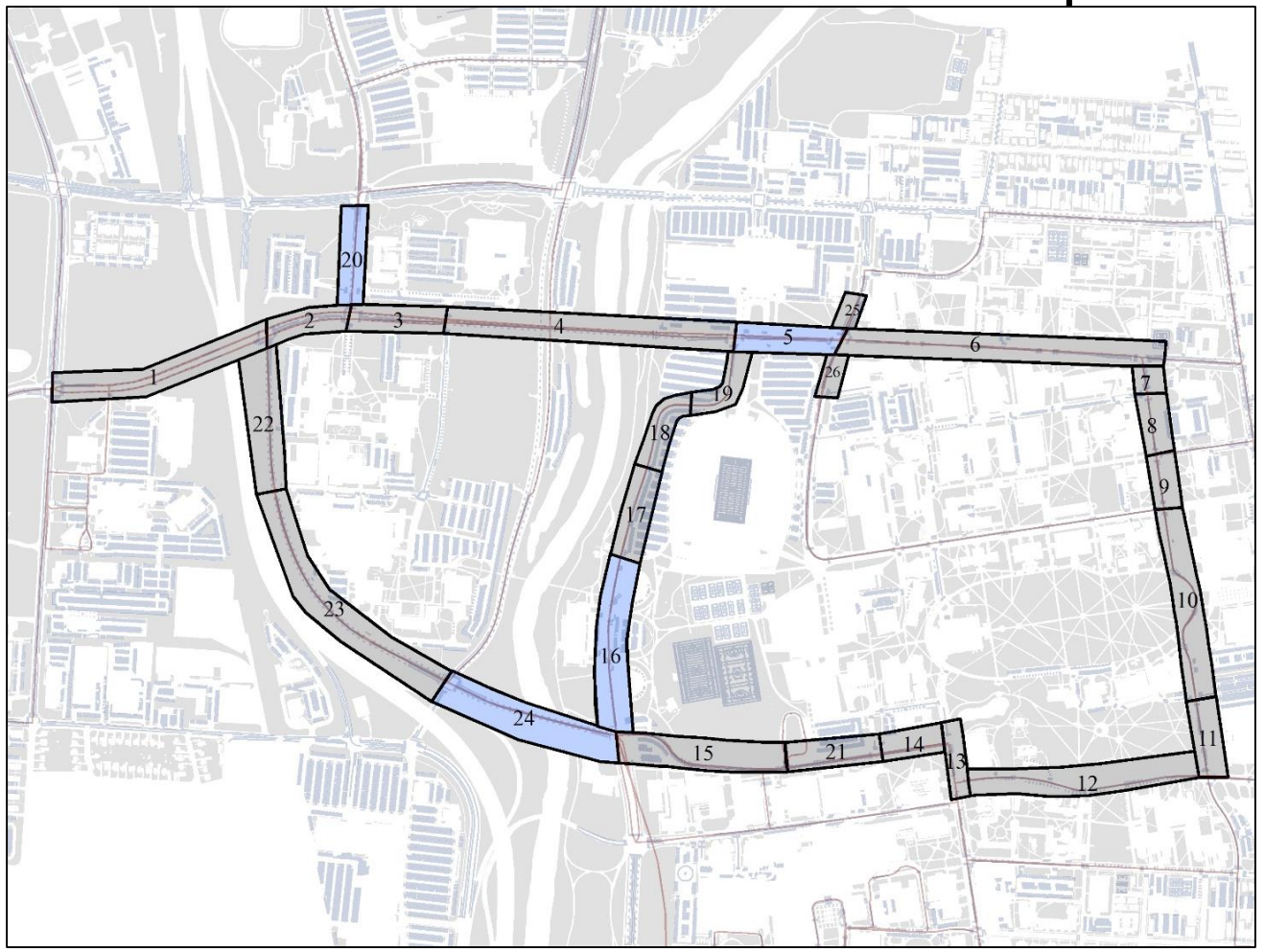


2019 VMT Study

7.86 directional road miles

8 am to 6 pm, Thursday, 24 October 2019

Vehicle miles traveled: under development



Quality and Usefulness of Video Estimates

10/25/2018 video volumes where road tube data were available

Segment and Direction	Sg. Length (miles)	Variables	Start Time of 1-hour period												12-hour Period
			7	8	9	10	11	12	13	14	15	16	17	18	
2.1	0.2563	Video Volumes	275	423	276	154	412	332	309	377	539	757	851	442	5147
		Tube Volumes	278	277	232	269	346	422	338	505	479	662	766	453	5027
		# passes	3	4	4	4	3	3	3	4	4	3	3	3	41
2.2	0.2563	video	706	630	398	330	310	358	192	262	182	640	320	185	4512
		tube	695	679	455	334	297	360	303	268	342	463	406	297	4899
		# passes	4	4	3	3	4	3	4	3	3	4	4	3	42
5.1	0.3262	video	164	236	257	266	345	371	384	432	550	478	669	551	4703
		tube	192	202	237	304	319	451	349	506	581	643	725	560	5069
		# passes	8	10	9	10	9	9	9	9	7	9	10	10	109
5.2	0.3262	video	671	849	656	504	373	410	353	292	467	558	420	322	5876
		tube	775	814	654	502	356	436	353	353	423	442	455	360	5923
		# passes	6	9	9	8	8	10	9	8	9	10	10	9	105
11.1	0.2316	video	135	90	164	116	104	274	191	165	196	200	199	162	1997
		tube	115	119	150	151	166	153	146	139	183	165	283	182	1952
		# passes	4	4	4	2	3	3	4	4	4	4	1	4	41
11.2	0.2316	video	149	164	174	178	141	226	168	227	285	225	424	174	2535
		tube	110	120	135	147	147	186	182	180	193	235	270	216	2121
		# passes	4	6	4	6	4	6	6	5	4	5	5	5	60
17.1	0.1939	video	429	233	266	305	188	378	402	366	673	807	965	593	5605
		tube	332	201	252	217	296	296	297	341	458	590	576	392	4248
		# passes	3	3	4	4	4	3	4	4	3	4	3	4	43
17.2	0.1939	video	725	667	247	349	320	343	352	311	209	320	301	374	4518
		tube	547	461	327	275	284	349	283	287	284	308	299	408	4112
		# passes	4	5	4	5	6	5	6	6	4	6	6	6	63
21.1	0.1121	video	363	183	196	203	109	133	157	90	143	137	215	207	2136
		tube	350	320	237	188	175	196	186	204	160	175	170	147	2508
		# passes	3	5	3	5	5	5	6	3	3	3	4	4	49
21.2	0.1121	video	90	210	153	179	226	400	154	376	267	183	435	188	2862
		tube	80	100	131	166	161	181	174	230	257	235	308	181	2204
		# passes	4	3	4	4	4	3	3	4	4	3	4	4	44

Quality and Usefulness of Video Estimates, cont.

Comparisons of 12 hourly and one 12-hour video-based and road tube-based estimates (from 2018 VMT study); RD: relative difference; ABSRD: absolute value of relative difference

Segment-Direction	Hourly volumes					12-hour volumes		
	N	RD		ABSRD		N	RD	ABSRD
		Mean	S.D.	Mean	S.D.			
2.1	12	0.0225	0.2511	0.1918	0.1531	1	0.0238	0.0238
2.2	12	-0.0755	0.2456	0.1809	0.1755	1	-0.0497	0.0497
5.1	12	-0.0468	0.1316	0.1192	0.0647	1	-0.0721	0.0721
5.2	12	0.0427	0.1800	0.1115	0.1443	1	0.0381	0.0381
11.1	12	0.0489	0.3266	0.2582	0.1913	1	0.0232	0.0232
11.2	12	0.1992	0.2384	0.2580	0.1660	1	0.1954	0.1954
17.1	12	0.3415	0.3348	0.4025	0.2502	1	0.3583	0.3583
17.2	12	0.0694	0.2332	0.1872	0.1464	1	0.0909	0.0909
21.1	12	-0.0929	0.3328	0.2972	0.1544	1	-0.0879	0.0879
21.2	12	0.3235	0.4545	0.3793	0.4047	1	0.2986	0.2986
Mean	120	0.0833		0.2386		12	0.0819	0.1238
S.D.		0.3127		0.2177			0.1545	0.1196

Hourly volumes show "large" differences with limited numbers of passes, but 12-hour volumes show much smaller differences

Quality and Usefulness of Video Estimates, cont.

Regress difference between hourly road tube and average hourly video estimates against number of bus passes in the hour and the length of the segment

$$\text{ABSRD(hourly volumes)} = 0.638 - 0.017(\#\text{ Bus Passes}) - 0.552(\text{Segment Length})$$

- *Low R^2 (0.142): Other factors are important*
- *Coefficients have meaningful signs with significance (p-values 0.061 and 0.059)*
- *Implies that additional bus passes should improve estimates*

Quality and Usefulness of Video Estimates, cont.

RD and ABSRD for 12-hour bi-directional volumes obtained from simulated expanded coverage counts and for the 12-hour bi-directional video volumes

Segment	Expanded Volumes					Video Volumes			Pr(Video Better)
	N	RD		ABSRD		N	RD	ABSRD	
		Mean	S.D.	Mean	S.D.				
2	12	-0.0070	0.1202	0.1021	0.0559	1	-0.0125	0.0125	1.00
5	12	0.0029	0.0887	0.0679	0.0533	1	-0.0127	0.0127	0.75
11	12	0.0079	0.2081	0.1560	0.1296	1	0.1129	0.1129	0.50
17	12	-0.0010	0.1209	0.0894	0.0768	1	0.2268	0.2268	0.08
21	12	0.0150	0.1237	0.0999	0.0683	1	0.0929	0.0929	0.50
Mean	120	0.0036		0.1031		5	0.0815	0.0915	0.57
S.D.		0.1337		0.0841			0.0999	0.0883	0.34

Video-based estimates might replace traditional coverage count approach

Investigating Improvements in Estimation

- Investigating better ways to estimate volumes from single pass
- Investigating better ways to aggregate across passes
- Determining roadway characteristics that lead to particularly good or bad estimates

Ongoing and Future Efforts

- Develop and deliver 2019 VMT estimate
- Continue empirical validation and usefulness studies with task of demonstrating potential and improving estimates
- Determine ongoing monitoring approach

- Contacts
  - Mark McCord: mccord.2@osu.edu
  - Rabi Mishalani: mishalani@osu.edu
  - Benjamin Coifman: coifman.1@osu.edu

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