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**THE LOCATIONS OF SIGNALING
AND LIGHTING EQUIPMENT ON
PASSENGER VEHICLES SOLD
IN THE U.S.**

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16. Abstract <p>This report presents detailed data regarding the locations of signaling and lighting equipment for the 15 best-selling cars and 15 best-selling light trucks, constituting approximately 48% of model year 2002 vehicles in the U.S. Actual vehicle measurements and descriptions were recorded for the three-dimensional locations of 14 items of signaling and lighting equipment. This information was then weighted by the current sales data to derive sales-weighted mean locations. The location data were analyzed in two subgroups: cars and light trucks (15 vehicles each). Descriptive summaries are presented for the entire sample of 30 vehicles. The summaries contain information about headlamp locations that can be compared to a previous, similarly market-weighted summary (UMTRI-96-36).</p> <p>The data in this report can be used to evaluate the expected locations of the various external signaling and lighting functions on current cars and light trucks in the U.S. This information can also be used when investigating the geometric visibility of these various functions.</p>					
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Introduction

In 1996, an UMTRI report was published describing the locations of headlamps and driver eye positions for the 15 best-selling cars and 15 best-selling light trucks for that year (Sivak et al., 1996). That study provided detailed information regarding the locations of headlamps and driver eye positions in a three-dimensional space for approximately 52% of vehicles sold in the U.S. that year. Those data were intended to support estimates of driver visual performance issues that are influenced by driver eye position, headlamp position, or the relationship between them.

Information regarding the locations of signaling and lighting equipment is equally important when investigating visibility issues related to these types of equipment. The purpose of this study was to develop an analogous database of three-dimensional locations for the other major lighting and signaling equipment installed on vehicles sold in the U.S., as well as to update the information regarding headlamp locations for the current model year. Actual vehicle measurements and descriptions were recorded for the external signaling and lighting equipment on the 15 best-selling cars and 15 best-selling light trucks for model year 2002, accounting for approximately 48% of vehicles sold in that model year. This information was then weighted by the current sales data to derive sales-weighted descriptions of the signaling and lighting equipment installed in current cars and light trucks in the U.S.

Method

To determine the physical locations of the signaling and lighting equipment, actual measurements were made on the 15 best-selling cars and 15 best-selling light trucks for model year 2002. The vehicles sampled were made by six manufacturers (DaimlerChrysler, Ford, General Motors, Honda, Nissan, and Toyota). These 30 vehicles make up approximately 48% of model year 2002 vehicles sold during the first five months of sales (October 2001 through February 2002) (Ward's AutoInfoBank, 2002). The sales data for these five months were used to determine the individual weighting values. See the Appendix for a detailed listing of model selection and weighting information.

The 15 best-selling cars sampled were as follows (in descending order of total U.S. sales): Toyota Camry, Honda Accord, Ford Taurus, Honda Civic, Chevrolet Cavalier, Ford Focus, Chevrolet Impala, Toyota Corolla, Nissan Altima, Ford Mustang, Pontiac Grand Am, Chevrolet Malibu, Saturn S-series, Buick LeSabre, and Buick Century (Ward's AutoInfoBank, 2002). These 15 cars represent approximately 41% (by sales) of the 30 vehicles sampled, or 20% of model year 2002 vehicles sold.

The 15 best-selling light trucks sampled were as follows (in descending order of total U.S. sales): Ford F-series, Chevrolet Silverado, Ford Explorer, Dodge Ram Pickup, Chevrolet TrailBlazer, GMC Sierra, Jeep Grand Cherokee, Dodge Caravan, Chevrolet Tahoe, Ford Ranger, Chevrolet Suburban, Ford Expedition, Ford Windstar, Ford Escape, and Jeep Liberty (Ward's AutoInfoBank, March 2002). For the purpose of this study, "light truck" includes pickup trucks, SUVs, and minivans. As determined by actual sales data, no full-size vans were present in the sample. These 15 light trucks represent approximately 59% (by sales) of the 30 vehicles sampled, or 28% of model year 2002 vehicles sold.

Three location measurements were made for each lamp or reflex reflector installed on each vehicle. The three measurements included: vertical distance from the ground (lamp/reflector center to ground), lateral distance to the vehicle centerline (center to center separation, divided by 2), and longitudinal distance to the closest bumper (center of the lens surface to the vehicle edge tangent). Figure 1 illustrates examples of these three measurements. (For vehicle models using two or more lamps or reflectors to perform a single function, the locations of these individual pieces of equipment were averaged for that specific model to get a centralized, mean location for that function.)

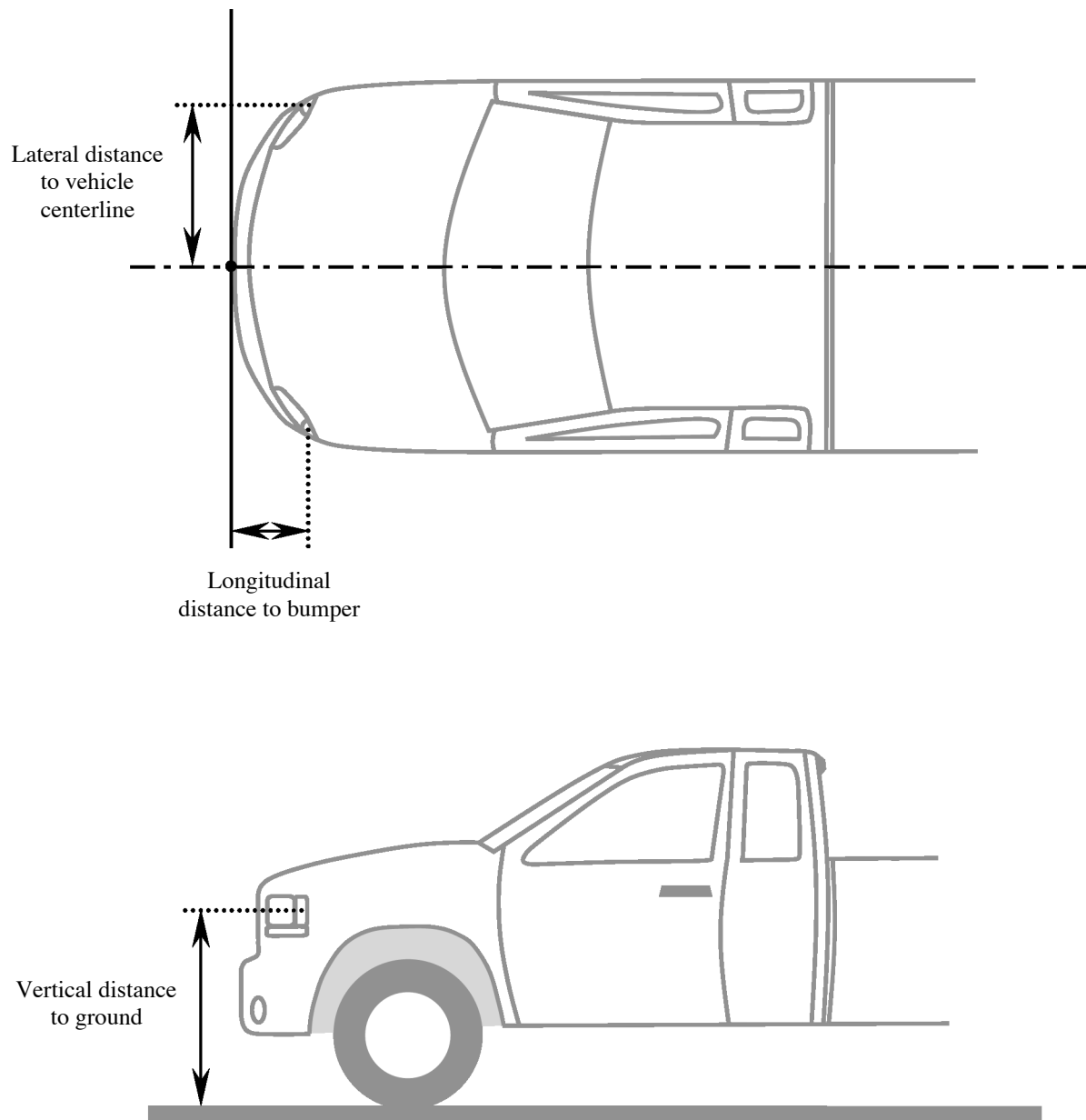


Figure 1. Illustration of the three location measurements recorded for all lamps on each vehicle.

All measurements were made at new-car dealerships in the Ann Arbor area. All vehicles were new inventory with typical manufacturer-specified trim levels and configurations. Tire pressure, fuel levels, and vehicle fluid levels were not monitored during the course of this study. All measurements were recorded with no passengers and no cargo or special equipment present in the vehicles. All measurements were made on flat, level ground.

While recording the location measurements for each lamp, function-specific design characteristics were also documented. See Tables 6 and 7 in the Results section for more information on these design characteristics.

A summary of the lamps and functions analyzed in this study is presented in Table 1. The last column in the table lists the basic U.S. requirements (FMVSS, 1999) for each lamp or function included in this study.

Table 1
Summary of the signaling and lighting equipment examined in this study
and the associated U.S. requirements (FMVSS, 1999).

Location	Equipment	Required number, required color
Front	Turn signal lamp	2, amber
	Side marker lamp	2, amber
	Side reflex reflector	2, amber
	Low-beam headlamp	2, white
	High-beam headlamp	2, white
	Fog lamp	- none -
Rear	Turn signal lamp	2, red or amber
	Tail lamp	2, red
	Stop lamp	2, red
	Side marker lamp	2, red
	Side reflex reflector	2, red
	Rear reflex reflector	2, red
	Center high-mounted stop lamp (CHMSL)	1, red
	Backup (reverse) lamp	1, white

Results

Lamp locations

Tables 2 and 3 present the means and standard deviations of the sales-weighted distributions of front lamp locations for cars and light trucks, respectively. The analogous information for rear lamps is shown in Tables 4 and 5.

To more accurately describe the CHMSL installations in Table 4, the car group was separated into two sub-groups: 1) rear window installation and 2) rear deck lid installation. This was done because of the notable differences between the two installation locations. For the same purpose, the light truck group in Table 5 was also separated into two sub-groups: 1) pickups and 2) SUVs and minivans. This was done because of the dissimilarity of the two body styles and the resulting locations of the CHMSL in each body type. Though fundamentally different in design, SUVs and minivans were similar enough in their rear body style (and resulting CHMSL location) to group together.

Descriptive summaries

Tables 6 and 7 contain sales-weighted summaries of the design characteristics of the front turn signals, and rear turn signals and CHMSL, respectively.

Additional summaries

Table 8 presents a sales-weighted summary of the three basic external dimensions of the sampled vehicles: height, length, and width. These dimensions were collected for each model from dimension specifications posted on the respective vehicle manufacturer's website.

Table 9 includes a summary of the light sources used in the high- and low-beam headlamps within the sample.

Table 2
The sales-weighted locations of front lamps for cars (N = 15 unless noted).
The main entries are the means; the entries in parentheses are the standard deviations.

<i>Front lamps – Cars</i>			
Equipment	Distance (m)		
	Vertical ¹	Lateral ²	Longitudinal ³
Turn signal lamp	0.66 (0.07)	0.65 (0.14)	0.34 (0.12)
Side marker lamp	0.65 (0.07)	0.89 † (0.03)	0.41 (0.08)
<i>with</i> turn signal function (N = 11)	0.66 (0.07)	0.89 † (0.03)	0.40 (0.08)
<i>without</i> turn signal function (N = 4)	0.62 (0.07)	0.91 † (0.03)	0.44 (0.09)
Side reflex reflector	0.64 (0.07)	0.89 † (0.03)	0.43 (0.07)
Low-beam headlamp	0.66 (0.03)	0.60 (0.07)	0.25 (0.06)
High-beam headlamp	0.65 (0.02)	0.52 (0.09)	0.21 (0.05)
Fog lamp (N = 9)	0.36 (0.01)	0.61 (0.06)	0.17 (0.04)

¹ Vertical distance from the ground to the lamp center.

² Lateral distance from the vehicle centerline to the lamp center.

³ Longitudinal distance from the *front* vehicle edge to the lamp lens.

† Lateral locations of side markers and side reflex reflectors were not measured; the information in this table was computed from the sales-weighted widths of each applicable vehicle.

Table 3
The sales-weighted locations of front lamps for light trucks (N = 15 unless noted).
The main entries are the means; the entries in parentheses are the standard deviations.

<i>Front lamps – Light trucks</i>			
Equipment	Distance (m)		
	Vertical ¹	Lateral ²	Longitudinal ³
Turn signal lamp	0.81 (0.09)	0.78 (0.10)	0.29 (0.10)
Side marker lamp	0.81 (0.08)	0.98 † (0.04)	0.31 (0.10)
<i>with</i> turn signal function (N = 10)	0.82 (0.08)	0.98 † (0.05)	0.30 (0.10)
<i>without</i> turn signal function (N = 5)	0.75 (0.07)	0.97 † (0.04)	0.34 (0.07)
Side reflex reflector	0.82 (0.09)	0.98 † (0.04)	0.39 (0.08)
Low-beam headlamp	0.89 (0.06)	0.69 (0.06)	0.23 (0.04)
High-beam headlamp	0.89 (0.06)	0.62 (0.06)	0.21 (0.05)
Fog lamp (N = 12)	0.46 (0.07)	0.68 (0.06)	0.22 (0.04)

¹ Vertical distance from the ground to the lamp center.

² Lateral distance from the vehicle centerline to the lamp center.

³ Longitudinal distance from the *front* vehicle edge to the lamp lens.

† Lateral locations of side markers and side reflex reflectors were not measured; the information in this table was computed from the sales-weighted widths of each applicable vehicle.

Table 4
The sales-weighted locations of rear lamps for cars (N = 15 unless noted).
The main entries are the means; the entries in parentheses are the standard deviations.

<i>Rear lamps – Cars</i>			
Equipment	Distance (m)		
	Vertical ¹	Lateral ²	Longitudinal ³
Turn signal lamp	0.86 (0.05)	0.67 (0.02)	0.19 (0.03)
Tail lamp	0.86 (0.04)	0.63 (0.05)	0.18 (0.03)
Stop lamp	0.85 (0.04)	0.66 (0.04)	0.19 (0.03)
Side marker lamp	0.83 (0.06)	0.89 † (0.03)	0.24 (0.09)
<i>with</i> turn signal function (N = 2)	0.87 (0.03)	0.85 † (0.03)	0.22 (0.10)
<i>without</i> turn signal function (N = 13)	0.78 (0.08)	0.91 † (0.03)	0.23 (0.09)
Side reflex reflector	0.83 (0.06)	0.89 † (0.03)	0.31 (0.06)
Rear reflex reflector	0.83 (0.03)	0.62 (0.08)	0.19 (0.03)
CHMSL: Rear window (N = 9)	1.14 (0.05)	0.00 ‡ (0.00)	0.73 (0.12)
CHMSL: Rear deck lid (N = 6)	1.03 (0.03)	0.00 ‡ (0.00)	0.15 (0.03)
Backup (reverse) lamp	0.81 (0.04)	0.51 (0.11)	0.16 (0.03)

¹ Vertical distance from the ground to the lamp center.

² Lateral distance from the vehicle centerline to the lamp center.

³ Longitudinal distance from the *rear* vehicle edge to the lamp lens.

† Lateral locations of side markers and side reflex reflectors were not measured; the information in this table was computed from the sales-weighted widths of each applicable vehicle.

‡ CHMSLs must be installed on the vehicle centerline (FMVSS, 1999).

Table 5
The sales-weighted locations of rear lamps for light trucks (N = 15 unless noted).
The main entries are the means; the entries in parentheses are the standard deviations.

<i>Rear lamps – Light trucks</i>			
Equipment	Distance (m)		
	Vertical ¹	Lateral ²	Longitudinal ³
Turn signal lamp	1.02 (0.04)	0.84 (0.06)	0.17 (0.05)
Tail lamp	1.05 (0.08)	0.84 (0.06)	0.17 (0.05)
Stop lamp	1.06 (0.09)	0.84 (0.06)	0.17 (0.05)
Side marker lamp	1.06 (0.09)	0.98 † (0.04)	0.17 (0.05)
<i>with</i> turn signal function (N = 4)	1.03 (0.02)	0.97 † (0.05)	0.15 (0.03)
<i>without</i> turn signal function (N = 11)	1.08 (0.11)	0.98 † (0.04)	0.19 (0.06)
Side reflex reflector	0.95 (0.08)	0.98 † (0.04)	0.27 (0.07)
Rear reflex reflector	0.91 (0.11)	0.84 (0.07)	0.16 (0.05)
CHMSL: SUV/minivan (N = 10)	1.69 (0.18)	0.00 ‡ (0.00)	0.47 (0.13)
CHMSL: Pickups (N = 5)	1.80 (0.06)	0.00 ‡ (0.00)	2.44 (0.27)
Backup (reverse) lamp	0.93 (0.07)	0.84 (0.06)	0.17 (0.04)

¹ Vertical distance from the ground to the lamp center.

² Lateral distance from the vehicle centerline to the lamp center.

³ Longitudinal distance from the *rear* vehicle edge to the lamp lens.

† Lateral locations of side markers and side reflex reflectors were not measured; the information in this table was computed from the sales-weighted widths of each applicable vehicle.

‡ CHMSLs must be installed on the vehicle centerline (FMVSS, 1999).

Table 6
 Summary of front turn signal design characteristics for all vehicles (N = 30).

<i>Front turn signals – All vehicles</i>			
Characteristic		Number of vehicles	Sales-weighted percentage
Light source type	Incandescent	30	100.0
	LED	0	0.0
	Neon	0	0.0
Color source	Bulb	21	75.1
	Cap	1	2.9
	Lens	8	22.0
Side marker functions as a turn signal?	Yes	21	80.3
	No	9	19.7

Table 7
Summary of rear turn signal and CHMSL design characteristics for all vehicles
(N = 30 unless noted).

<i>Rear turn signals and CHMSL – All vehicles</i>			
Characteristic		Number of vehicles	Sales-weighted percentage
Turn signal light source type	Incandescent	30	100.0
	LED	0	0.0
	Neon	0	0.0
Turn signal color	Amber	14	45.2
	Red	16	54.8
Turn signal color source	Cap	2	9.8
	Lens	28	90.2
Side marker functions as a turn signal?	Yes	6	28.4
	No	24	71.6
Turn signal combined with stop lamp?	Yes	11	38.0
	No	19	62.0
CHMSL light source type	Incandescent	21	75.0
	LED	8	22.0
	Neon	1	3.0
CHMSL installation location (cars only; N = 15)	Rear window	9	63.2
	Rear deck lid	6	36.8

Table 8

The sales-weighted external dimensions of the sampled vehicles (N = 15 for each sample group).
The main entries are the means; the entries in parentheses are the standard deviations.

Sample	Distance (m)		
	Height	Length	Width
Cars	1.43 (0.04)	4.75 (0.21)	1.78 (0.06)
Light trucks	1.83 (0.07)	5.31 (0.45)	1.95 (0.08)

Table 9

High beam and low beam light sources used in the sampled vehicles (N = 30 for each beam type).

Beam type	Light source	Number of vehicles	Sales-weighted percentage
Low	H1	1	2.2
	HB2 (9003)	3	8.5
	HB4 (9005)	15	51.1
	HB5 (9007)	11	38.2
High	HB2 (9003)	3	8.5
	HB3 (9006)	16	53.3
	HB5 (9007)	11	38.2

Summary

This study presents detailed data regarding the locations of signaling and lighting equipment for the 15 best-selling cars and 15 best-selling light trucks, constituting approximately 48% of model year 2002 vehicles. Actual vehicle measurements and descriptions were recorded for the three-dimensional locations of 14 items of signaling and lighting equipment. This information was then weighted by the current sales data to derive sales-weighted locations and descriptions of this equipment. The location data were analyzed in two subgroups: cars and light trucks (15 vehicles each). Descriptive summaries are presented for the entire sample of 30 vehicles. The summaries contain information about headlamp locations that can be compared to a previous, similarly market-weighted summary (UMTRI-96-36).

The data in this report can be used to evaluate the expected locations of the various external signaling and lighting functions on current cars and light trucks in the U.S. This information can also be used when investigating the geometric visibility of these various functions.

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Appendix

Sales ranked listing of sampled vehicles, in descending order of total sample and market share.
Shaded rows indicate light trucks (pickups, SUVs, and minivans).

Model	Manufacturer	Sample share	Market share	Sampled trim level
F-series	Ford	11.72%	5.60%	F-150 – XLT SuperCab – 4x2 (SB)
Silverado	Chevrolet	10.11%	4.83%	1500 – LS Regular Cab – 2WD (LB)
Explorer	Ford	5.24%	2.51%	XLT
Camry	Toyota	5.23%	2.50%	SE
Accord	Honda	4.56%	2.18%	LX Sedan
Ram pickup	Dodge	4.50%	2.15%	1500 – SLT Quad Cab – 4x4 (SB)
Taurus	Ford	3.72%	1.78%	SE
Civic	Honda	3.51%	1.68%	LX Sedan
TrailBlazer	Chevrolet	3.06%	1.46%	LT – 4x4
Sierra	GMC	3.03%	1.45%	1500 – SL Extended Cab – 4x4 (SB)
Grand Cherokee	Jeep	2.97%	1.42%	Limited
Cavalier	Chevrolet	2.90%	1.39%	LS Sport Coupe
Focus	Ford	2.89%	1.38%	SE
Caravan	Dodge	2.83%	1.36%	Sport
Impala	Chevrolet	2.78%	1.33%	LS
Tahoe	Chevrolet	2.77%	1.32%	LT – 2WD
Corolla	Toyota	2.74%	1.31%	S
Ranger	Ford	2.72%	1.30%	XLT SuperCab – 4x4 (SB)
Altima	Nissan	2.17%	1.04%	2.5 SL
Suburban	Chevrolet	2.09%	1.00%	1500 – LT – 4x4
Expedition	Ford	2.08%	0.99%	XLT – 4x4
Windstar	Ford	2.07%	0.99%	LX
Escape	Ford	2.06%	0.99%	XLT
Liberty	Jeep	2.03%	0.97%	Sport
Mustang	Ford	1.92%	0.92%	GT
Grand Am	Pontiac	1.76%	0.84%	SE
Malibu	Chevrolet	1.74%	0.83%	LS
S-series	Saturn	1.61%	0.77%	SL1
LeSabre	Buick	1.60%	0.77%	Limited
Century	Buick	1.59%	0.76%	Limited
Total:		100.00 %	47.82 %	

(SB) = Short cargo bed

(LB) = Long cargo bed