Estimating Traffic Volumes from Bus-based Video Imagery Obtained during Regular Transit Operations

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Traffic21/Mobility 21 Deployment Partner
Consortium Symposium
Online

November 20, 2020

Motivation

Traditional traffic studies obtain data to estimate traffic volumes over long time durations but only at *limited locations* and on an *infrequent basis*

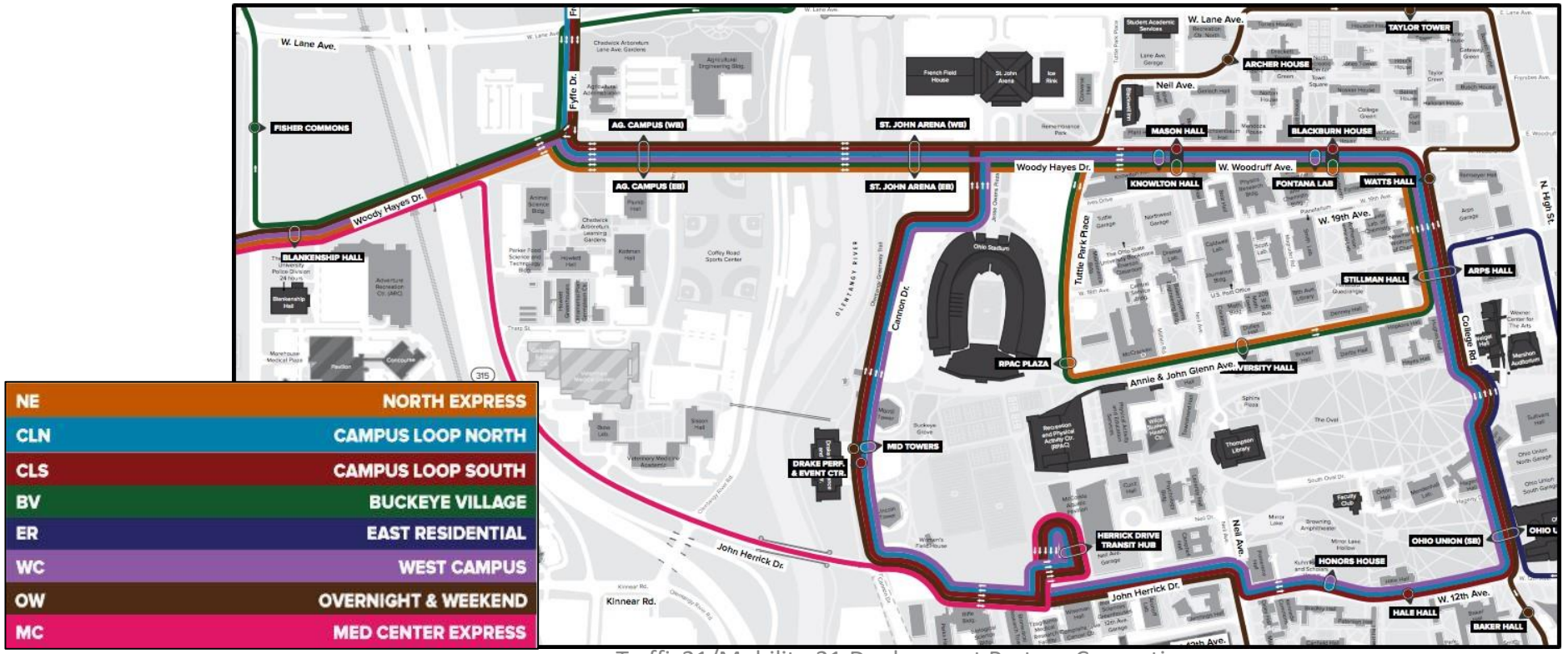
Manual Counting

Road Tubes

Motivation, cont.

Transit buses cover major roadways *across the urban network* on a *regular, repeated, and ongoing basis*

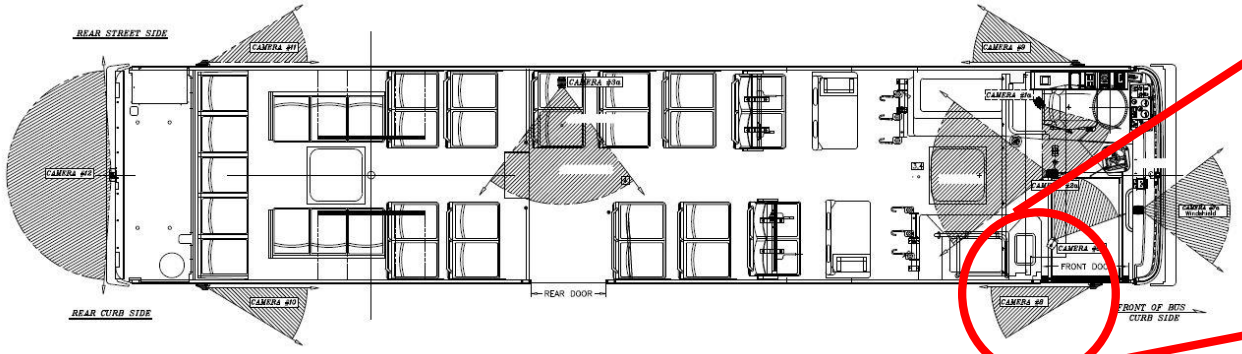
Part of OSU Campus Area Bus Service (CABS) Route Map



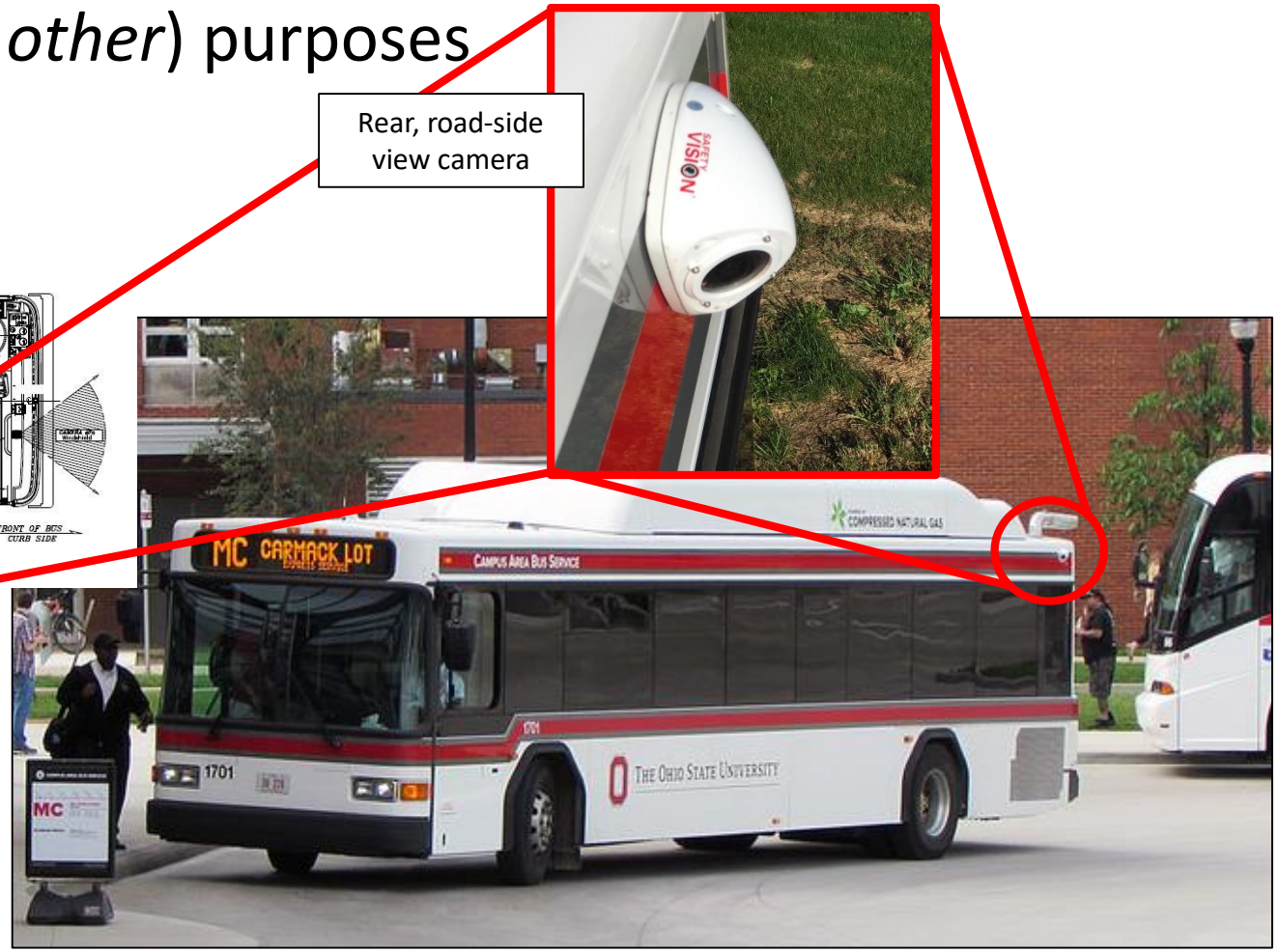
Motivation, cont.

Transit buses are increasingly being equipped with video cameras for safety, security, and liability (i.e., *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 repeated, ongoing coverage of fixed schedule transit buses to estimate traffic volumes on most major roadways in an urban area while the buses are providing regular service

Estimation Methodology: Hourly Volumes from Mobile Observations

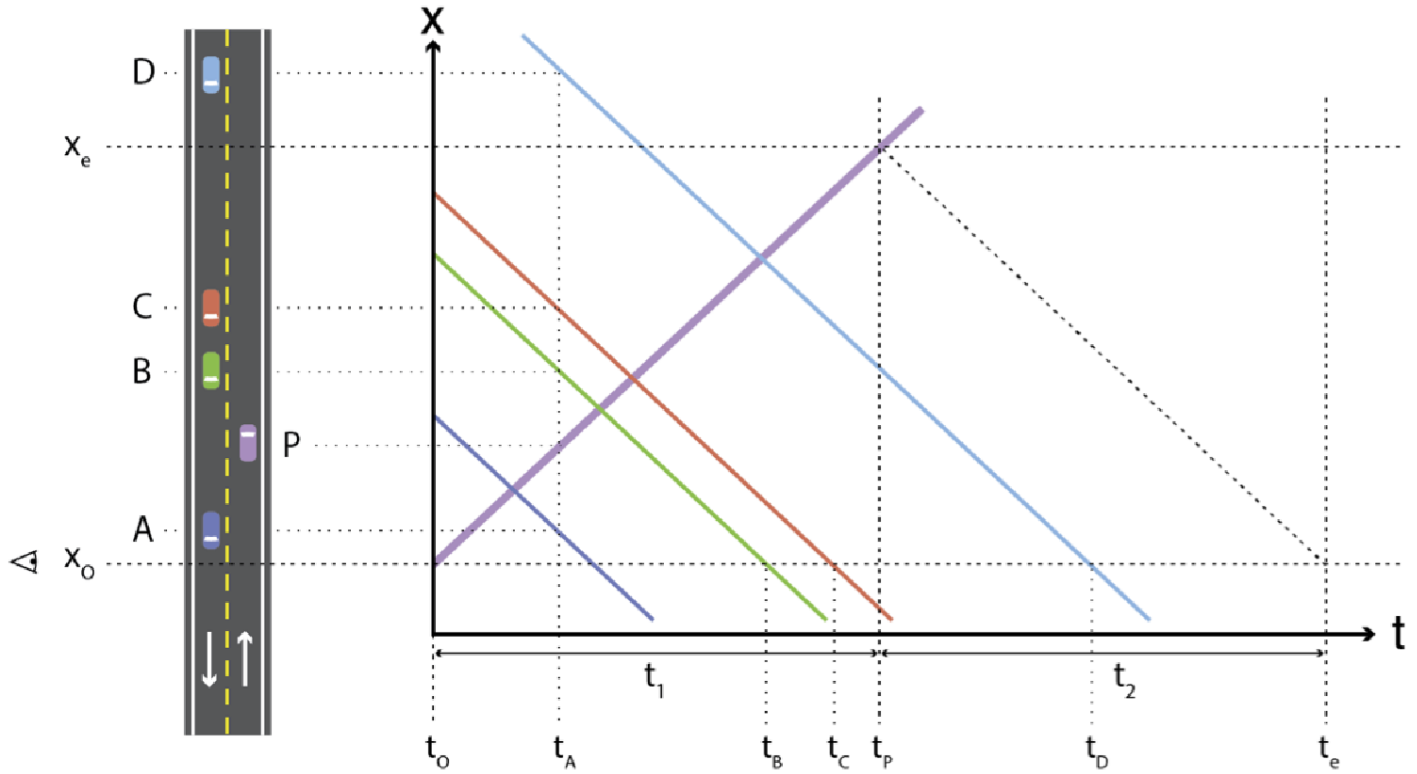
Traffic volumes traditionally from vehicles past a fixed location over time

"Textbook" moving observer method modified for volume estimation from transit buses

- Flow rate q from an individual bus pass over a segment

$$q = n^{veh}/(t_1 + t_2)$$

- Aggregate q values from individual passes into hourly volumes



Present Vehicle Detection and Processing: Video-based Vehicle Counting GUI

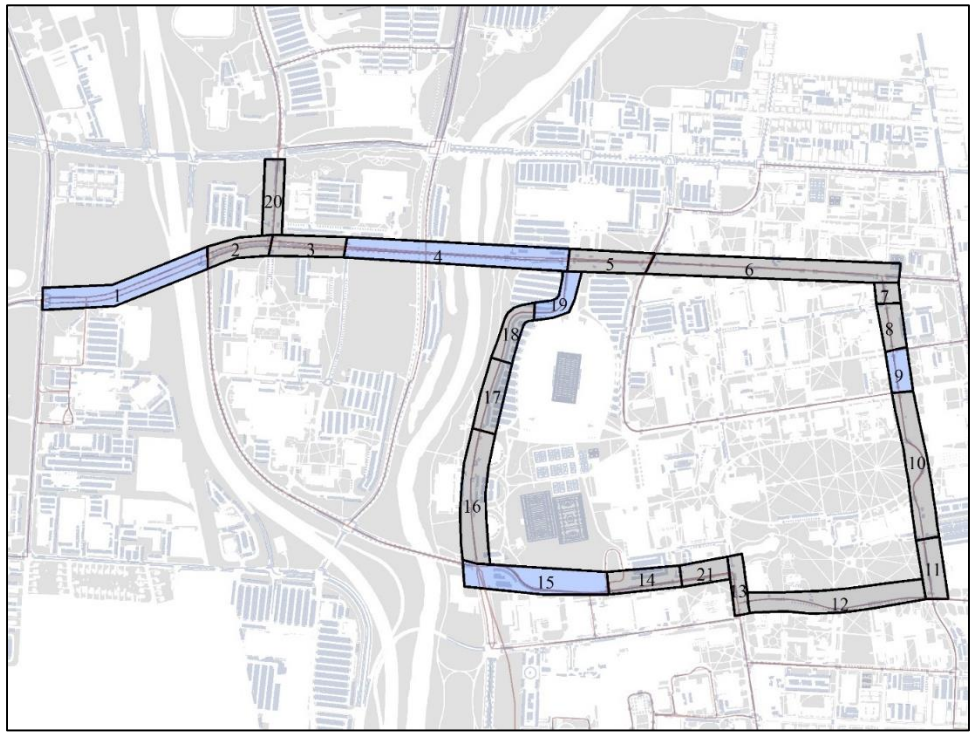
Developed in MATLAB to digitize vehicle observations, locations, and passage times

Vehicle Upstream of Count Line

Vehicle Passing Count Line

Empirical Study

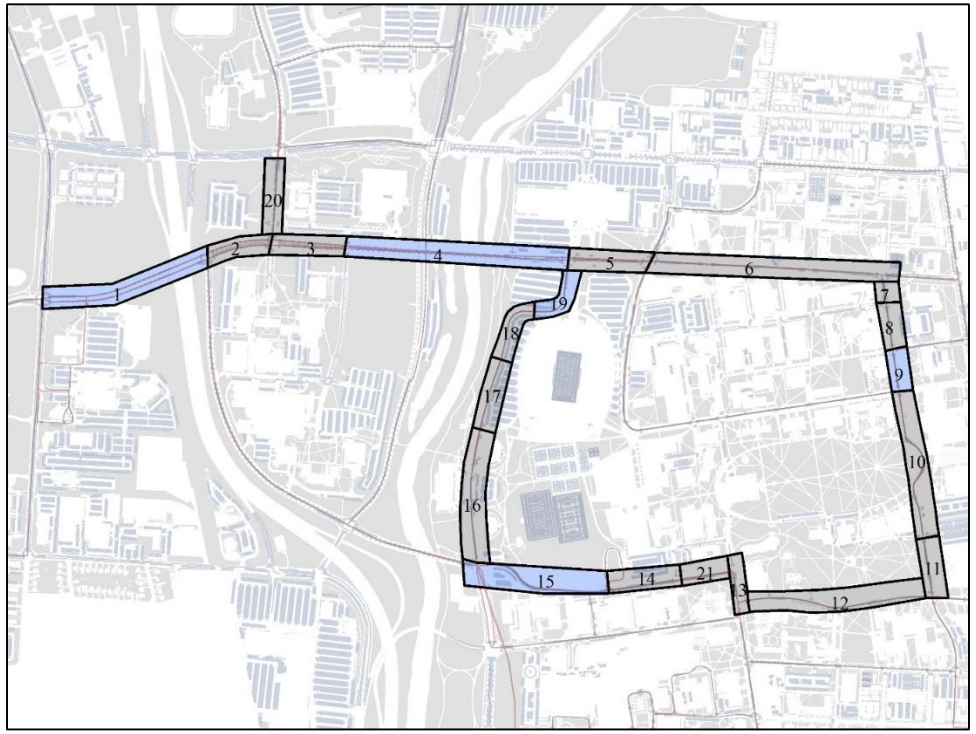
Traffic study on The Ohio State University campus roadway network, 7 a.m. to 7 p.m., October 18, 2018 (repeated in 2019, 2020)



Empirical Study, cont.

Traffic study on The Ohio State University campus roadway network, 7 a.m. to 7 p.m., October 18, 2018 (repeated in 2019, 2020)

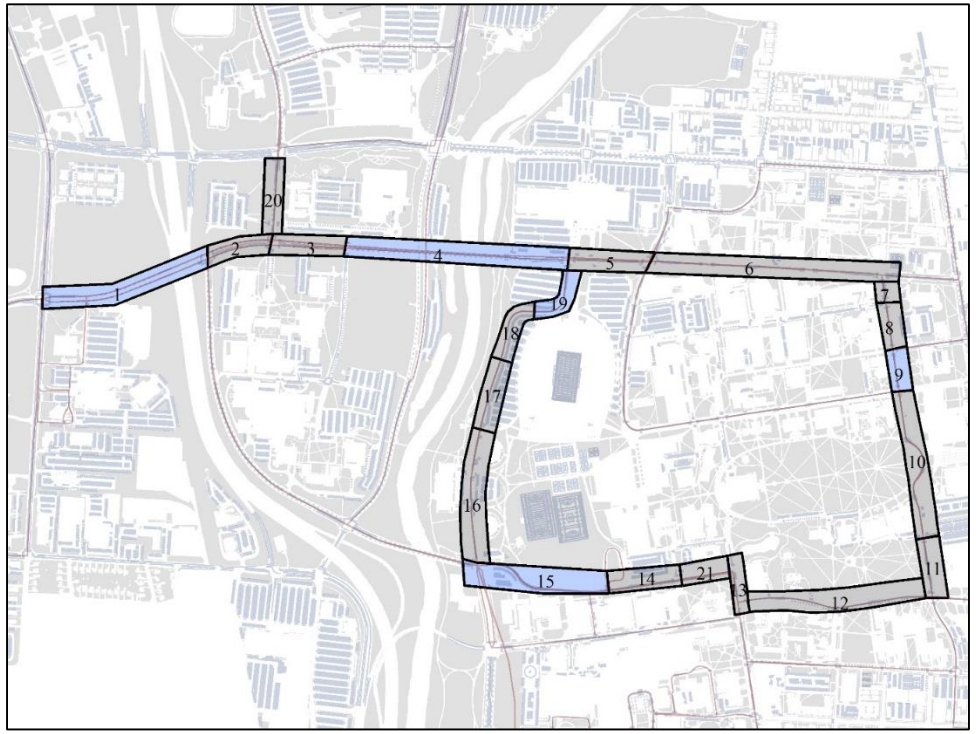
- Mid-Ohio Regional Planning Commission (local MPO) laid road tubes on 5 segments for entire period



Empirical Study, cont.

Traffic study on The Ohio State University campus roadway network, 7 a.m. to 7 p.m., October 18, 2018 (repeated in 2019, 2020)

- OSU Transportation and Traffic Management provided ~60 hours of bus video covering the networks segments



Empirical Results

Video and Road Tube Volumes for 120 Segment-Direction-Hours

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

Relative Difference (Sign and magnitude):

$$RD = \frac{Video\ Volume - Road\ Tube\ Volume}{Road\ Tube\ Volume}$$

Absolute Relative Difference (Magnitude):

$$ABSRD = |RD|$$

"*Difference*": Road tubes are not ground truth

Empirical Results, cont.

Comparisons of 12 Hourly and One 12-hour Video-based and Road Tube Volumes

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

While differences in hourly volumes are somewhat large, differences in 12-hour volumes are approaching "reasonable" (10%) levels

Empirical Results, cont.

Comparisons of 12 Hourly and One 12-hour Video-based and Road Tube Volumes

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		Mean	S.D.	Mean	S.D.			
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Some segments have very low differences

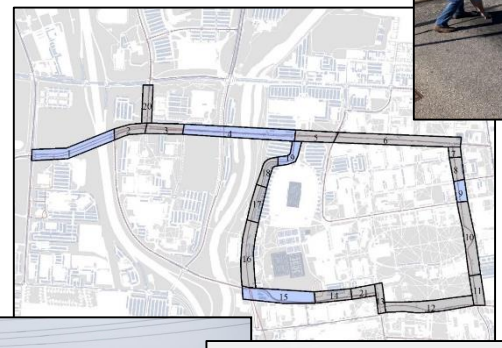
Determining explanatory characteristics is ongoing and encouraging

Empirical Results, cont.

Vehicle Miles Traveled (VMT) Study, Video-based vs. Traditional Volumes

Very small (4-5%) differences between VMT determined from video-based volumes and from traditional volumes

Network Considered	Video-based VMT	Traditional VMT	Relative Difference
Segments w/ road tubes	9,581	9,221	0.0390
Entire network	23,554	Mean: 22,589	0.0476



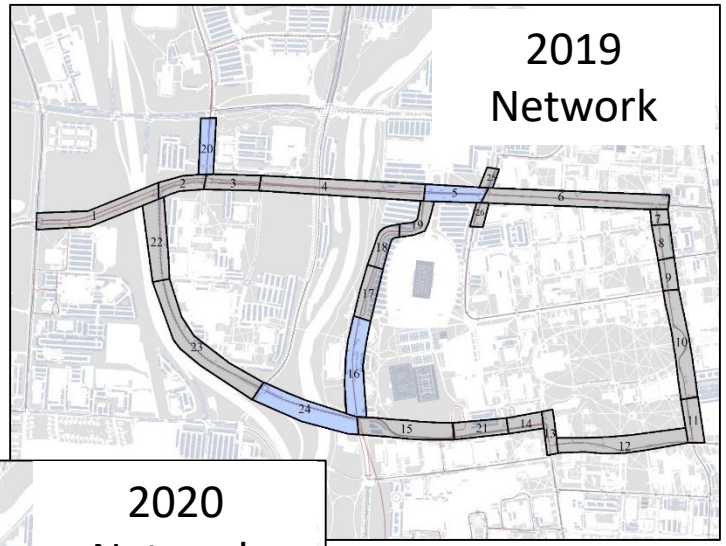
Empirical VMT in Outreach Dimension

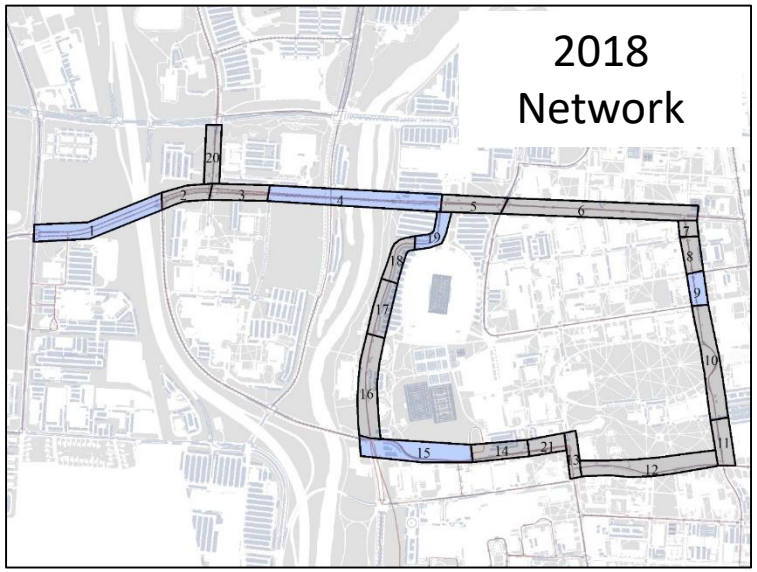
- The Ohio State University Columbus Campus Community
  - One of largest single campuses worldwide
  - Multiple and diverse land uses and transportation network

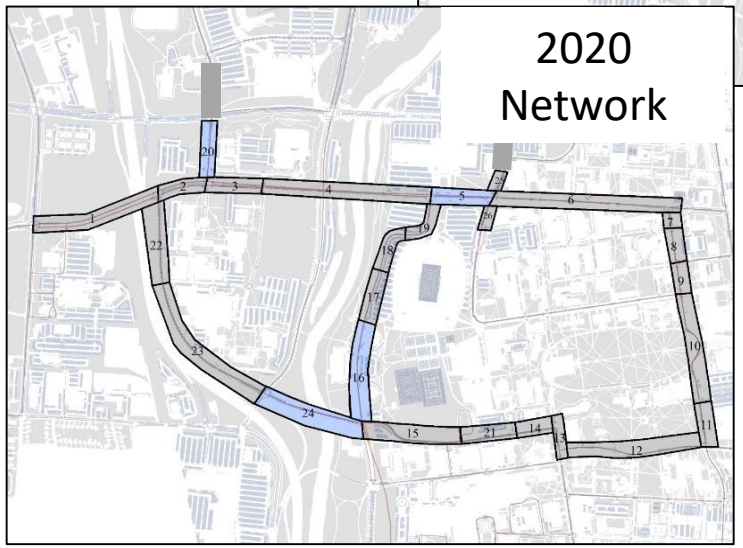
Functions like a small city

Empirical VMT in Outreach Dimension, cont.

- Empirical VMT estimates are provided to campus planners and decision-makers for ongoing monitoring



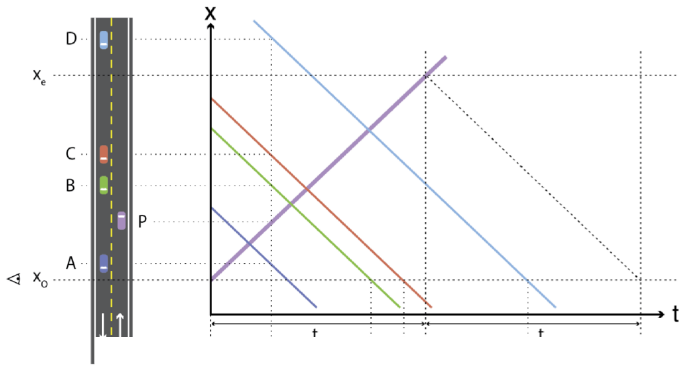




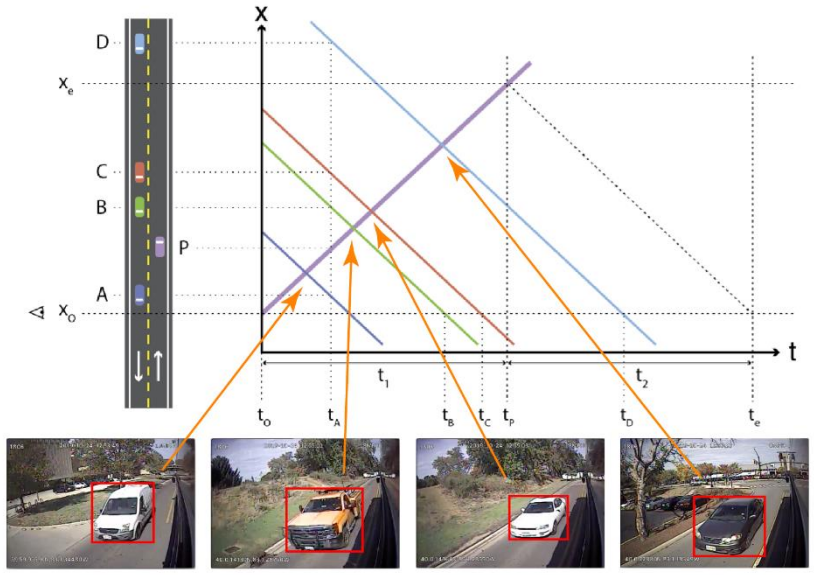
Ongoing and Future Efforts, cont.

- Research
  - Confirm promising results
  - Determine explanatory variables associated with good or bad performance
  - Improve volume estimation
  - Automate vehicle detection

Network Considered	Video-based VMT	Traditional VMT	Relative Difference
Segments with road tubes	9,581	9,221	0.0390
Entire network	23,554	Mean: 22,589 Range: [20,568, 25,709]	0.0476 (from mean)



- $q = n^{veh}/(t_1 + t_2)$
- Aggregation of q values



Summary

- Developing, demonstrating, and promoting an approach for obtaining traffic flow estimates across extensive urban roadway networks from video data collected from transit buses
- Taking advantage of repeated, ongoing coverage of fixed schedule transit buses to “observe” traffic on most major roadways in an urban area while providing regular service
- Extensive monitoring of the OSU campus network using video imagery since 2018 producing encouraging results
- Several research and development components underway
- Empirical results obtained already being used in outreach dimensions

- Contacts
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- Acknowledgements
  - OSU Graduate Students: Gio Hansel, Serkan Bicici, Mo Wu, Stephanie Ferzli, Diego Ribeiro de Oliveira Galdino, Shahrzad Charmchi Toosi
  - OSU Transportation and Traffic Management: Beth Snoke, Tom Holman, Sean Roberts
  - Mid-Ohio Regional Planning Commission: Nick Gill, Hwashik Jang, Zhuojun Jiang