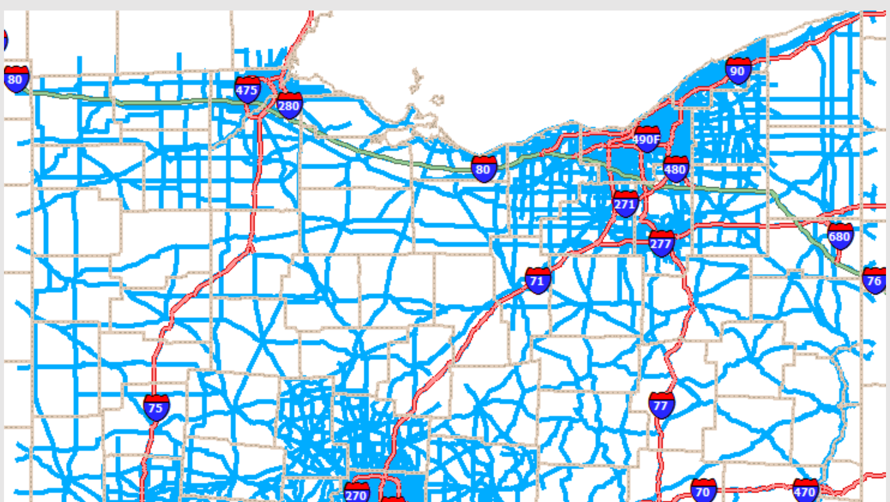
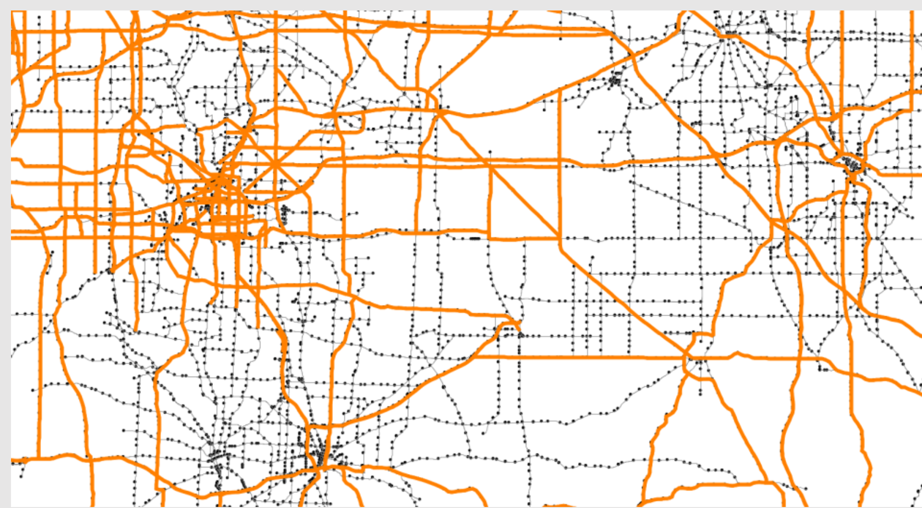
Using Both NPMRDS (Performance Measurement) and New XD Network Data for Network Speed Fields/model validation for the 2020 Base Year:

Sam Granato, Ohio DOT

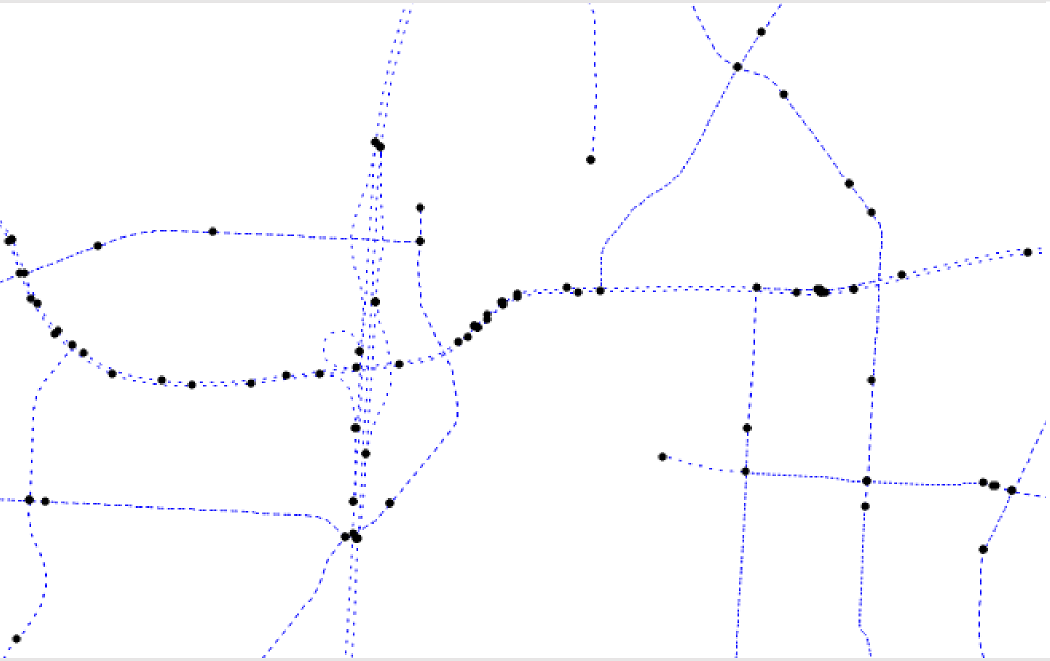
The full proposal:

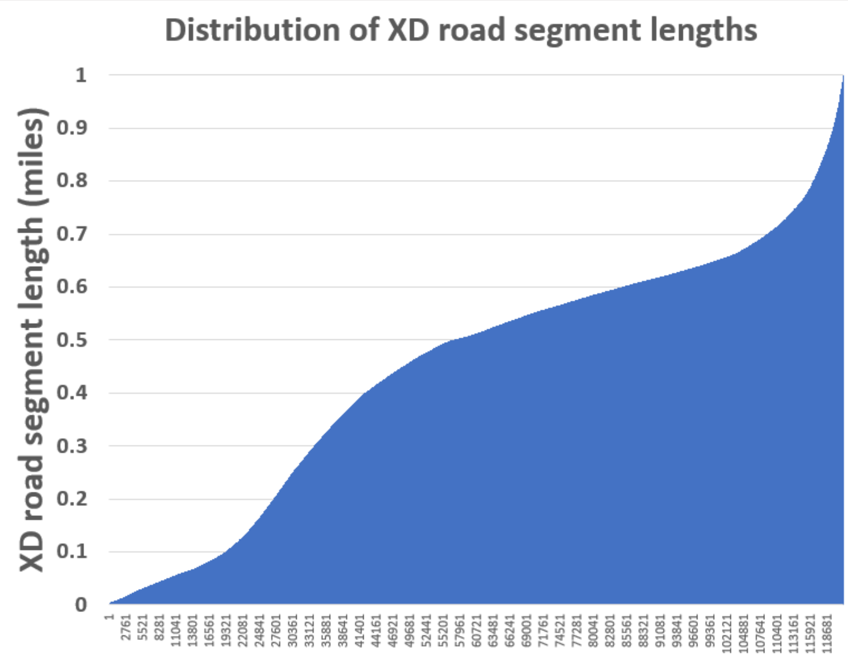
- **Floating car** data still good for the initial speed coding.
- On freeways & rest of NHS – **NPMRDS** data (already used for PM3) has separate speeds for auto and truck.
- Rest of road system –**XD network** has both more granularity than TMC (0.42 m average segment length vs 1.35 m) & more roadway coverage (53,000 directional miles statewide vs 35,000), especially in smaller MPOs.



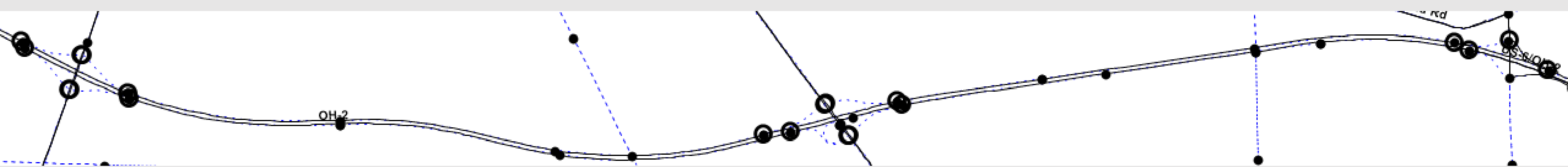


….but what to do about too <u>much</u> granularity for modeling in the XD network?





- Model segments may conflate to very small XD segments.
- How to properly aggregate XD road segments for this use?
- (can avoid for freeways, NPMRDS uses the TMC network)



Means of developing aggregated XD road segments for travel models:

- First part a “semi-automated” aggregation of road segments in GIS statewide* between major (within-XD) intersections.

- Second part a (optional) manual application specific to each MPO region – a function of local network geography plus further aggregation of segments by corridor, mostly by checks to see if any model road segments still conflate to significantly smaller XD road segments.

- *-including out-of-state portion of bi-state regions

GIS procedure for segment aggregation:

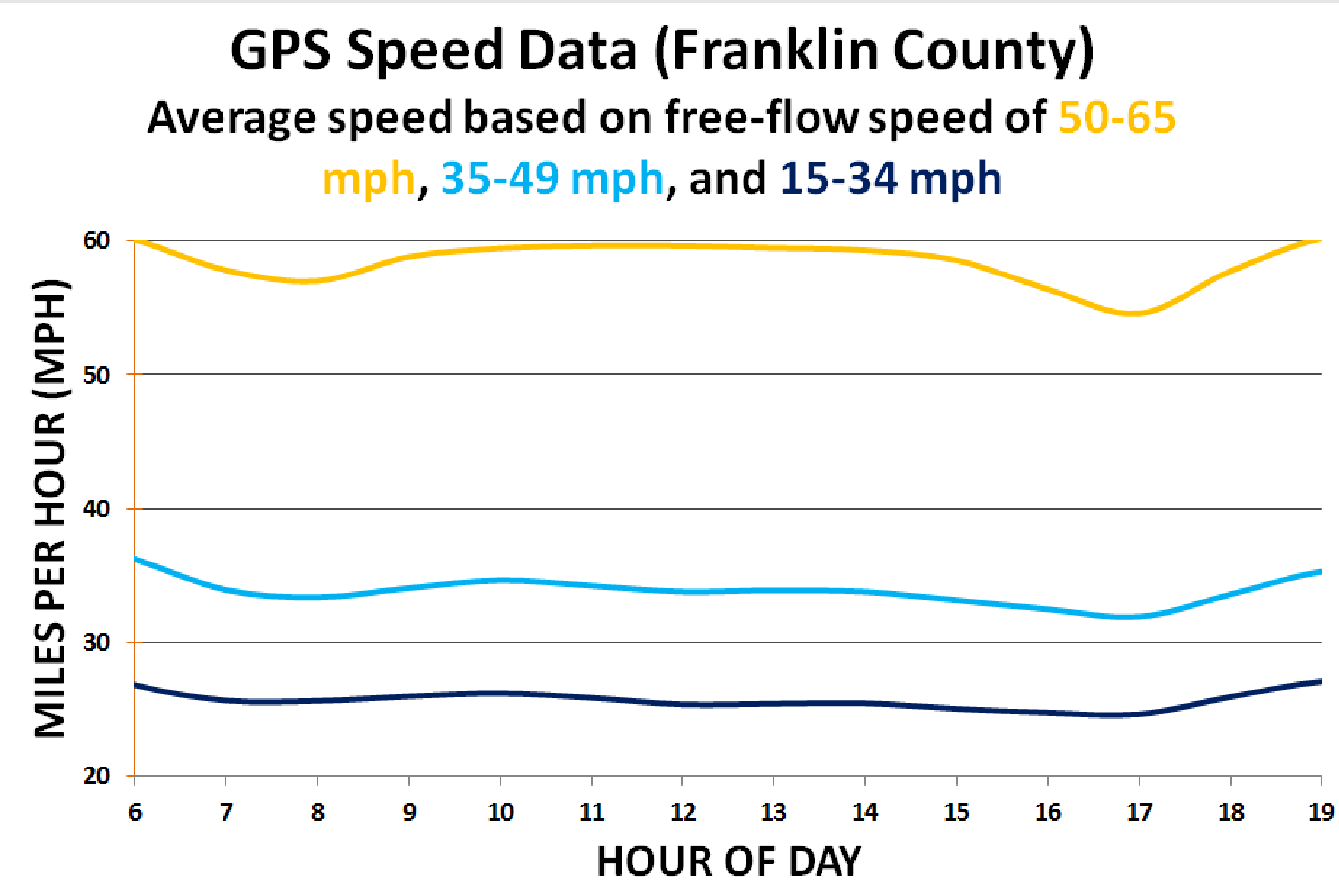
- Break up statewide XD network in 2, based on cardinal (NB/EB bearing) vs non-cardinal directions.
- Find # of links at each node, connect dis-jointed segments
- Filter out short links without network continuity (or data).
- A "Simplify" procedure to aggregate segments between intersections (reduces the number of XD segments by over 2/3rds).

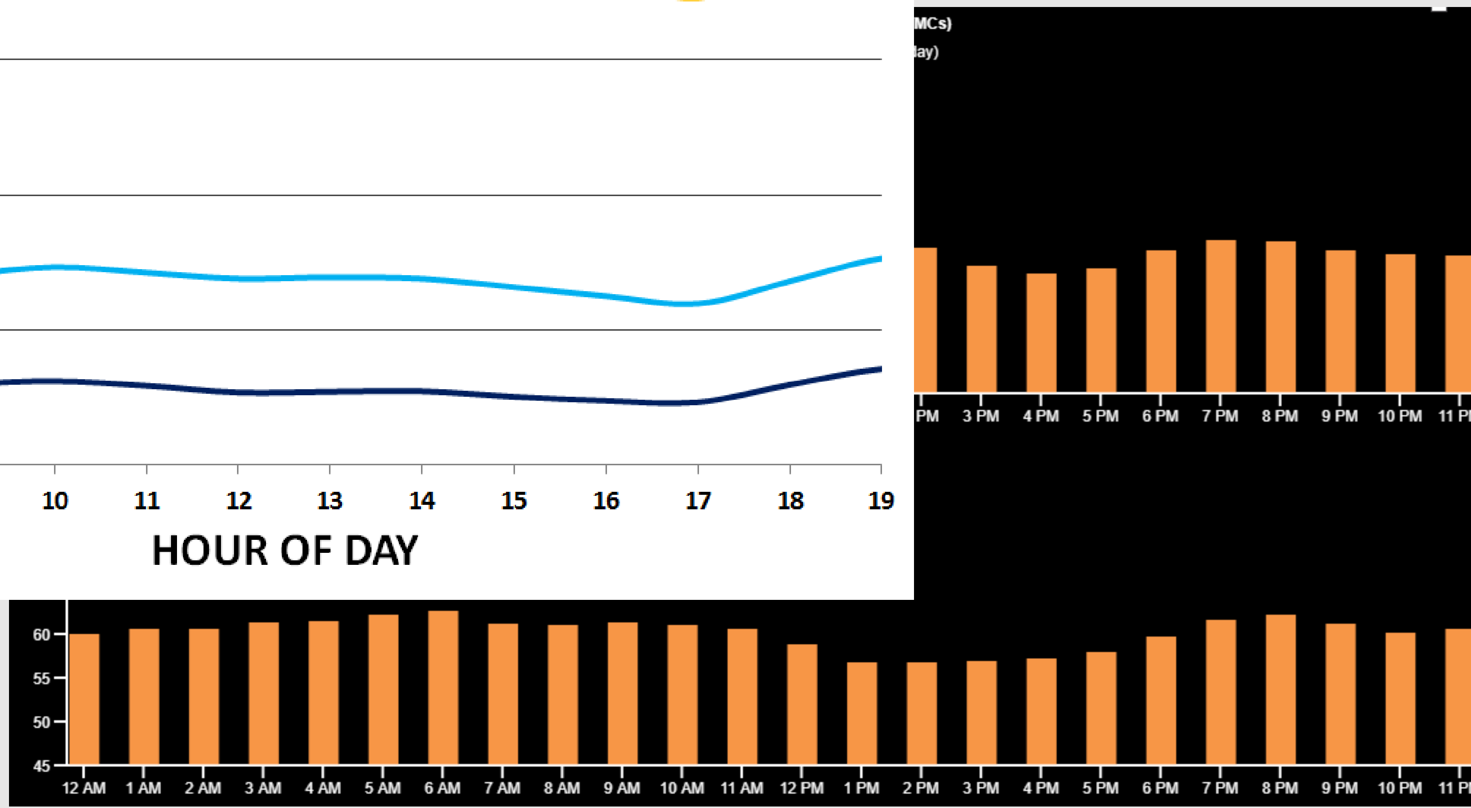
Preliminary procedure for subsequent manual aggregations:

- Conflate (overlay & tag) aggregated XD segment names and lengths to model network road segments, see which segments have joined to XD segments that are <u>significantly</u> shorter.

- Per HCM guidance for urban streets, flag aggregated XD segments still < 1 mile as <u>potential</u> for further manual aggregation within a corridor.

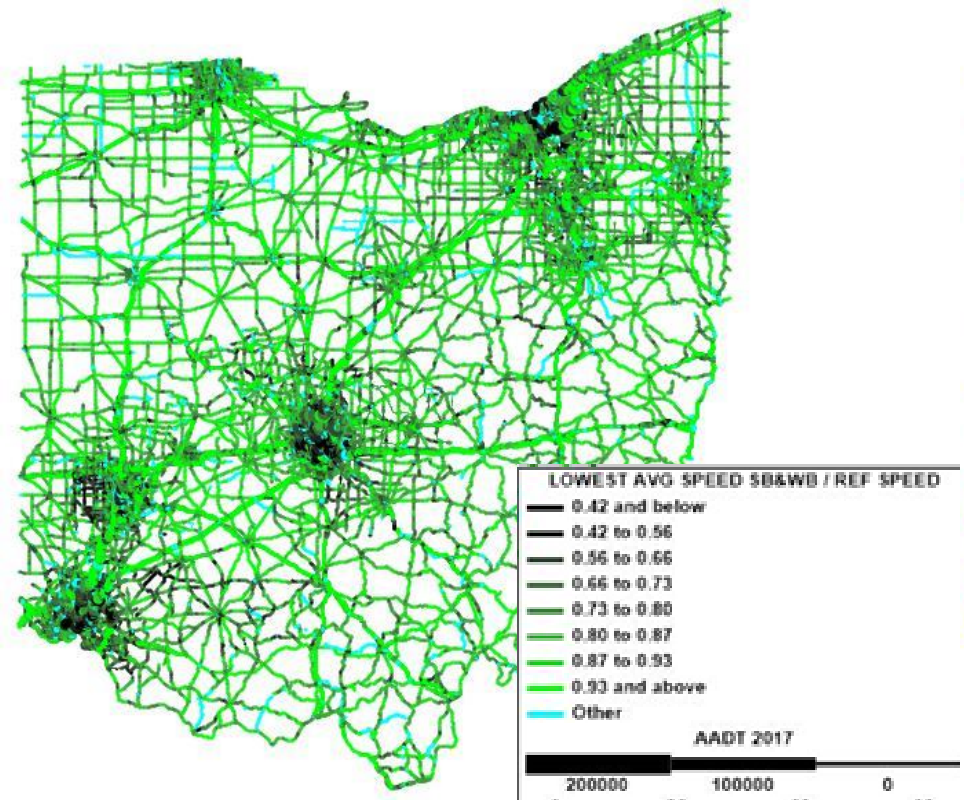
As before, don't expect to see <u>that</u> much difference <u>overall</u> in speed/travel time by time of day:

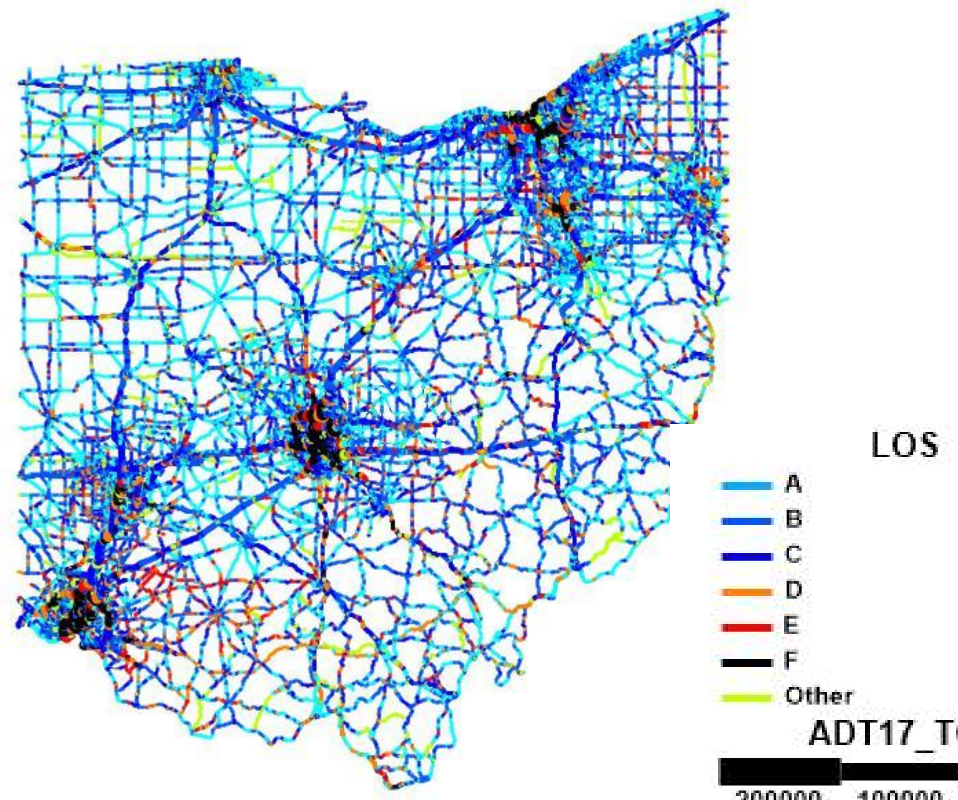




“Coming Attractions:” Use of data to re-estimate Congestion/HCM Level of Service

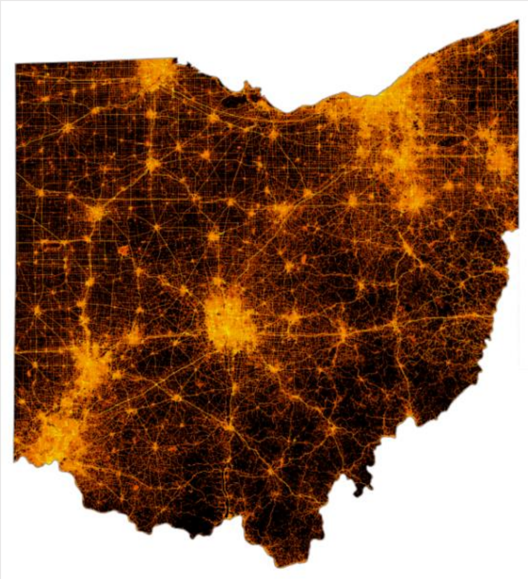
- HCM over time trending toward use of average/FF speeds across road types (though LOS threshold values still vary considerably by road type).
- Recent data “explosion” means a lack of stability in results over time.
- May need different level of aggregation in XD segments than for models.





Use of GPS Trip & Waypoint Data for Route Choice Analysis and Other Applications

Sam Granato, Ohio DOT



The Road Not Taken, 999th ed.

2 roads diverged past the Office of the Examiner
1 had turbulent traffic flow, the other quite laminar
The clues of the scour were apparent near here
And that has made all the difference quite clear

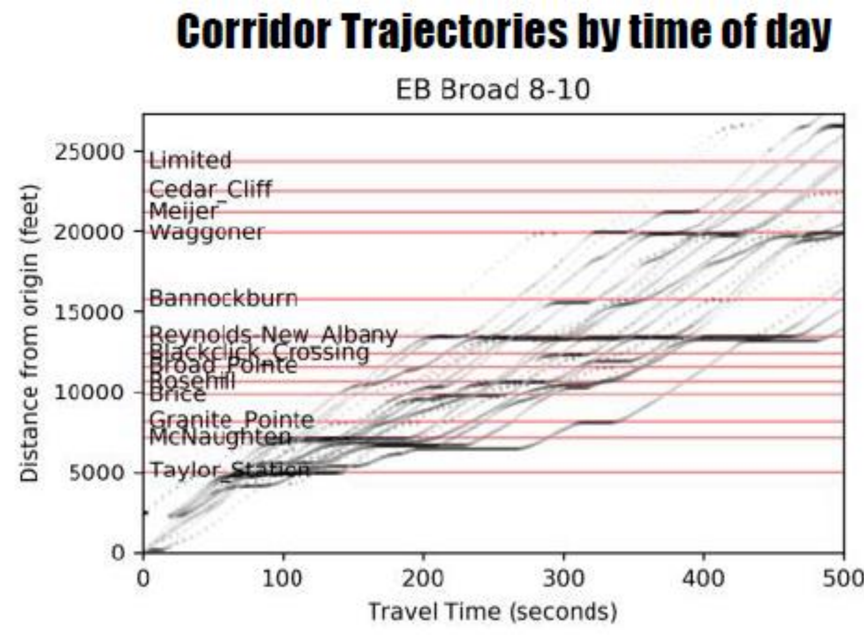
Information available:

- **Trip file:**
- Start & end point date and time
- Start & end point lat/lon values
- Travel distance & vehicle type
- Device and Provider ID#s

- **Waypoint file:**
- Trip ID# & (joined) XD segment
- Date/time & lat/lon values
- (Instantaneous) speed

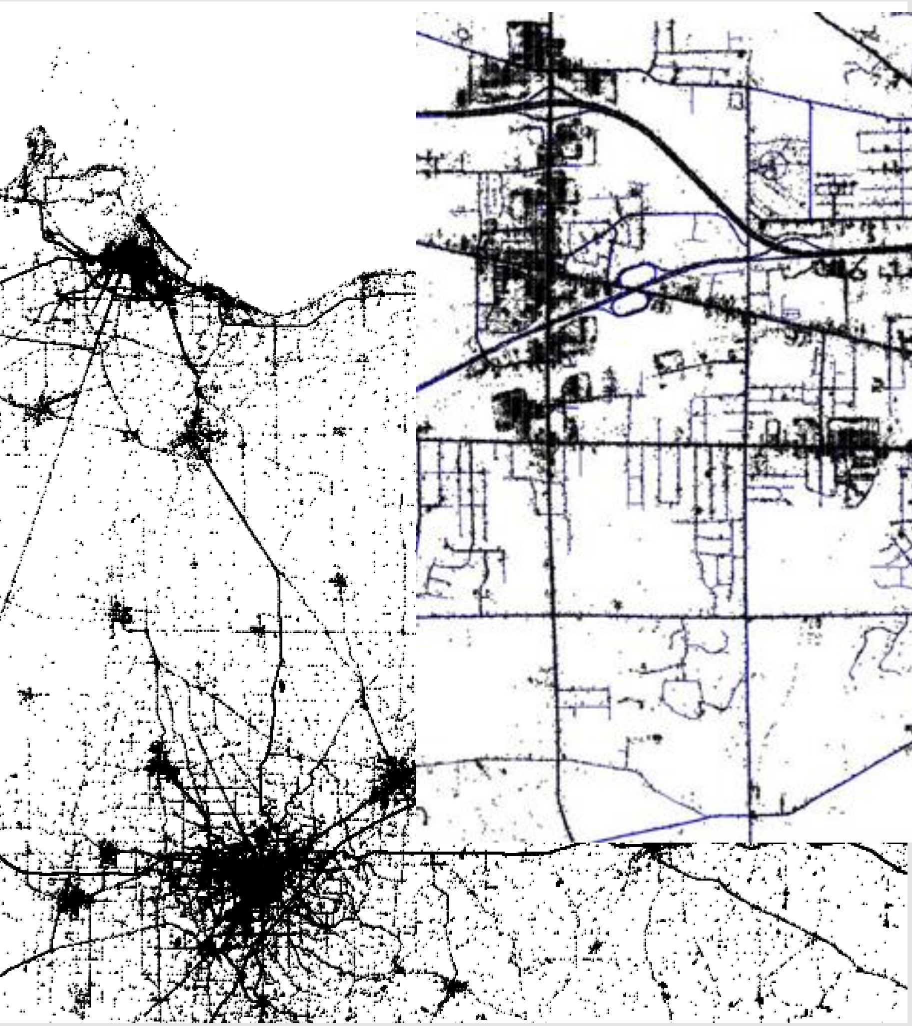
Use of this "trajectory" data, to date:

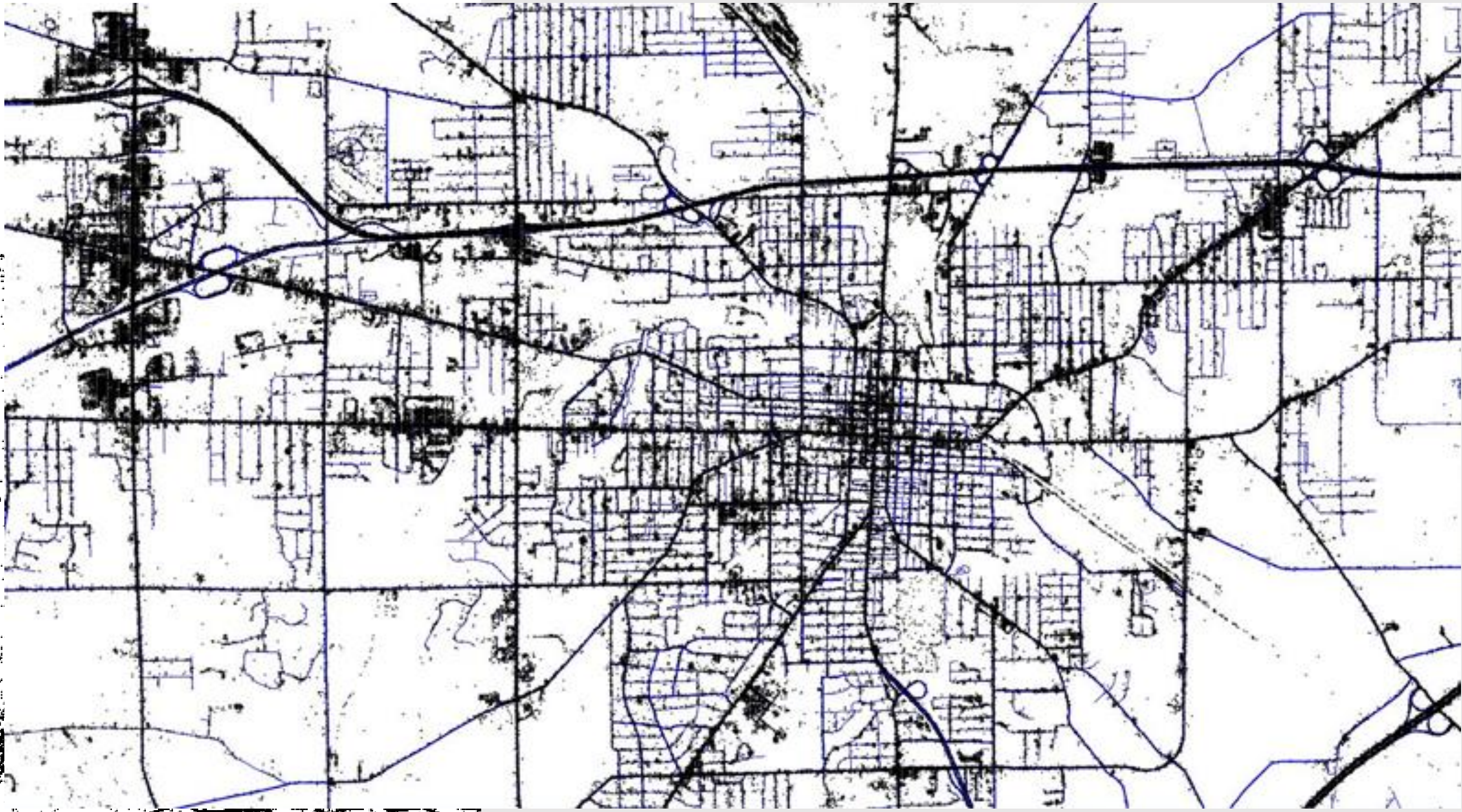
- **City of Columbus:**
- Vehicle dwell times & locations for EV charging stations.
- Traffic signal coordination/performance measures.



- **Ohio DOT:**
- Traffic volume K and D factors.
- **O/D travel route choice.**
- Trip-level travel time reliability.
- Delay at Railroad crossings.
- Vehicle acceleration/deceleration rates "in the field."

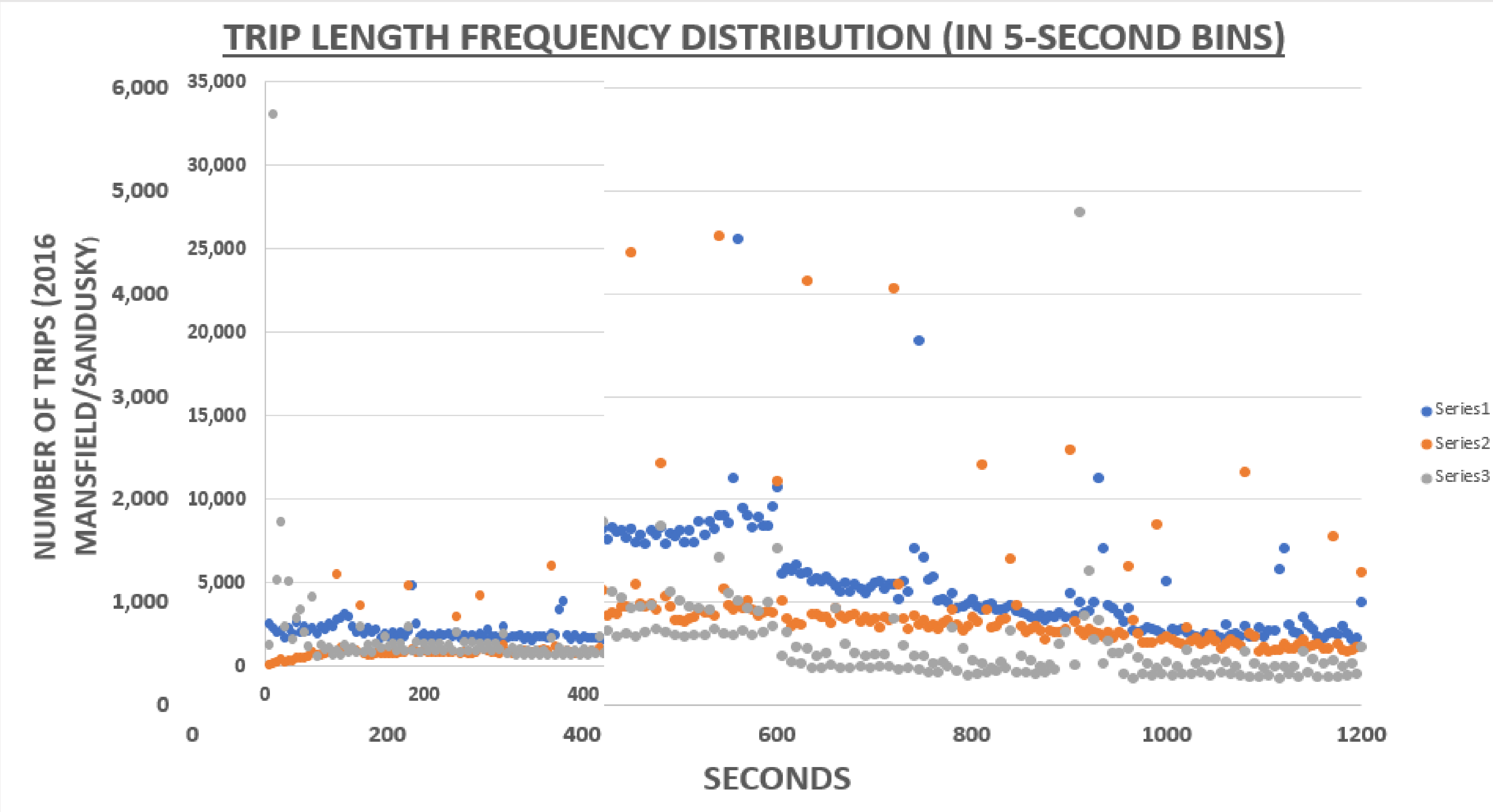
Started with trip & waypoint data for two smaller urban areas with detailed data on modeled travel paths….





Trip lengths by vehicle class:

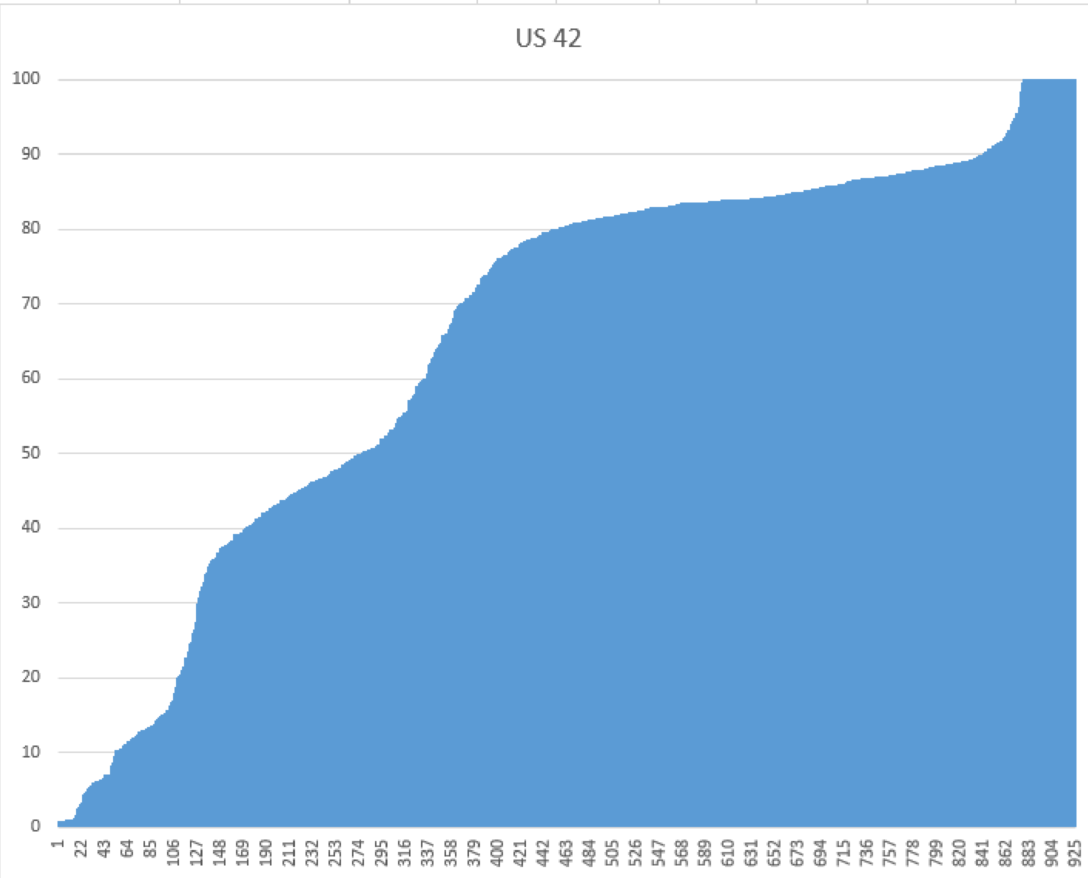
- Many are "short bursts" (exp. smartphone app use) that for most applications would get filtered out.

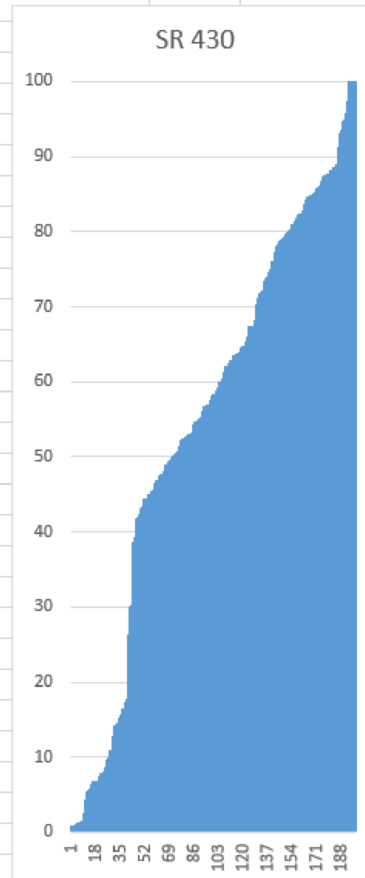


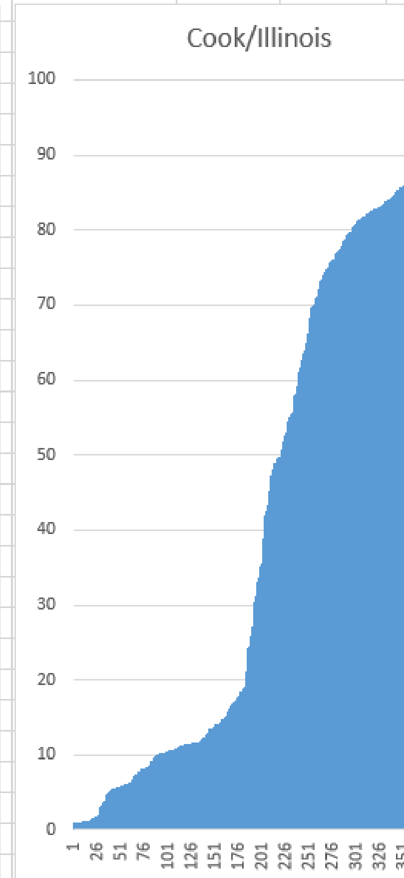
Distribution of Trips by average waypoint density (sample of small urban arterials):

Sample Arterial Corridor (Mansfield)	From	To	Length (miles)	Direction of travel	N XD segments	AADT (2w) range	First XD seg ID	Length (miles)	Last XD seg ID	Length (miles)	N Trip IDs both in first&last XD	N Trips w/Waypt spacing < 5 sec
US42 (Lexington)	Orchard Park Rd	SR13 (Main)	5.7	NB	15	8-13,000	1346316466	0.36	1346364809	0.44	925	26
SR430 (Park Ave)	SR13 (Mulberry)	SR309	4.6	WB	13	6-17,000	1346378350	0.27	1346458668	0.51	198	10
Cook Rd/Illinois St	US42	SR39	4.3	EB>NB	10	9-11,000	1346361506	0.48	1346463019	0.47	434	37

Graphs of average waypoint spacing (y-axis) by the number of Trip records (x-axis)







Trip/Waypoint file filtering for route choice and trip-level reliability:

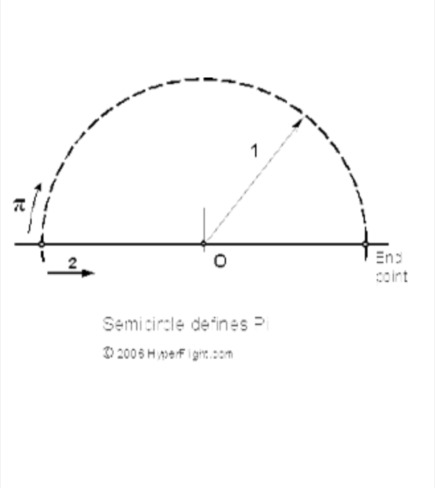
- Focus for this application on **cars** and on **surface streets.**
- Criteria not "hard & fast" (balance ideal w/sample size).
- Filtered out 95% of car trips (down to about N=25,000).

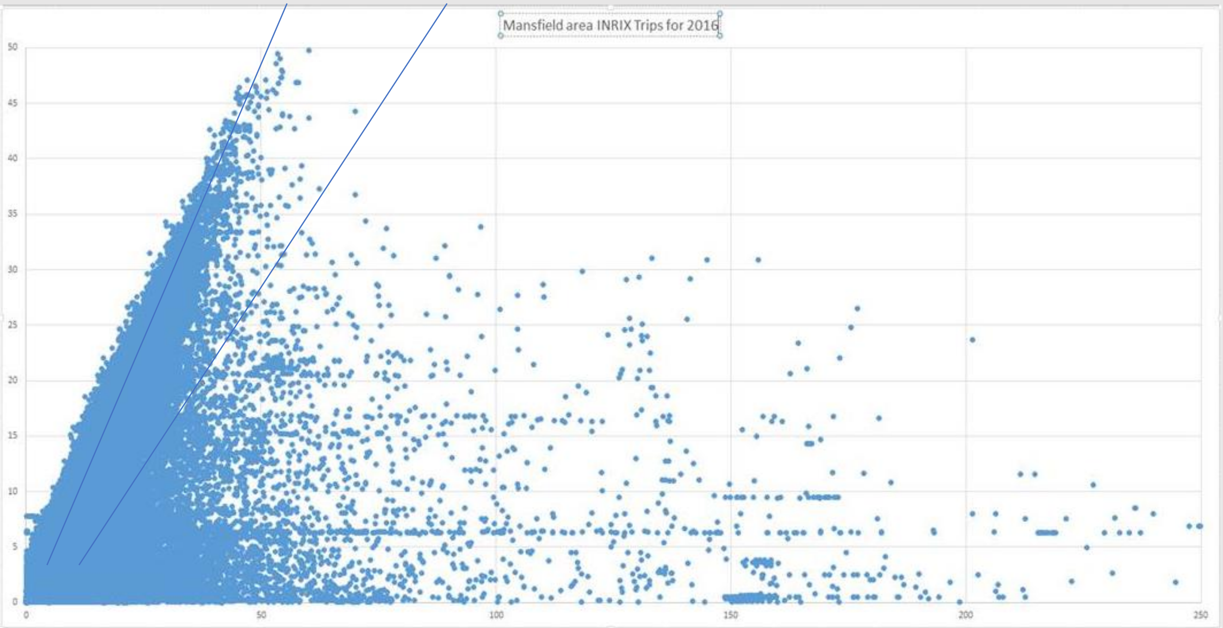
B—Route Choice, and Trip-level travel time reliability (for cars only)

Field		
Vehicle Class	1	
OD_CONCAT (on MPO network)	<>null, N>9	(at least 10 records meeting specs to then use WP file)
Seconds per waypoint:	<15	
Average FRC value	>=2	(avoid Interstates, which are not within either UZA)
Number of waypoints	>39	(affects accuracy of measured trip distance)
Percent of waypoints snapped to XD	>69	(focus more on trip record side data for B)
Trip average speed kph	15-80	(10-50 mph, to keep the focus on arterials)
Distance from trip start/end to model network node	<0.25 m	
Minimum Trip distance	(O/D modeled shortest distance) – D2StartNode - D2EndNode	
Maximum Trip distance	(O/D modeled distance on shortest time path *(3.14157/2)) ± join distances	
Travel time (seconds)	>480	(i.e. the longer the trip, the less the join distance matters)

Example of "wholesale" filtering for trip distance (vs O/D network distance)

- Trip circuity as indicator of "intermediate" stops.
- Arc-based formula (+ distance to & from the modeled network) removed about 10% of the Trips in the file (manual reviews were then conducted for the most frequently observed travel paths).



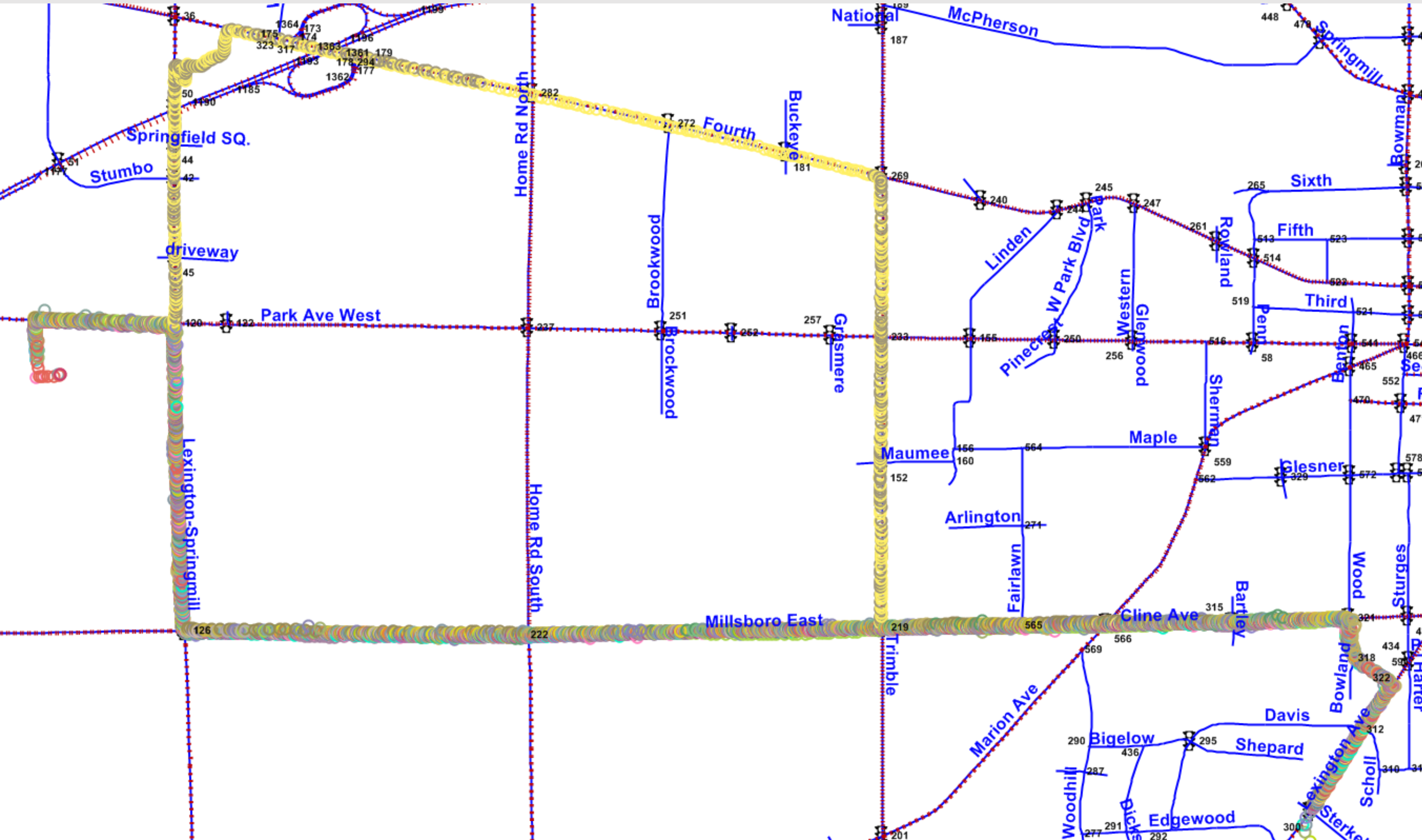


Results found to date (1 of 2):

- Top 12 O/D movements by (filtered) sample size below.
- Some "intermediate stops" easier to detect than others.
- Occasional issues with modeled vs observed travel time (in large part due to sampled vehicle driver).

								From travel demand model:						Percent dif
			Observed (GPS) travel time and distance					Observed travel path:			Estimated shortest path:			between s
Orig Node	Dest Node	N	Avg.Dist (miles)	Std Dev	Avg.time (minutes)	Std Dev	XD net** Avg.time	Avg.Dist (miles)	Avg.time (minutes)	Std Dev	Avg.Dist (miles)	Avg.time (minutes)	Std Dev	and GPS pa Distance
117	300	31	5.4	0.1	10.1	1.12		5.7	10.1	2.62	5.5	10.1	2.62	3.8%
3199	201	27	14.4	0.2	19.3	2.16		14.5	20.0	4.14	11.2	17.7	4.74	29.6%
1011	40	32	6.6	0.2	12.8	2.42	11.3	6.4	10.6	2.25	6.4	10.6	2.25	0.0%
769	250	52	3.7	0.1	8.2	1.24		3.7	8.5	2.14	3.7	8.5	2.14	0.0%
237	2220	17	11.5	0.2	22.1	2.79	20.0	11.9	18.9	3.97	11.8	18.7	3.64	0.5%
863	1038	21	10.6	0.1	16.2	1.34		11.0	15.7	3.85	7.4	15.5	3.50	48.9%
2182	410	18	12.2	0.1	16.3	1.05		12.4	18.1	3.84	11.9	16.9	4.21	4.2%
462	572	16	5.7	0.1	9.8	0.69		6.3	9.4	2.36	5.1	9.0	2.24	24.7%
1038	543	12	6.8	0.1	13.7	0.76		7.1	13.0	2.64	6.3	12.6	2.68	14.2%
2313	635	11	12.3	0.2	19.1	1.91		13.4	21.2	4.76	12.6	21.2	4.76	6.1%
1044	912	8	13.2	0.1	24.0	1.71		13.6	22.8	5.48	12.6	20.1	4.51	7.6%
1058	1492	8	7.0	0.1	13.8	1.77	11.1	7.1	11.6	2.59	7.0	11.6	2.59	1.2%
Overall average:			9.1	0.1	15.4	1.58		9.4	15.0	3.39	8.5	14.4	3.32	11.7%

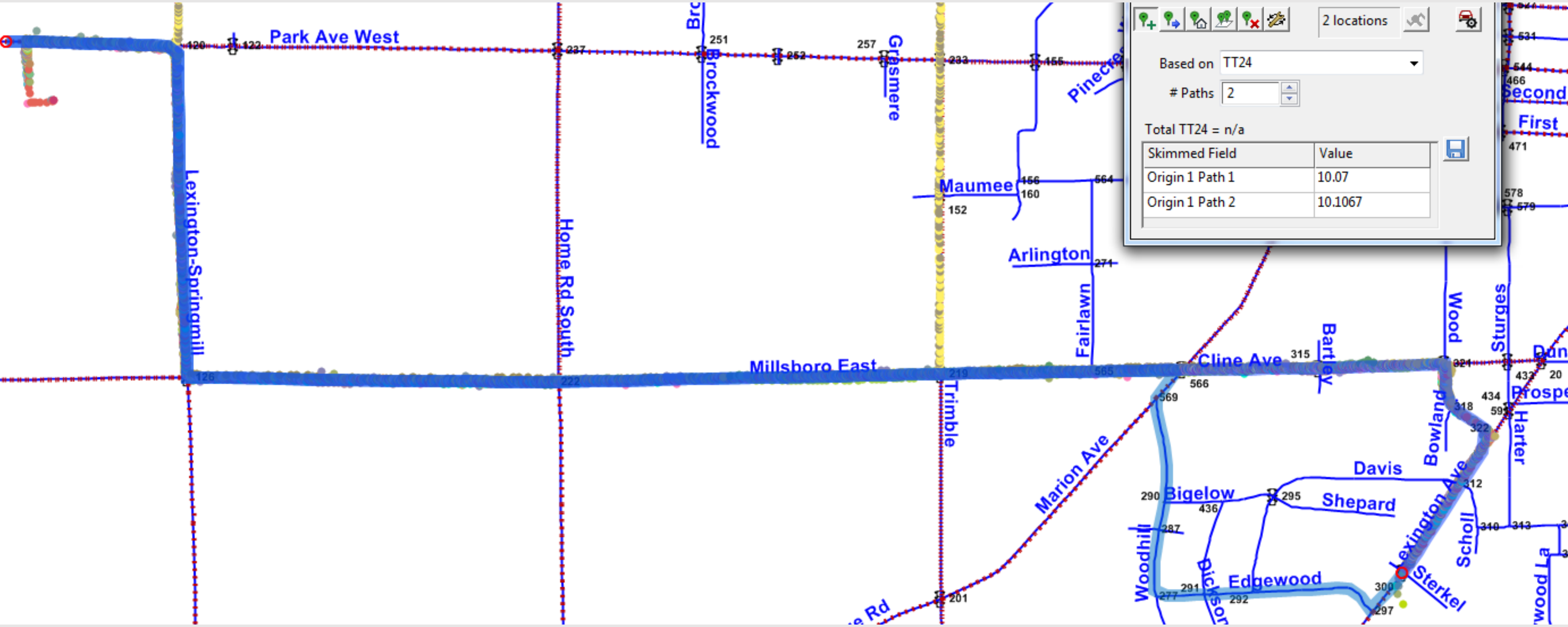
O/D pairing example #1 (> 30 trip records)



- 2 trips filtered out by distance.
- 2 more trips clearly have an intermediate stop (not filtered).
- Modeled time = time from data.

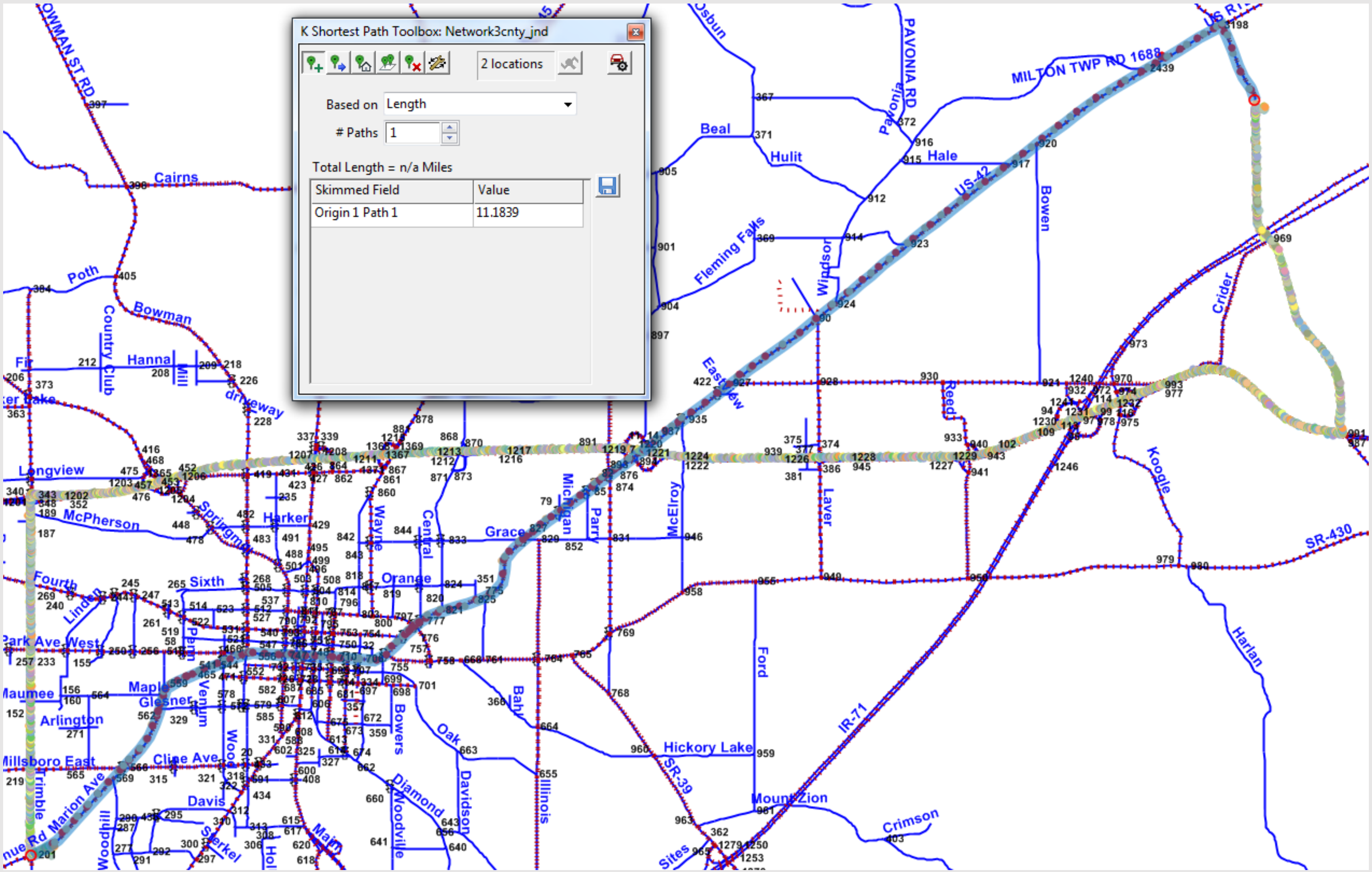
O/D pairing (still using example #1):

The (most) observed travel path is estimated to have the most “reliable” travel time, 2nd best for average travel time, and 12th best for distance.

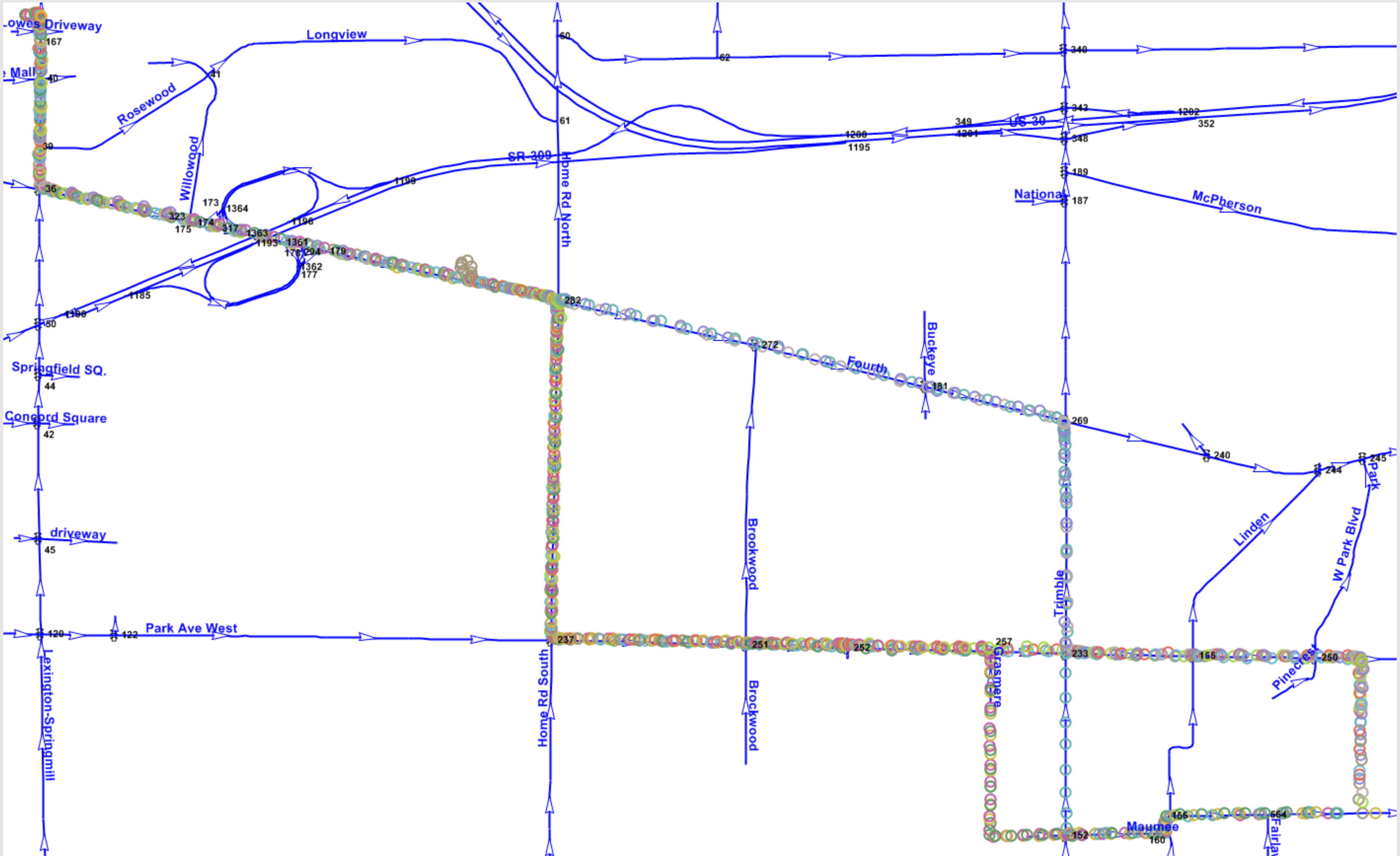


O/D pairing example #2: 29 trip records

- 2 trips followed the shortest distance path, rest on a path maximizing freeway distance - not minimizing either total time or distance.



Example of O/D pair that was not used.



Results found to date (2 of 2):

- Identical result to more extensive study done at Univ. of Minnesota regarding relative importance of time and distance (1/3 of travelers on shortest time path, none on shortest distance path unless identical to shortest time).

					From travel demand model:						Percent difference		
Observed (GPS) travel time and distance					Observed travel path:			Estimated shortest path:			between shortest		
Avg.Dist	Std Dev	Avg.time	Std Dev	XD net**	Avg.Dist	Avg.time	Std Dev	Avg.Dist	Avg.time	Std Dev	and GPS paths (model)		
(miles)		(minutes)		Avg.time	(miles)	(minutes)		(miles)	(minutes)		Distance	Avg.time	Avg +SD
5.4	0.1	10.1	1.12		5.7	10.1	2.62	5.5	10.1	2.62	3.8%	0.4%	0.0%
14.4	0.2	19.3	2.16		14.5	20.0	4.14	11.2	17.7	4.74	29.6%	13.0%	7.5%
6.6	0.2	12.8	2.42	11.3	6.4	10.6	2.25	6.4	10.6	2.25	0.0%	0.0%	0.0%
3.7	0.1	8.2	1.24		3.7	8.5	2.14	3.7	8.5	2.14	0.0%	0.0%	0.0%
11.5	0.2	22.1	2.79	20.0	11.9	18.9	3.97	11.8	18.7	3.64	0.5%	1.1%	2.4%
10.6	0.1	16.2	1.34		11.0	15.7	3.85	7.4	15.5	3.50	48.9%	1.3%	2.9%
12.2	0.1	16.3	1.05		12.4	18.1	3.84	11.9	16.9	4.21	4.2%	7.3%	4.1%
5.7	0.1	9.8	0.69		6.3	9.4	2.36	5.1	9.0	2.24	24.7%	5.4%	5.4%
6.8	0.1	13.7	0.76		7.1	13.0	2.64	6.3	12.6	2.68	14.2%	2.9%	2.1%
12.3	0.2	19.1	1.91		13.4	21.2	4.76	12.6	21.2	4.76	6.1%	0.0%	0.0%
13.2	0.1	24.0	1.71		13.6	22.8	5.48	12.6	20.1	4.51	7.6%	13.4%	14.9%
7.0	0.1	13.8	1.77	11.1	7.1	11.6	2.59	7.0	11.6	2.59	1.2%	0.0%	0.0%
9.1	**0.1**	**15.4**	**1.58**		**9.4**	**15.0**	**3.39**	**8.5**	**14.4**	**3.32**	**11.7%**	**3.7%**	**3.3%**

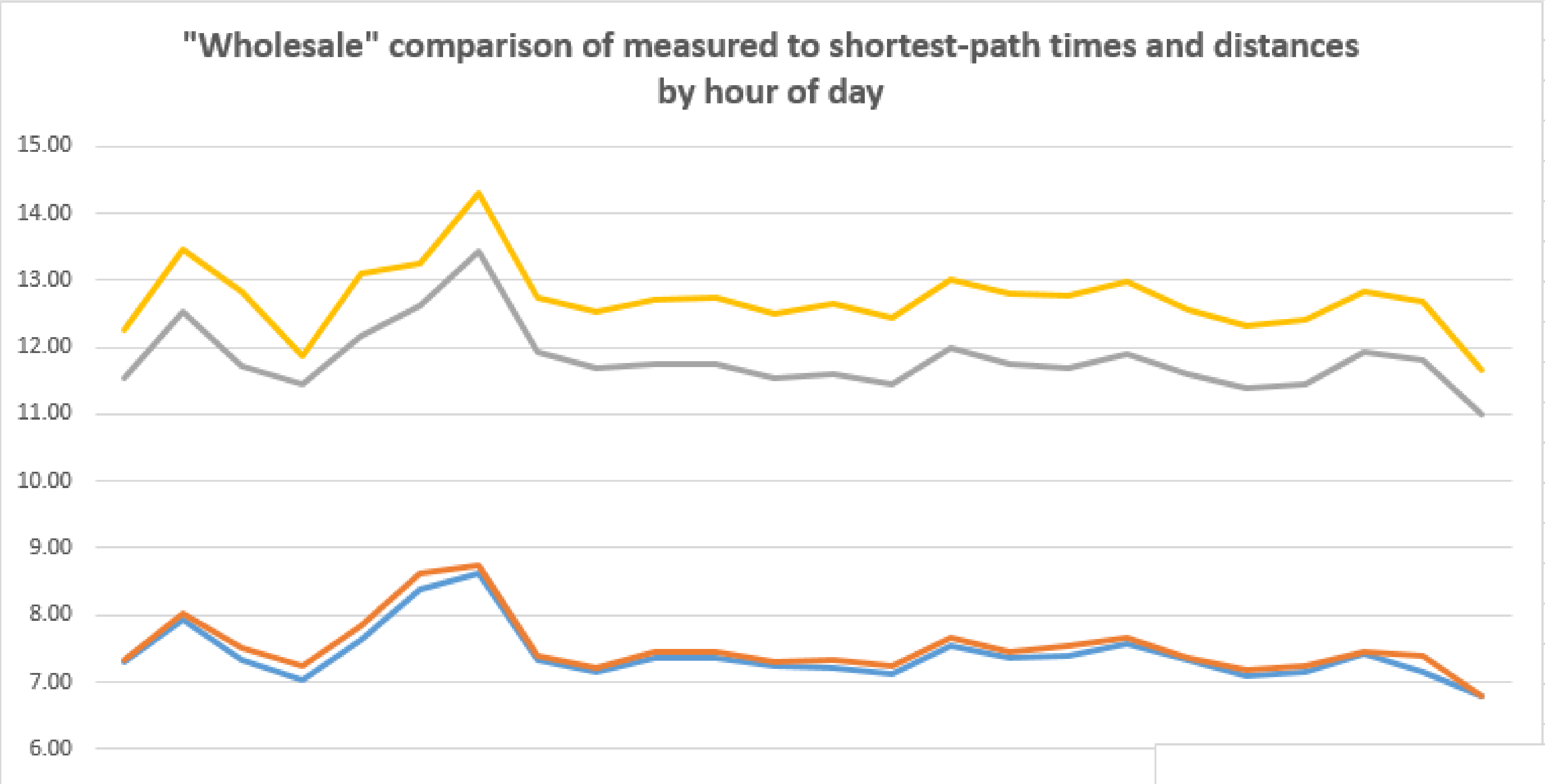
Any insight from a more "wholesale" analysis of the trip records without **<u>any</u>** manual review?

- Cursory comparison of measured Trip times and distances with (modeled) shortest paths found a closer comparison to shortest <u>distances</u> instead – is it due to differences in driver/trip purposes (largest O/D sample sizes used were all in the AM peak period), or is it the lack of "weeding out" the intermediate stops?

- If trip <u>purpose</u> is the reason, than we might see a pattern in terms of the <u>hour of day</u> the Trip is made.
- A more abbreviated filtering of Trips was conducted, based on "constrained" values of measured/modeled trip times.

.....But <u>no significant difference</u> by TOD was found

- X-axis=hour of day, y-axis=average distance (7-9 miles) or average times (11-14 minutes).
- So there's still a need to "manually" review records.



Conclusion: “further research is needed”

- So far, minimizing travel time still more important than minimizing distance for traffic assignment, with the impact of the variability (reliability) of travel time somewhat smaller (light congestion levels in tested regions).
- Observed variability in O/D travel time considerably less than estimates used for modeling. (Likely due to little or no heterogeneity in sampled vehicle drivers by O/D pairing.)
- Need better/more extensive filtering of intermediate stops before moving to a more “wholesale” analysis of the full data set.

Questions?

RR grade crossing delay analysis:

- Typically, RRX delay filtered out of GPS travel time data for road segments. So, hoped to use waypoints to find delay to motorists as well as general pattern of train arrivals.

- Can be difficult to see these patterns, esp. when road or rail volumes are low, or other sources of delay are nearby.

- Specific locations could be estimated when consecutive waypoints are found to have no "spot speed." Data needs review for directionality relative to the crossing and not due to other causes. (And max trip "delay" of 10 minutes.)

Sample RRX: NS crossing @ Remington Ave

- Double-track, Xing about 800’ SW of traffic signal @ US 6.
- AADT=6,000, estimated 94 trains/day (avg. 4/hour).
- Waypoints from 3,300 vehicle trips were mapped within 500 feet of the crossing in 2018, about 15% of the trips had at least one waypoint with no travel speed (after filtering).

Sample use of consecutive waypoints to solve a modeling question:

SIMPLE CASE OF UNIFORM TRAIN HEADWAY AND CHARACTERISTICS:

A = TIME THE RR CROSSING IS BLOCKED

B = TIME FOR THE VEHICLE QUE TO CLEAR

C = TIME BETWEEN TRAINS **(A < B << C)**

SAMPLE VALUES: A = 2.15 MINUTES, B = 2.4 MINUTES, C = 15 MINUTES

AVERAGE DELAY = 0.22 MINUTES

STD. DEVIATION = 0.47 MINUTES, CV = 2.1

ESTIMATE FROM REMINGTON AVE WAYPOINT DATA:

AVERAGE DELAY = 0.13 MINUTES

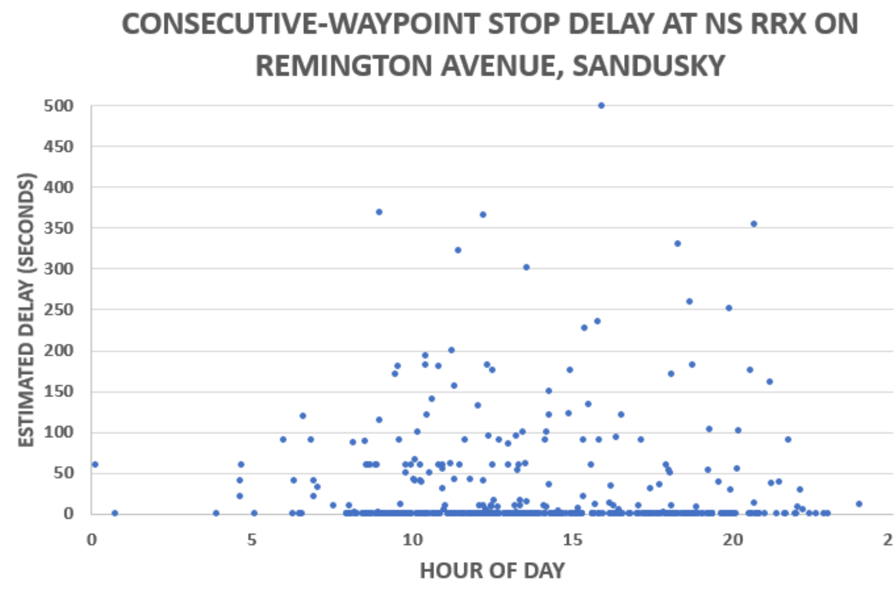
STD. DEVIATION = 0.44 MINUTES, CV = 3.5

TRAVEL MODEL'S CV EQUATIONS FOR PATH-BUILDING:

FREEWAY: CV = 0.16 * (t/to)^1.02 * ((dist)^-.39)

SURFACE STREET: CV = 0.106 * (t/to)^.776 * ((dist)^-.122)

(SURFACE STREET W/RRX?: data suggests use constant term of around 3.3 - or around 2.8 if reducing distance coefficient value to zero.)



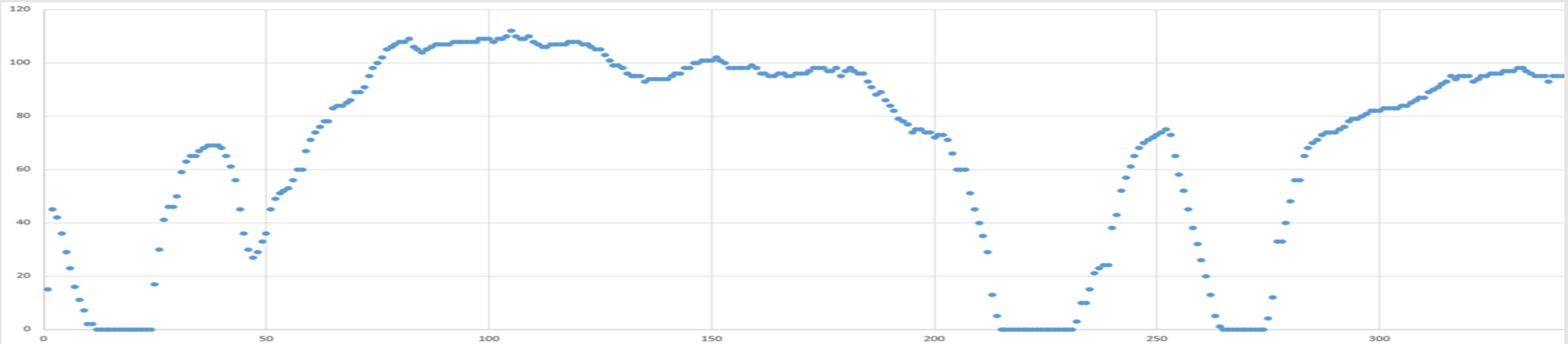
File filtering for vehicle acceleration profiles:

- Criteria used for vehicle acceleration profiles are shown below: focus on tight waypoint spacing.
- Only **<u>9</u>** truck Trips (of 2.2 million) and **<u>90</u>** car Trips (of 600,000) met the criteria…

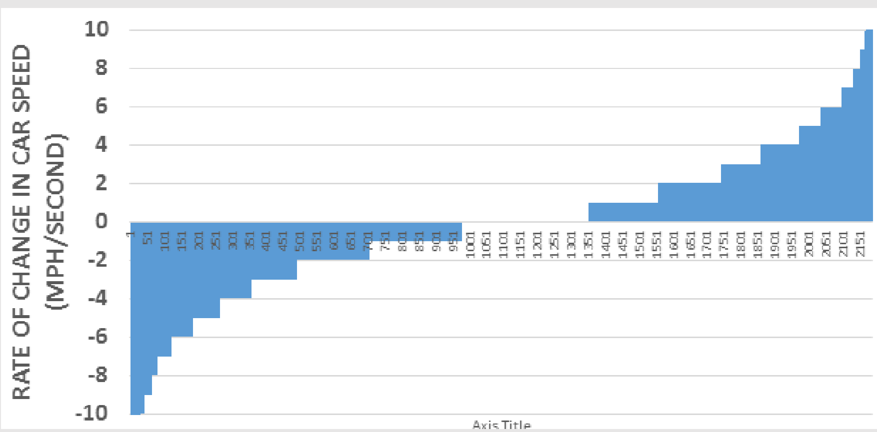
A—Vehicle Acceleration Profiles

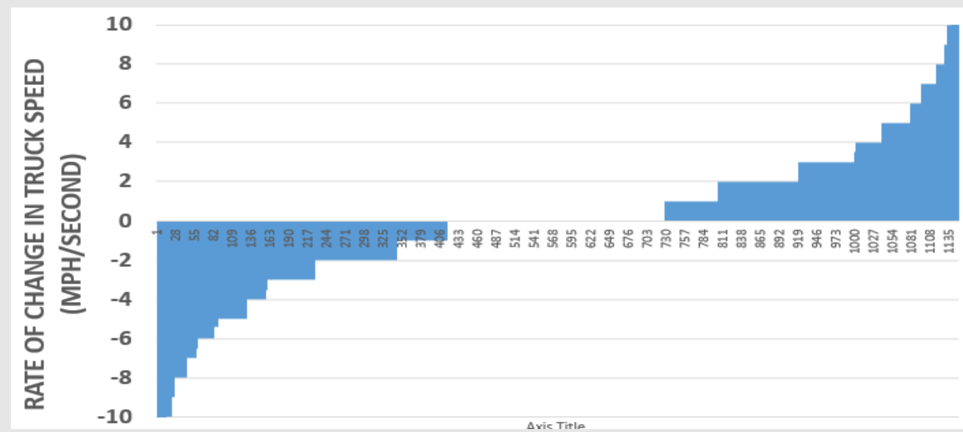
Field	Car	Truck:	
Vehicle Class	1	3	
Seconds per waypoint:	=1.0	<1.3	(ideally 1.0 per second, but no truck trip records meet that)
Average FRC value	>=3.5	>=2	(avoid freeways, but US30 as well as US42&SR13 are FRC=2)
Number of waypoints	>299	>99	(need large number to find some accel/decel locations)
Pct snapped waypoints	>74	>49	(so that trucks are not just found in parking lots?)
Trip average speed kph	31-60		(already down to just 9 truck records
Max trip speed kph	<100		“ “
OD_CONCAT (on MPO net)	<>null		“ “

- Sample car speed record from waypoints every second.



- Range of car (left) and truck (right) values of change in MPH per second, sorted by value:





Puzzling to find (so far) that accel rates = decel rates, and rates for cars = rates for trucks . . .

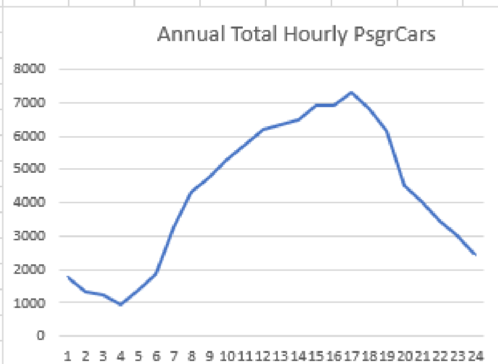
K & D factors:

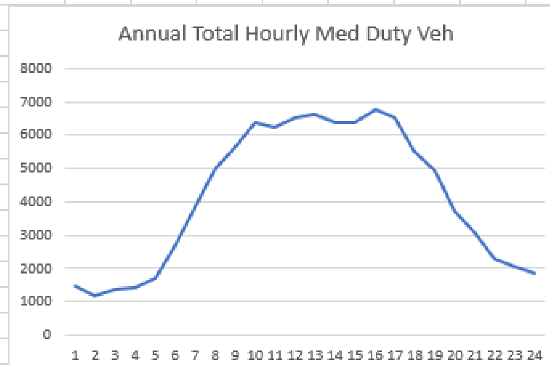
Annual Totals

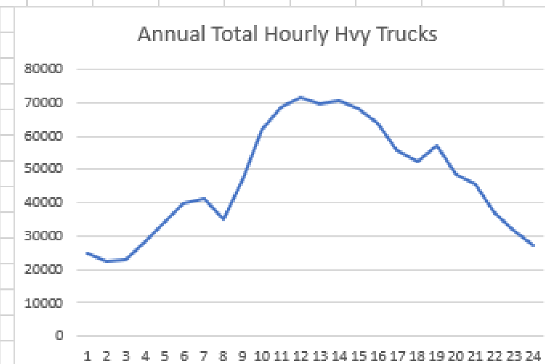
	Hour											
	0	1	2	3	4	5	6	7	8	9	10	11
Cars	1775	1327	1216	968	1377	1839	3237	4310	4754	5306	5739	6208
Med Duty	1491	1163	1377	1442	1702	2668	3891	4996	5600	6388	6238	6507
Hvy Trk	24767	22269	23060	28316	33976	39678	41088	34860	47098	62054	68854	71761
Total	28033	24759	25653	30726	37055	44185	48216	44166	57452	73748	80831	84476
%Truck est	88.3%	89.9%	89.9%	92.2%	91.7%	89.8%	85.2%	78.9%	82.0%	84.1%	85.2%	84.9%
% Cars	1.73%	1.29%	1.19%	0.94%	1.34%	1.79%	3.16%	4.21%	4.64%	5.18%	5.60%	6.06%
%Med Duty	1.50%	1.17%	1.38%	1.45%	1.71%	2.68%	3.91%	5.02%	5.63%	6.42%	6.27%	6.54%
%Trk	2.20%	1.98%	2.05%	2.52%	3.02%	3.53%	3.65%	3.10%	4.19%	5.52%	6.12%	6.38%

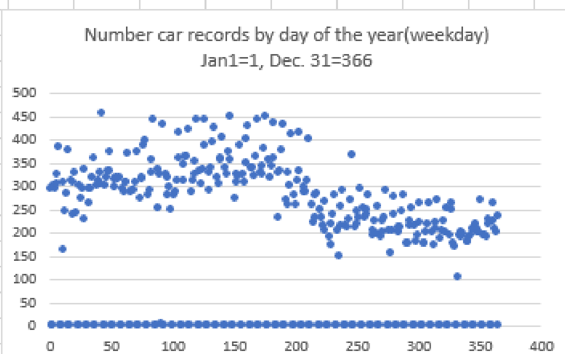
	Hour												Total	
	12	13	14	15	16	17	18	19	20	21	22	23		
Cars	6345	6508	6911	6942	7317	6818	6171	4517	4009	3435	3027	2428	102484	
Med Duty	6629	6379	6370	6745	6535	5515	4929	3717	3075	2288	2054	1847	99546	
Hvy Trk	69535	70718	68100	63689	55844	52366	56920	48250	45669	36961	31841	27197	1124871	
Total	82509	83605	81381	77376	69696	64699	68020	56484	52753	42684	36922	31472	1326901	
%Truck est	84.3%	84.6%	83.7%	82.3%	80.1%	80.9%	83.7%	85.4%	86.6%	86.6%	86.2%	86.4%	Avg	84.77%
													85.54%	
% Cars	6.19%	6.35%	6.74%	6.77%	7.14%	6.65%	6.02%	4.41%	3.91%	3.35%	2.95%	2.37%	100.00%	
%Med Duty	6.66%	6.41%	6.40%	6.78%	6.56%	5.54%	4.95%	3.73%	3.09%	2.30%	2.06%	1.86%	100.00%	
%Trk	6.18%	6.29%	6.05%	5.66%	4.96%	4.66%	5.06%	4.29%	4.06%	3.29%	2.83%	2.42%	100.00%	

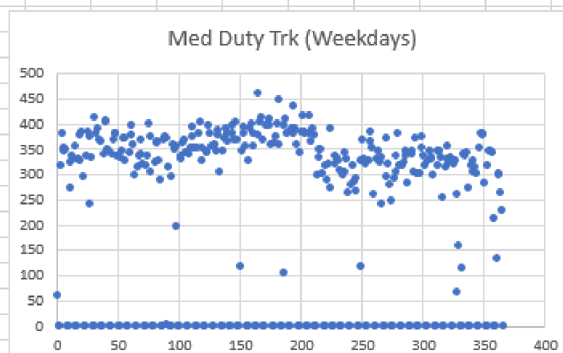
Year Total
1326901
Average
3625.41
30th Hour
342
K30
0.0943

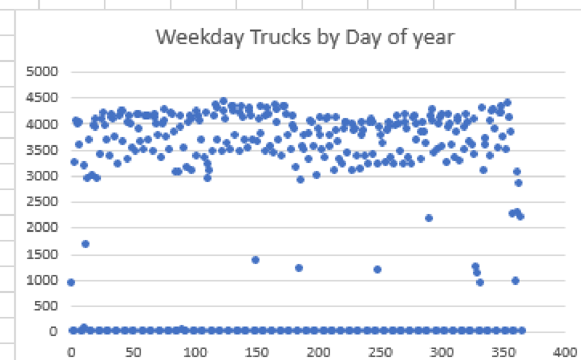












Sample RRX: CSX@SR 161 near Don Scott

- 4600’ e/o airport entrance, 800’ w/o signal @ Linworth Rd.
- AADT=8,000, estimated 30 trains/day.
- Waypoints from 336 EB trips were found within 400 feet of RRX in 2016, 10% of the trips had at least one waypoint w/no travel speed (after filtering).