Modeling Americans' Target Driving Speed by Road Type

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The operating speed of vehicles is used to perform many types of traffic studies, but little is known about the driving speed American drivers target in their minds. To model drivers' speed targets and resulting speed distributions, the author performed a web-based survey of 252 drivers across the United States and asked how fast they would try to drive in relation to the posted speed limit on different highway facilities. The results revealed that the majority of drivers try to drive faster than the posted speed limit. In drivers' minds, less than the 40th percentile and 20th percentile target driving speed on local streets and freeways, respectively, were lower than the posted speed limit. Compared to the posted speed limit, the 85th percentile target speed was 10 mph faster on local streets and 15 mph faster on freeways. Simulations indicated that the resulting speed distribution (observable speed) on local streets can be approximated by a normal distribution when speed fluctuations normally distributes around the target speed with $\sigma = 6$ mph or larger. On the same condition, the normality was not observed for a simulated speed distribution on freeways. Further modeling of target driving speed by posted speed limit in conjunction with more detailed highway facility type and local driver populations will improve the model's external validity.

Keywords: Speed Choice, Driving Speed, Speed Limit, Speeding, Speed Enforcement

HIGHLIGHTS

- Americans' target driving speed distributions were modeled in relation to posted speed limit by road type.
- Compared to the posted speed limit, an average driver wants to drive 4-5 mph faster on local streets and 7-8 mph faster on freeways.
- When a driver's speed fluctuation normally distributes with 6-mph σ, the resulting speed distribution can be approximated by N(4.14, 9.41²) on local streets.
- The presented speed distribution can be used as initial input for traffic studies when no speed distribution is available.
- The cumulative distcibution functions (CDFs) are attached in the Appendix.

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I. INTRODUCTION

O^{PERATING} speed is a fundamental element of vehicular traffic. Because higher driving speed is associated with larger stopping sight distance (SSD) and kinetic energy (American Association of State Highway and Transportation Officials, 2018), crash rate and severity tend to have positive correlations with driving speed (Aarts and van Schagen, 2006; Elvik et al., 2019).

Driving speed and its distribution are critical variables in traffic studies. In the United States, observed 85th percentile speed had been widely used as a basis of setting posted speed limits (Federal Highway Administration, 2009). Furthermore, current engineering practices—from signal warrant studies to microscopic traffic simulations—often let engineers consider the 85th percentile speed as an equivalent of the existing posted speed limit when no other information is available. For example, Section 4C.01 Paragraph 17 of the Manual on Uniform Traffic Control Devices states "the posted or statutory speed limit or the 85th-percentile speed" can be used to determine the applicability of a lower volume thresholds for signal warrants (Federal Highway Administration, 2009).

Speed distributions are also often required in microscopic simulations. Although ideally the distributions should be obtained or constructed through field measurement, assumptions are made in the absence of field data. In the Traffic Engineering Handbook, Findley (2016) introduces the rules of thumb of spot speed variance by road types (i.e., rural vs. urban, two-way vs. four-way) in the United States based on values collected by Box and Oppenlander (1976). Prior to the publication, Berry and Belmont (1951) had reported that empirically spot speed could be well approximated by a normal distribution. Such parametric speed distributions provide some rationale when practitioners need to estimate speed information as input of traffic studies.

Now some questions arise. When no speed distribution data is available, what is a reasonable relationship between an existing posted speed limit and an actual speed distribution? In fact, literature reports that 85th percentile speed tends to exceed posted speed limit (Savolainen et al., 2018). In free-flow conditions, why can driving speed be approximated by a unimodal (i.e., characterized by one peak) distribution such as a normal distribution? As Hauer (2009) points out, there is a gap or scarcity of research approaching why or how speed distributions are shaped from a driver's mental model. Based on the theory of planned behavior, Warner and Åberg (2006) identified that attitude towards the speeding, subjective norm, and perceived behavioral control as significant determinants of self-reported speeding, but how drivers' target speed distributes? Modeling such relationships will contribute not only to common traffic studies but also to the development of anthropomorphic driving models.

The objective of this preliminary research was to narrow this knowledge gap by modeling American drivers' target driving speed. Because the author has heard multiple people saying, "I usually drive *** mph faster than the speed limit," drivers' target speed distributions were modeled by road type in relation to the posted speed limit.

The distribution of drivers' speed target is likely to be discrete because it, for example, is hard to try to drive 3.776 mph faster than the posted speed limit. On the other hand, a vehicle's realized speed, either as a result of drivers' output or autonomous driving features, distributes around the target speed because vehicle control consists of a constant feedback loop of human, vehicle, and environment. Driving speed can fluctuate around one's target speed when the driver's speed choice is influenced by other vehicles (e.g., passing behavior). Even without interactions with other vehicles, one's driving speed can vary by 1-2 mph or so². In addition, drivers could have a target driving speed "range" rather than a target speed. For these reasons, this paper first obtained discrete speed distributions and further modeled the expression of the driver's target speed as continuous distributions. The following section describes the research methodology.

II. METHODS

A web-based survey was conducted on SurveyMonkey³ for people of 16 years or older across the United States on May 9, 2021. While participants of a web-based survey could be more tech-savvy than the general driver population, the potential bias on results was considered as negligible as there do not seem to be reasons to believe tech-savvy people's driving behavior is different from

² One can experience this with cruise control on rolling or mountainous terrain.

³ https://www.surveymonkey.com/

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a general driver population (Savolainen et al., 2012). The author paid SurveyMonkey \$1.25 per responder for a minimum of 200 responders. Participants were compensated from SurveyMonkey though the author is not aware of the monetary value they received in exchange for the participation. Because the sampling process was not truly random, it is difficult to evaluate estimation precision statistically, but 200 was larger than the required sample size for mean estimation assuming $\alpha = 0.05$, $\sigma = 5.3$ mph (Box and Oppenlander, 1976), and a 1-mph margin of error.

In the survey, participants were asked to fill in the blank of the following statements with an integer by sliding a handle on a scale (Fig. 1):

"On uncongested [road type], I try to drive ____ mph faster than the posted speed limit."

* 1. On uncongested urban loca	al streets , I try to drive *** mpł	n faster than the posted speed limit.
-40	0	+40
0		

Fig. 1. A scale bar to indicate a target speed in integer. The number appeared in the right box when participants moved the handle.

The questions were repeated four times to collect responses for different road types: urban local streets, urban freeways, rural local streets, and rural freeways. Among the seven Highway Functional Classifications designated by the Federal Highway Administration (2013), equivalents of only three classifications (*Interstate + Other Freeways and Expressways* vs. *Local*) were considered in this study because an average driver would not recognize highway types by the FHWA's Highway Functional Class.

To provide clarity on how to respond, the following examples were shown at the beginning of the survey.

- "+3" means 3 mph faster than the posted speed limit.
- "0" means equal to the posted speed limit.
- "-3" means 3 mph slower than the posted speed limit.

There is no guarantee that all drivers have their target driving speed in relation to the posted speed limit, so participants were asked to indicate values between -38 mph and -30 mph from the posted speed limit if they do not target specific driving speed based on the posted speed limit. This operation was not ideal since it creates a possibility to miss true responses from those who aim 38-30 mph slower than the posted speed limit. However, this was a practical solution given the author's budget and the assumption that few people would want to drive at such a slow speed.

The four questions were followed by six other questions on separate pages that were not related to this study. To eliminate unreliable responses from those who randomly answer questions as quickly as possible to make money quickly, one minute (six seconds per question) was set as the minimum threshold for responses to be considered valid.

Statistical analysis was performed in Microsoft Excel and R 4.0.2. Discrete speed distributions were first determined based on the responses. In addition, a continuous speed distribution was modeled to explore how drivers' operating speed would emerge from the target speed distributions. Fluctuations of speed control are assumed to be normally distributed around each driver's target speed. The standard deviations of 1-6 mph were modeled at a 1-mph increment.

III. RESULTS

A total of 306 people participated in the survey. Of the 306 responders, 54 responders (17.65 percent) who completed the questionnaire in less than a minute were eliminated from the study. As a result, responses from 252 participants were analyzed. The self-reported demographics of the participants consisted of 147 females and 104 males (one participant did not indicate gender) between 16 and 89 years old (M = 46.46, SD = 16.60).

Table 1 displays descriptive statistics of the responses. In each condition, mean target speed was positive. Freeways were associated with a larger positive deviation from the posted speed.

TABLE 1. Descriptive statistics of response	ΤA	ABLE	1.	Descrip	ptive	statistics	of	responses
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Road type	n	М	SD	Min	P ₁₅	P ₂₅	Mdn	P ₇₅	P ₈₅	Max	10-mph pace
Urban local street	252	4.52	8.46	-21	0	0	3	6	10	40	0-9
Rural local street	251	4.68	8.39	-20	0	0	2	6	10	40	0-9
Urban freeway	252	7.67	9.14	-27	0	1	6	10	15.35	40	0-9
Rural freeway	252	8.23	9.75	-27	0	3	7	10	15	40	3-12

Note: Unit is mph; n = sample size; M = mean; SD = sample standard deviation; Min = minimum; $P_q = q$ th percentile; Mdn = median; Max = maximum.

Fig. 2 shows histograms of the responses. All the distributions have modes (peaks) at a 5-mph increment. Through visual inspection, there seemed to be two types of drivers: those who aim at a 5-mph increment starting from the speed limit and those who target regardless of multiples of 5 mph. By large, the latter distribution looks unimodal. On freeways, 40 mph showed sudden increases from 35 mph. Because (i) the increase at 40 mph shows a large deviation from the frequencies at 30 mph or 35 mph; and (ii) the data collection had a ceiling effect, the data in 40 mph were removed from further analyses. This was a limitation of this research.



Fig. 2. Histograms of responses.

Discrete distribution

Fig. 3 is the cumulative density functions (CDFs) of the responses after the data in 40 mph was removed. Cumulative densities at the posted speed limit (the proportions of drivers trying to drive at the posted speed limit or less) were 41.8 percent for urban local streets, 42.0 percent for rural local streets, 25.0 percent for urban freeways and 21.6 percent for rural freeways. In Fig. 3a,

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the distributions seem to be characterized mainly by highway class (i.e., local streets vs. freeways) rather than the area type. Because the differences between rural and urban did not seem to be meaningful in the collected data, the distributions across the areas were combined in further analyses. The CDFs of the combined distributions were shown in Fig. 3b, and detailed values were included in the Appendix.





Resulting speed distributions

To simulate how drivers' target speed generates an operating speed distribution, continuous speed distributions were modeled by assuming normally distributed fluctuations from each target speed with different standard deviation σ . Fig. 4 shows the probability density functions (PDFs) and CDFs in each condition. When driver's speed fluctuates around their target speed, multimodality is apparent when $\sigma = 1$ mph. The distribution of speed output approaches a normal distribution as the standard deviation becomes larger. When $\sigma = 6$ mph, the resulting speed distributions in relation to the posted speed limit resemble normal distributions. A Kolmogorov-Smirnov test with 500 samples generated from the PDFs of the local streets revealed that the resulting speed distribution on local streets can be wel approximated as a normal distribution of $N(4.14, 9.41^2)^4$ with a 95 percent confidence interval (D = 0.078, p = 0.005 < 0.05). On the other hand, a Kolmogorov-Smirnov test did not support the normality ($N(7.17, 7.69^2)$) of the continuous speed distribution on freeways (D = 0.044, p = 0.299 > 0.05), as it has a long tail on the right side (higher speed) of the distribution. The values were tabulated in the Appendix.

⁴ A normal distribution can be noted as $N(\mu, \sigma^2)$ where μ is mean and σ^2 is variance.

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IV. DISCUSSION

This research aimed to model American drivers' target driving speed in relation to the posted speed limit by road type (e.g., local streets vs. freeways). Based on a survey from 252 participants across the United States, the following points were revealed:

- 1. On average, drivers target approximately 4-5 mph and 7-8 mph faster speed than the posted speed limit on local streets and freeways, respectively.
- 2. Only less than 42 percent of drivers on local streets and 23 percent drivers on freeways try to drive at the posted speed limit or less.
- 3. The 85th percentile drivers try to drive faster than the posted speed limit by 10 mph on local streets and 15 mph on freeways.
- 4. Many drivers target driving speed at a 5-mph increment, but that is only true for nonnegative speed deviations from the posted speed limit. Because of this, drivers' target speed distributions were multimodal (i.e., characterized by more than one peaks).

- 5. Assuming drivers' speed control normally distributes around the target speed in their minds, resulting operating speed distributions becomes unimodal (i.e. characterized by one peak) once the standard deviation of the fluctuation (σ) exceeds 2 mph.
- 6. The resulting speed distributions can be well approximated by a normal distributions ($N(4.14, 9.41^2)$) on local streets. On freeways, a larger σ would be required to assume a normal distribution.

Considering the scarcity of research on American drivers' target driving speed, it was fruitful that the speed distributions were estimated. In particular, the fact that more than a half of the driver population have been trying to drive above the posted speed limit matches a phenomenon called the "evolution of speed" (Hauer, 2009), an increase in driving speed over time even when conditions of the highway facilities stay the same.

One interesting finding was that many drivers had speed targets at a 5 mph increment even though the slider in the survey (Fig. 1) did not have 5-mph snapping points. Because five is a frequently used cut-off number, it is intuitive that drivers have it in their minds. As illustrated in Fig. 4, this insight is not necessarily observable through field speed measurement. The simulated resulting speed distributions (Fig. 4) exemplified that an operating speed distribution can be unimodal when speed control fluctuates even as little as 2-mph σ . This research was preliminary in that the author does not know the real quantity of σ on roadways; therefore, further research will be required to determine likely speed distributions generated from drivers' target speed.

Limitations

The developed model was associated with assumptions and limitations. The developed model can be used as a starting point of speed input in traffic simulations, but more thorough modeling will contribute to simulation validity to a greater degree. For example, the presented models do not consider target speed below -39 mph or above 39 mph from the posted speed limit, local driver characteristics, or different posted speed limits, or other contexts (McCourt et al., 2019; Fitzpatrick et al., 2021) which may affect drivers' speed selection. In fact, the developed speed distributions cannot be directly applied to facilities with low posted speed limits because that would generate negative driving speed. This issue infers that the variance of speed distribution is likely to be different across different posted speed limits, so further modeling drivers' speed targets by different posted speed limits or different contexts would be a good future research topic. In particular, it is encouraged to develop local models since driving behavior can vary across different regions.

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APPENDIX

TABLE A. CDFs

Speed in relation	Discr	ete						Cont	tinuous					
to the posted					Local	street					Free	way		
speed limit (mph)	Local street	Freeway	σ = 1	σ = 2	$\sigma = 3$	σ = 4	σ = 5	σ = 6	$\sigma = 1$	σ = 2	σ = 3	σ = 4	σ = 5	σ = 6
-27	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.001	0.001	0.001	0.001	0.001
-26	0.000	0.004	0.000	0.000	0.000	0.000	0.001	0.001	0.003	0.002	0.001	0.001	0.001	0.001
-25	0.000	0.004	0.000	0.000	0.000	0.001	0.001	0.001	0.003	0.003	0.002	0.002	0.002	0.002
-24	0.000	0.004	0.000	0.000	0.001	0.001	0.001	0.002	0.003	0.003	0.003	0.003	0.002	0.002
-23	0.000	0.006	0.000	0.001	0.001	0.002	0.002	0.002	0.004	0.004	0.004	0.003	0.003	0.003
-22	0.000	0.006	0.001	0.001	0.002	0.002	0.003	0.003	0.005	0.005	0.004	0.004	0.004	0.004
-21	0.002	0.008	0.002	0.003	0.003	0.003	0.004	0.004	0.006	0.006	0.005	0.005	0.005	0.005
-20	0.004	0.008	0.004	0.004	0.004	0.004	0.005	0.005	0.007	0.006	0.006	0.006	0.006	0.006
-19	0.006	0.008	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.006	0.006	0.006	0.007
-18	0.006	0.008	0.006	0.006	0.007	0.007	0.007	0.008	0.007	0.007	0.007	0.007	0.007	0.008
-17	0.008	0.008	0.008	0.008	0.008	0.008	0.009	0.010	0.008	0.008	0.008	0.008	0.009	0.010
-16	0.008	0.010	0.009	0.009	0.010	0.010	0.010	0.013	0.009	0.009	0.009	0.009	0.010	0.011
-15	0.010	0.012	0.011	0.011	0.011	0.011	0.012	0.016	0.010	0.010	0.010	0.011	0.012	0.013
-14	0.014	0.012	0.013	0.013	0.013	0.013	0.015	0.019	0.011	0.011	0.012	0.012	0.013	0.016
-13	0.014	0.012	0.014	0.014	0.015	0.015	0.018	0.024	0.012	0.013	0.013	0.014	0.016	0.019
-12	0.014	0.016	0.016	0.016	0.017	0.018	0.022	0.031	0.014	0.015	0.015	0.016	0.019	0.024
-11	0.020	0.016	0.019	0.018	0.019	0.021	0.027	0.039	0.017	0.017	0.017	0.019	0.022	0.029
-10	0.022	0.024	0.021	0.020	0.021	0.025	0.035	0.049	0.021	0.020	0.020	0.022	0.027	0.035
-9	0.022	0.024	0.022	0.022	0.024	0.031	0.045	0.062	0.023	0.022	0.023	0.026	0.033	0.043
-8	0.022	0.024	0.023	0.024	0.028	0.040	0.058	0.079	0.024	0.025	0.026	0.032	0.041	0.054
-7	0.026	0.026	0.025	0.027	0.035	0.052	0.075	0.099	0.027	0.028	0.031	0.039	0.051	0.066
-6	0.026	0.033	0.029	0.032	0.046	0.070	0.097	0.123	0.031	0.031	0.038	0.050	0.064	0.081
-5	0.034	0.037	0.034	0.041	0.064	0.094	0.124	0.152	0.035	0.037	0.048	0.063	0.081	0.099
-4	0.038	0.039	0.041	0.058	0.092	0.126	0.157	0.184	0.038	0.046	0.063	0.081	0.101	0.120
-3	0.052	0.043	0.053	0.089	0.131	0.166	0.196	0.222	0.044	0.062	0.084	0.104	0.124	0.145
-2	0.064	0.051	0.083	0.143	0.182	0.214	0.240	0.263	0.059	0.090	0.111	0.132	0.152	0.173
-1	0.074	0.055	0.176	0.219	0.245	0.269	0.290	0.308	0.107	0.129	0.146	0.165	0.185	0.204
0	0.419	0.234	0.328	0.308	0.316	0.329	0.343	0.356	0.186	0.177	0.187	0.203	0.221	0.238
1	0.453	0.252	0.438	0.398	0.390	0.393	0.399	0.405	0.243	0.227	0.232	0.245	0.260	0.275
2	0.495	0.270	0.496	0.480	0.465	0.458	0.456	0.456	0.274	0.276	0.281	0.291	0.303	0.315
3	0.543	0.301	0.546	0.551	0.536	0.522	0.513	0.507	0.308	0.327	0.333	0.340	0.348	0.357
4	0.577	0.331	0.613	0.617	0.601	0.583	0.568	0.557	0.369	0.382	0.387	0.390	0.395	0.400
5	0.733	0.488	0.696	0.677	0.660	0.640	0.621	0.605	0.450	0.441	0.441	0.442	0.443	0.444
6	0.766	0.514	0.755	0.730	0.713	0.691	0.670	0.651	0.513	0.498	0.496	0.494	0.491	0.488
7	0.792	0.561	0.785	0.774	0.758	0.738	0.715	0.693	0.556	0.554	0.551	0.545	0.538	0.532
8	0.798	0.589	0.807	0.811	0.797	0.778	0.755	0.732	0.596	0.609	0.604	0.594	0.584	0.575
9	0.824	0.618	0.841	0.843	0.831	0.813	0.791	0.768	0.657	0.663	0.654	0.641	0.628	0.616
10	0.908	0.778	0.883	0.871	0.859	0.842	0.821	0.799	0.735	0.715	0.700	0.685	0.670	0.656
11	0.914	0.797	0.909	0.894	0.881	0.866	0.848	0.827	0.787	0.759	0.741	0.724	0.708	0.693
12	0.918	0.811	0.918	0.910	0.899	0.886	0.870	0.851	0.809	0.794	0.776	0.760	0.743	0.727
13	0.922	0.819	0.923	0.921	0.913	0.902	0.888	0.871	0.821	0.819	0.806	0.791	0.775	0.759
14	0.926	0.823	0.929	0.929	0.923	0.915	0.903	0.888	0.837	0.839	0.831	0.819	0.804	0.789
15	0.940	0.872	0.936	0.934	0.931	0.924	0.915	0.903	0.860	0.857	0.852	0.843	0.830	0.815
16	0.942	0.878	0.941	0.939	0.936	0.932	0.925	0.915	0.877	0.874	0.871	0.864	0.853	0.839
17	0.942	0.886	0.942	0.942	0.941	0.938	0.933	0.925	0.888	0.889	0.888	0.883	0.873	0.861
18	0.942	0.898	0.942	0.944	0.944	0.942	0.939	0.933	0.900	0.905	0.904	0.900	0.891	0.880
19	0.942	0.907	0.944	0.946	0.946	0.946	0.944	0.940	0.919	0.921	0.919	0.915	0.907	0.897
20	0.948	0.951	0.947	0.948	0.949	0.949	0.949	0.946	0.942	0.93/	0.933	0.928	0.921	0.912
21	0.950	0.963	0.949	0.950	0.951	0.953	0.953	0.951	0.960	0.951	0.945	0.940	0.933	0.925
22	0.950	0.967	0.950	0.952	0.954	0.950	0.956	0.955	0.967	0.962	0.956	0.950	0.944	0.937
25	0.950	0.970	0.952	0.955	0.957	0.959	0.959	0.959	0.971	0.969	0.964	0.959	0.954	0.94/
24	0.934	0.972	0.930	0.939	0.900	0.962	0.903	0.905	0.974	0.974	0.971	0.907	0.902	0.930
23	0.964	0.978	0.962	0.903	0.964	0.703	0.900	0.900	0.978	0.979	0.977	0.973	0.909	0.903
20	0.970	0.982	0.970	0.970	0.971	0.903	0.972	0.973	0.987	0.985	0.985	0.978	0.979	0.975
2/ 28	0.972	0.288	0.970	0.973	0.974	0.975	0.975	0.275	0.207	0.280	0.285	0.986	0.9/7	0.273
20	0.972	0.988	0.975	0.977	0.977	0.978	0.978	0.970	0.991	0.901	0.200	0.280	0.986	0.984
30	0.972	0.994	0.273	0.980	0.020	0.921	0.970	0.982	0.221	0.903	0.997	0.901	0.200	0.987
31	0.962	0.994	0.200	0.200	0.200	0.201	0.201	0.284	0.775	0.775	0.772	0.003	0.707	0.207
32	0.984	0.994	0.984	0.985	0.986	0.986	0.987	0.987	0.223	0.995	0.995	0.994	0.993	0.997
33	0.984	0.994	0.986	0.988	0.988	0.989	0.989	0.989	0.995	0.996	0.996	0.995	0.995	0.994
34	0.988	0.994	0.989	0.990	0.991	0.991	0.991	0.997	0.996	0.996	0.996	0.996	0.996	0.995
35	0.994	0.996	0.992	0.993	0.993	0.994	0.994	0.994	0.997	0.997	0.997	0.997	0.997	0.997
36	0.994	0.996	0.995	0.995	0.995	0.996	0.996	0.996	0.997	0.998	0.998	0.998	0.998	0.998
37	0.996	0.996	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.998	0.999	0.999	0.999	0.999
38	1,000	0,996	0.999	0.999	0.999	0.999	0.999	0.999	0.998	0.999	0.999	0.999	0,999	0.999
39	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

TABLE B. Copy-friendly CDFs

speed = [-27, -26, -25, -24, -23, -22, -21, -20, -19, -18, -17, -16, -15, -14, -13, -12, -11, -10, -9, -8, -7, -6, -5,
-4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39]
discrete_local_street = [0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.002, 0.004, 0.006, 0.006, 0.008, 0.008, 0.010,
0.014, 0.014, 0.014, 0.020, 0.022, 0.022, 0.022, 0.026, 0.026, 0.034, 0.038, 0.052, 0.064, 0.074, 0.419, 0.453, 0.495, 0.543, 0.577, 0.733, 0.766, 0.792, 0.798, 0.824, 0.908, 0.914, 0.918, 0.922, 0.926, 0.940, 0.942, 0.
0.948, 0.950, 0.950, 0.950, 0.954, 0.964, 0.968, 0.970, 0.972, 0.972, 0.982, 0.984, 0.984, 0.984, 0.988, 0.994, 0.994,
0.996, 1.000, 1.000]
discrete_freeway = $\begin{bmatrix} 0.004, 0.004, 0.004, 0.004, 0.006, 0.006, 0.008, 0.008, 0.008, 0.008, 0.008, 0.010, 0.012, $
0.331, 0.488, 0.514, 0.561, 0.589, 0.618, 0.778, 0.797, 0.811, 0.819, 0.823, 0.872, 0.878, 0.886, 0.898, 0.907, 0.951, 0.331, 0.488, 0.514, 0.561, 0.589, 0.618, 0.778, 0.797, 0.811, 0.819, 0.823, 0.872, 0.878, 0.886, 0.898, 0.907, 0.951, 0.331, 0.488, 0.514, 0.561, 0.589, 0.618, 0.778, 0.797, 0.811, 0.819, 0.823, 0.872, 0.878, 0.886, 0.898, 0.907, 0.951, 0.331, 0.488, 0.514, 0.561, 0.589, 0.618, 0.778, 0.797, 0.811, 0.819, 0.823, 0.872, 0.878, 0.886, 0.898, 0.907, 0.951, 0.331, 0.488, 0.514, 0.561, 0.589, 0.618, 0.778, 0.797, 0.811, 0.819, 0.823, 0.872, 0.878, 0.886, 0.898, 0.907, 0.951, 0.331, 0.488, 0.514, 0.561, 0.589, 0.618, 0.778, 0.797, 0.811, 0.819, 0.823, 0.872, 0.878, 0.886, 0.898, 0.907, 0.951, 0.589, 0.907, 0.951, 0.598, 0.907, 0.951, 0.598, 0.907, 0.951, 0.598, 0.907, 0.951, 0.598, 0.907, 0.951, 0.598, 0.907, 0.951, 0.598, 0.907, 0.951, 0.598, 0.908, 0.907, 0.951, 0.598, 0.908, 0.907, 0.951, 0.598, 0.908,
0.963, 0.967, 0.970, 0.972, 0.978, 0.982, 0.988, 0.988, 0.988, 0.994, 0.994, 0.994, 0.994, 0.994, 0.996, 0.996, 0.996,
0.996, 1.000]
0.011, 0.013, 0.014, 0.016, 0.019, 0.021, 0.022, 0.023, 0.025, 0.029, 0.034, 0.041, 0.053, 0.083, 0.176, 0.328, 0.438,
0.496, 0.546, 0.613, 0.696, 0.755, 0.785, 0.807, 0.841, 0.883, 0.909, 0.918, 0.923, 0.929, 0.936, 0.941, 0.942, 0.942,
0.994, 0.947, 0.949, 0.950, 0.952, 0.956, 0.962, 0.967, 0.970, 0.972, 0.975, 0.980, 0.983, 0.984, 0.986, 0.989, 0.992, 0.995, 0.997, 0.999, 1.000]
continuous_local_street_2mph_σ = [0.000, 0.000, 0.000, 0.001, 0.001, 0.003, 0.004, 0.005, 0.006, 0.008, 0.009,
0.011, 0.013, 0.014, 0.016, 0.018, 0.020, 0.022, 0.024, 0.027, 0.032, 0.041, 0.058, 0.089, 0.143, 0.219, 0.308, 0.398,
0.480, 0.551, 0.617, 0.677, 0.730, 0.774, 0.811, 0.843, 0.871, 0.894, 0.910, 0.921, 0.929, 0.934, 0.939, 0.942, 0.944, 0.946, 0.948, 0.950, 0.952, 0.955, 0.959, 0.963, 0.966, 0.970, 0.973, 0.977, 0.980, 0.983, 0.985, 0.988, 0.990, 0.993
_0.995, 0.997, 0.999, 1.000]
continuous_local_street_3mph_o = [0.000, 0.000, 0.000, 0.001, 0.001, 0.002, 0.003, 0.004, 0.005, 0.007, 0.008, 0.010,
0.011, 0.013, 0.015, 0.017, 0.019, 0.021, 0.024, 0.028, 0.035, 0.046, 0.064, 0.092, 0.131, 0.182, 0.245, 0.316, 0.390, 0.465, 0.536, 0.601, 0.660, 0.713, 0.758, 0.797, 0.831, 0.859, 0.881, 0.899, 0.913, 0.923, 0.931, 0.936, 0.941, 0.944
0.946, 0.949, 0.951, 0.954, 0.957, 0.960, 0.964, 0.967, 0.971, 0.974, 0.977, 0.980, 0.983, 0.986, 0.988, 0.991, 0.993,
0.995, 0.997, 0.999, 1.000]
continuous_local_street_4mph_ σ = [0.000, 0.000, 0.001, 0.001, 0.002, 0.002, 0.003, 0.004, 0.006, 0.007, 0.008, 0.010,
0.458, 0.522, 0.583, 0.640, 0.691, 0.738, 0.778, 0.813, 0.842, 0.866, 0.886, 0.902, 0.915, 0.924, 0.932, 0.938, 0.942,
0.946, 0.949, 0.953, 0.956, 0.959, 0.962, 0.965, 0.968, 0.971, 0.975, 0.978, 0.981, 0.984, 0.986, 0.989, 0.991, 0.994,
0.996, 0.997, 0.999, 1.000]
0.012, 0.015, 0.018, 0.022, 0.027, 0.035, 0.045, 0.058, 0.075, 0.097, 0.124, 0.157, 0.196, 0.240, 0.290, 0.343, 0.399,
0.456, 0.513, 0.568, 0.621, 0.670, 0.715, 0.755, 0.791, 0.821, 0.848, 0.870, 0.888, 0.903, 0.915, 0.925, 0.933, 0.939,
0.944, 0.949, 0.953, 0.956, 0.959, 0.963, 0.966, 0.969, 0.972, 0.975, 0.978, 0.981, 0.984, 0.987, 0.989, 0.991, 0.994,
continuous local street 6mph $\sigma = [0.000, 0.001, 0.001, 0.002, 0.002, 0.003, 0.004, 0.005, 0.007, 0.008, 0.010, 0.013, 0.010, 0.010, 0.010, 0.010, 0.010, 0.010, 0.010, 0.010, 0.010, 0.010, 0.010, 0.010, 0.010, 0.010, 0.001, 0$
0.016, 0.019, 0.024, 0.031, 0.039, 0.049, 0.062, 0.079, 0.099, 0.123, 0.152, 0.184, 0.222, 0.263, 0.308, 0.356, 0.405,
0.456, 0.507, 0.557, 0.605, 0.651, 0.693, 0.732, 0.768, 0.799, 0.827, 0.851, 0.871, 0.888, 0.903, 0.915, 0.925, 0.933, 0.940, 0.946, 0.951, 0.955, 0.959, 0.963, 0.966, 0.970, 0.973, 0.976, 0.979, 0.982, 0.984, 0.987, 0.989, 0.992,
_0.996, 0.997, 0.999, 1.000]
continuous_freeway_1mph_o = [0.002, 0.003, 0.003, 0.003, 0.004, 0.005, 0.006, 0.007, 0.007, 0.007, 0.008, 0.009,
0.010, 0.011, 0.012, 0.014, 0.017, 0.021, 0.023, 0.024, 0.027, 0.031, 0.035, 0.038, 0.044, 0.059, 0.107, 0.186, 0.243, 0.274, 0.308, 0.369, 0.450, 0.513, 0.556, 0.596, 0.657, 0.735, 0.787, 0.809, 0.821, 0.837, 0.860, 0.877, 0.888, 0.900
0.919, 0.942, 0.960, 0.967, 0.971, 0.974, 0.978, 0.983, 0.987, 0.989, 0.991, 0.993, 0.995, 0.995, 0.995, 0.996, 0.997,
0.997, 0.997, 0.998, 1.000]
continuous_treeway_2mph_0 = [0.001, 0.002, 0.003, 0.003, 0.004, 0.005, 0.005, 0.005, 0.007, 0.007, 0.008, 0.009, 0 010 0 011 0 013 0 015 0 017 0 020 0 022 0 025 0 028 0 031 0 037 0 046 0 062 0 090 0 129 0 177 0 227
0.276, 0.327, 0.382, 0.441, 0.498, 0.554, 0.609, 0.663, 0.715, 0.759, 0.794, 0.819, 0.839, 0.857, 0.874, 0.889, 0.905,
0.921, 0.937, 0.951, 0.962, 0.969, 0.974, 0.979, 0.983, 0.986, 0.989, 0.991, 0.993, 0.994, 0.995, 0.996, 0.996, 0.997,
_0.998, 0.999, 0.999, 1.000] continuous freeway 3mph σ = [0.001 0.001 0.002 0.003 0.004 0.004 0.005 0.006 0.006 0.007 0.008 0.009
0.010, 0.012, 0.013, 0.015, 0.017, 0.020, 0.023, 0.026, 0.031, 0.038, 0.048, 0.063, 0.084, 0.111, 0.146, 0.187, 0.232,
0.281, 0.333, 0.387, 0.441, 0.496, 0.551, 0.604, 0.654, 0.700, 0.741, 0.776, 0.806, 0.831, 0.852, 0.871, 0.888, 0.904,
0.919, 0.933, 0.945, 0.956, 0.964, 0.971, 0.977, 0.981, 0.985, 0.988, 0.990, 0.992, 0.994, 0.995, 0.996, 0.996, 0.997, 0.998, 0.999, 0.999, 1.0001
continuous_freeway_4mph_σ = [0.001, 0.001, 0.002, 0.003, 0.003, 0.004, 0.005, 0.006, 0.006, 0.007, 0.008, 0.009,
0.011, 0.012, 0.014, 0.016, 0.019, 0.022, 0.026, 0.032, 0.039, 0.050, 0.063, 0.081, 0.104, 0.132, 0.165, 0.203, 0.245,
0.291, 0.340, 0.390, 0.442, 0.494, 0.545, 0.594, 0.641, 0.685, 0.724, 0.760, 0.791, 0.819, 0.843, 0.864, 0.883, 0.900, 0.915, 0.928, 0.940, 0.950, 0.950, 0.967, 0.973, 0.978, 0.982, 0.986, 0.989, 0.991, 0.993, 0.994, 0.995, 0.996, 0.997
0.998, 0.999, 0.999, 1.000]
continuous_freeway_5mph_o = [0.001, 0.001, 0.002, 0.002, 0.003, 0.004, 0.005, 0.006, 0.006, 0.007, 0.009, 0.010,
0.012, 0.013, 0.016, 0.019, 0.022, 0.027, 0.033, 0.041, 0.051, 0.064, 0.081, 0.101, 0.124, 0.152, 0.185, 0.221, 0.260, 0.303, 0.348, 0.395, 0.443, 0.491, 0.538, 0.584, 0.628, 0.670, 0.708, 0.743, 0.775, 0.804, 0.830, 0.853, 0.873, 0.891
0.907, 0.921, 0.933, 0.944, 0.954, 0.962, 0.969, 0.974, 0.979, 0.983, 0.986, 0.989, 0.991, 0.993, 0.995, 0.996, 0.997,
0.998, 0.999, 0.999, 1.000]
continuous_freeway_6mph_ σ = [0.001, 0.001, 0.002, 0.002, 0.003, 0.004, 0.005, 0.006, 0.007, 0.008, 0.010, 0.011,
0.315, 0.357, 0.400, 0.444, 0.488, 0.532, 0.575, 0.616, 0.656, 0.693, 0.727, 0.759, 0.789, 0.815, 0.839, 0.861, 0.880.
0.897, 0.912, 0.925, 0.937, 0.947, 0.956, 0.963, 0.970, 0.975, 0.980, 0.984, 0.987, 0.989, 0.992, 0.994, 0.995, 0.997,
0.998, 0.999, 0.999, 1.000]