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A MARKET-WEIGHTED DESCRIPTION OF LOW-BEAM HEADLIGHTING PATTERNS IN EUROPE

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16. Abstract

This study was designed to provide photometric information about current European low-beam headlamps. The sample included 20 low-beam headlamps manufactured for use on the 20 best-selling passenger vehicles for calendar year 1999 in 17 European countries. These 20 vehicles represent 47% of all vehicles sold in these countries. The lamps were purchased directly from vehicle dealerships, and photometered in 0.25° steps from 45° left to 45° right, and from 5° down to 7° up. The photometric information for each lamp was weighted by 1999 sales figures for the corresponding vehicle. The results are presented both in tabular form for the 25th-percentile, the median (50th-percentile), and the 75th-percentile luminous intensities, as well as in graphical form (for the median luminous intensities).

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INTRODUCTION

In 1997 we published a report that included a market-weighted description of low-beam headlighting patterns in the U.S. (Sivak, Flannagan, Kojima, & Traube, 1997). That information was based on photometry of headlamps on the 23 best selling passenger vehicles for model year 1997.

The only detailed photometric data in the open literature on European headlamps, based on a large number of headlamps, was published by Sivak, Flannagan, & Sato (1993). That study provided summary information on 37 European low-beam headlamps manufactured in the early 1980s. However, the sample in that study was not a systematic one, and those lamps are now somewhat dated.

The present study was designed to develop a market-weighted database of current European low-beam headlamps. The main features of this study were as follows: First, the lamps to be photometered were directly purchased from vehicle dealerships, thus avoiding the potential problem of self-selection with donated lamps. Second, the selected lamps were designed for use on 47% of all passenger vehicles currently being sold in 17 European countries. Third, the obtained photometric information was weighted by the current sales figures for the respective vehicle models.

METHOD

Approach

The approach consisted of the following steps:

(1) Obtain luminous-intensity matrix for lamps designed to be used on the best-selling passenger vehicles.

(2) Use the current sales data for the respective vehicles to derive a sales-weighted distribution of luminous intensities at each test point.

(3) For each test point, calculate selected percentiles—25th, 50th (median), and 75th—of the sales-weighted distribution of luminous intensities.

Photometry

We determined the luminous intensities at the 25th percentile, the median (50th percentile), and the 75th percentile for 17,689 test points. These test points were in a rectangular matrix defined by the following ranges of horizontal and vertical angles (in relation to the headlamp axes). In the horizontal direction, the angles ranged from 45° left (L) to 45° right (R) in steps of 0.25°. In the vertical direction, the angles ranged from 5° down (D) to 7° up (U) in steps of 0.25°. (In comparison, the U.S. data in Sivak et al., 1997 are for the same horizontal and vertical ranges, with a 0.5° step size in each direction.)

The measurements were made in a photometry lab using a goniometer. Visual aiming was used to align the lamps prior to the photometry. The horizontal aim placed the right end of the horizontal part of the vertical cutoff at the vertical axis. The vertical aim was set by first aligning the vertical cutoff on the left side with the horizontal, and then displacing the beam 0.6° (1%) down. The aiming of all lamps was performed by the same person—a lighting engineer with 34 years of headlighting experience.

The lamps were seasoned before the measurements were taken. All measurements were made at 12.8 V (the same as in Sivak et al., 1997), with the appropriate bulb. (Because we were interested in real-world light output, we did not use a rated bulb.)

Sample

A total of 20 lamps constituted the sample. All lamps (and the corresponding bulbs for each lamp) were for model year 2000, and they were purchased in June 2000 at vehicle dealerships in the Helsinki Metropolitan Area, Finland. All were left-side lamps. The lamps were manufactured for use on the 20 best-selling passenger vehicles in Europe for the calendar year 1999 (that includes model years 1999 and 2000). The vehicle sales data included the following 17 countries (in a descending order of total sales): Germany, Italy, United Kingdom, France, Spain,

The Netherlands, Belgium, Austria, Switzerland, Portugal, Sweden, Ireland, Denmark, Greece, Finland, Norway, and Luxemburg (Automotive News Europe, 2000). These 17 countries include all 15 members of the European Union, plus Norway and Switzerland.

The 20 vehicles were as follows (also in a descending order of sales): VW Golf, Opel Astra, Ford Focus, Renault Clio, Opel Corsa, Fiat Punto, Peugoet 206, VW Polo, Renault Megene, VW Passat, Ford Fiesta, Opel Vectra, BMW Series 3, Peugoet 306, Citroen Xsara, Renault Scenic/New Scenic (we tested a lamp for New Scenic), Ford Mondeo, Citroen Saxo, Peugeot 406, and Audi A4 (Automotive News Europe, 2000). These 20 vehicles constituted 47% of all passenger vehicles sold during 1999 (Automotive News Europe, 2000).

Several vehicles offered optional high-intensity discharge (HID) lamps, along with standard tungsten-halogen lamps. Our sample included only lamps with tungsten-halogen bulbs. A breakdown of lamps by light source for the 20 vehicle models surveyed is shown in Table 1. (Note that one lamp used a bulb usually employed for high beams—9005 [HB3].)

Table 1
Breakdown of the light sources used in the tested lamps.

Light source	Number of vehicles	Sales-weighted percentage of all vehicles
H7	14	67.9
H4 (HB2)	5	25.7
9005 (HB3)	1	6.4
Total	20	100.0

RESULTS

Figure 1 presents isocandela diagrams corresponding to the median (50th percentile) luminous intensities for the sales-weighted sample representing the low-beam headlamps on current passenger vehicles. Table 2 lists the 25th percentile, the median, and the 75th percentile luminous intensities. The horizontal steps in Table 2 are 0.5° between 0° and 5°, 1° between 5° and 10°, and 5° between 10° and 45° (all for left or right).

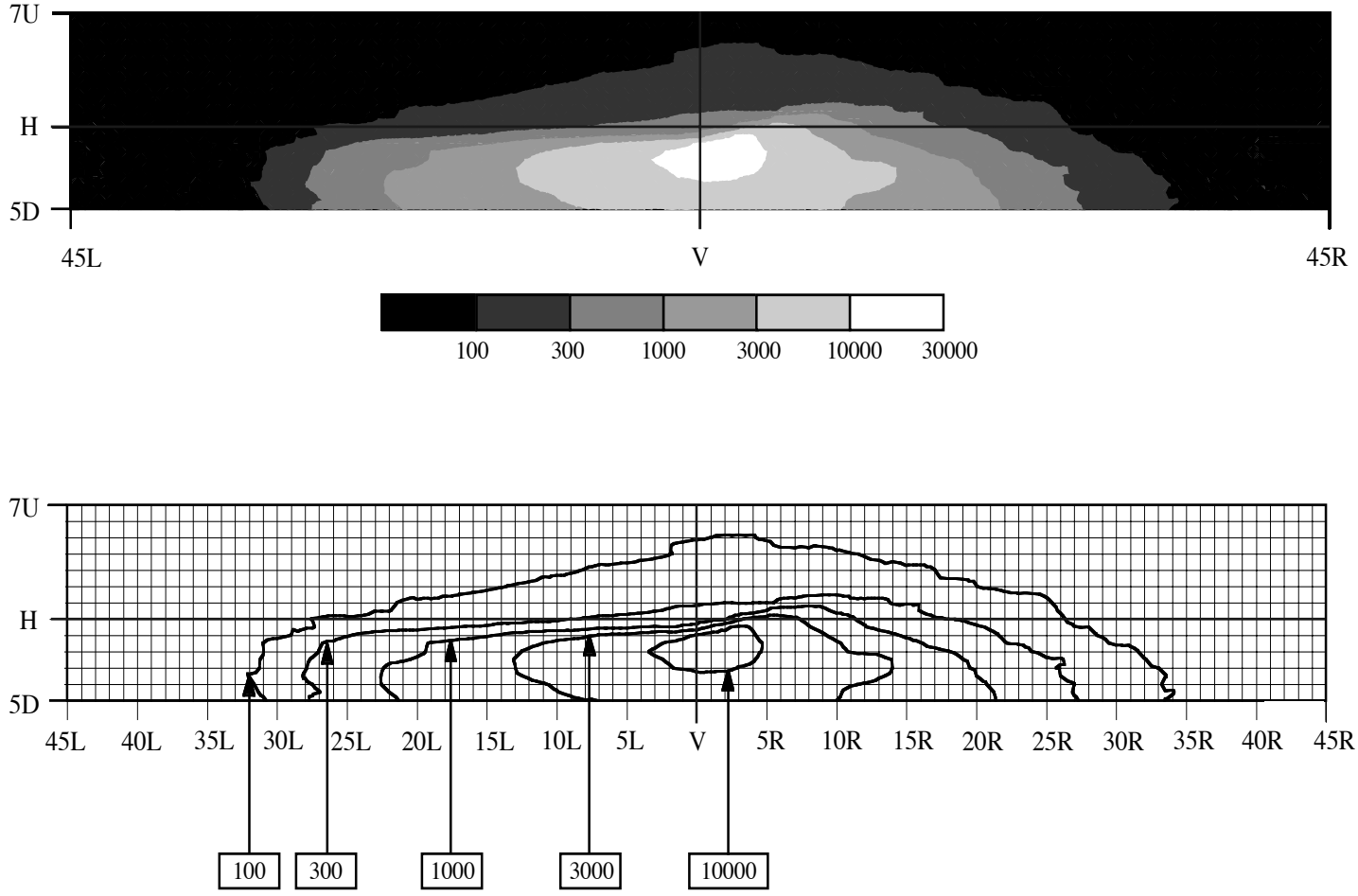

Figure 1. Isocandela diagrams of the median (50th percentile) luminous intensities for the sales-weighted sample representing the low-beam headlamps on current passenger vehicles in Europe. The two panels represent the same information in two different formats. (Test voltage: 12.8 V.)

Table 2
Luminous intensities (cd) for the sales-weighted sample representing the low-beam headlamps on current passenger vehicles in Europe. The entries in each cell are (from top to bottom) the 25th percentile, the median (50th percentile), and the 75th percentile. (Test voltage: 12.8 V.)

	45L	40L	35L	30L	25L	20L	15L	10L	9L	8L	7L	6L	5L	4.5L	4L	3.5L	3L	2.5L	2L	1.5L	1L	0.5L	0
	15	15	15	17	23	32	35	44	44	44	43	42	42	44	45	44	43	43	44	44	44	44	44
7U	30	22	22	28	35	41	44	52	52	52	54	56	59	60	59	60	61	60	62	64	65	69	71
	72	59	45	54	59	78	93	103	105	107	117	113	128	126	123	126	123	123	118	117	125	125	124
	15	15	15	17	23	32	37	47	47	46	45	44	44	45	47	45	46	46	47	47	47	49	49
6.5U	31	22	23	32	35	41	49	55	56	57	58	59	62	65	66	66	66	67	66	68	69	71	72
	69	55	43	53	66	79	96	110	116	119	123	120	131	130	129	127	130	129	125	124	126	125	125
	18	13	15	17	24	33	41	49	51	52	48	49	47	48	49	48	59	59	63	55	55	55	54
6U	28	22	23	33	36	41	56	59	62	60	63	63	63	64	67	69	68	69	71	72	73	75	77
	65	55	41	51	74	82	102	120	121	127	123	127	136	138	140	139	134	131	129	134	129	127	126
	19	13	15	19	24	34	39	51	52	51	49	52	52	55	55	55	53	54	54	56	75	61	60
5.5U	28	22	25	34	38	43	52	64	67	68	69	71	72	70	69	70	72	74	75	77	81	80	79
	60	55	40	54	76	81	110	136	127	129	133	146	147	150	148	148	141	135	133	137	139	135	134
	18	12	15	19	25	35	42	51	53	56	53	53	55	57	58	58	57	58	57	57	60	58	60
5U	28	22	26	32	39	44	48	66	68	72	72	74	79	84	82	85	85	84	82	84	87	91	93
	55	62	38	52	73	81	116	142	146	144	145	154	154	153	158	154	151	149	148	147	147	145	139
	18	13	15	19	25	37	41	54	56	58	56	58	60	61	59	60	59	60	62	64	62	63	63
4.5U	28	23	26	32	40	47	53	76	76	78	79	81	81	81	81	83	88	92	96	106	108	111	116
	55	53	36	52	66	84	124	145	153	166	158	163	164	165	164	164	163	161	159	162	165	167	168
	19	14	15	20	26	37	40	57	57	59	61	65	68	68	66	67	66	67	72	69	69	66	67
4U	27	27	28	35	41	52	57	79	84	83	88	88	89	90	91	92	94	96	98	102	110	118	128
	52	58	39	55	68	91	133	147	159	177	179	176	179	172	171	174	174	173	176	182	185	188	189
	20	16	14	19	27	38	44	57	60	64	65	65	68	69	70	71	72	72	73	77	72	71	72
3.5U	25	36	29	37	42	54	63	86	87	91	96	94	98	99	102	103	105	106	108	113	118	118	121
	73	61	39	53	71	100	140	155	163	184	189	186	187	181	181	186	186	184	190	196	200	203	204
	19	18	14	17	30	37	47	58	62	67	69	69	72	72	72	73	75	77	80	84	82	81	82
3U	24	36	29	38	44	57	71	96	96	101	107	112	116	113	113	116	119	122	124	128	129	132	135
	66	57	41	51	76	103	148	165	175	188	203	206	196	193	195	198	200	198	200	206	210	213	213
	20	18	14	17	28	38	51	64	66	71	74	79	81	82	82	83	85	91	96	96	95	96	96
2.5U	24	37	29	39	50	63	81	102	105	112	119	125	125	127	128	132	137	141	144	147	152	155	158
	71	57	42	55	82	108	155	180	194	205	216	228	215	214	218	220	221	222	222	226	232	237	238
	19	19	16	17	29	41	52	71	74	77	78	83	88	88	90	92	94	99	108	111	110	112	113
2U	23	36	30	39	52	75	92	113	118	126	135	140	142	145	149	154	160	164	170	176	181	185	188
	66	58	43	56	86	117	164	203	214	228	240	252	246	247	248	253	254	257	258	261	269	274	277
	16	20	18	22	34	45	56	85	92	93	92	94	98	100	105	107	110	113	118	120	121	122	125
1.5U	23	37	32	42	56	85	109	130	135	146	156	164	170	174	184	191	197	204	211	209	219	225	231
	65	56	50	61	89	123	176	219	232	250	265	282	282	280	284	290	290	292	296	302	305	311	313
	15	20	18	29	38	53	65	109	116	126	117	116	119	117	119	123	127	132	135	139	141	142	144
1U	23	46	36	43	59	110	129	159	164	178	193	203	213	219	227	232	252	256	258	269	278	276	278
	62	57	53	66	95	132	195	244	258	270	296	328	328	321	319	327	329	332	339	337	343	351	365
	13	18	18	39	41	62	87	136	149	151	157	172	164	163	161	161	163	167	174	191	212	216	217
0.5U	21	51	38	64	75	123	167	201	205	221	241	248	258	264	273	284	294	301	316	329	333	334	339
	64	58	60	80	106	149	207	255	273	296	336	374	382	384	382	382	378	378	384	394	408	420	451
	11	18	13	36	53	82	111	146	194	224	251	266	234	235	226	227	237	257	294	325	332	341	331
0	20	30	39	74	112	163	200	257	290	311	339	340	359	361	371	373	374	396	419	424	462	492	535
	64	55	59	87	140	219	337	320	330	357	414	464	463	470	474	481	494	511	529	543	563	606	665
	5	11	6	40	81	130	214	351	384	419	468	517	552	591	595	614	614	612	650	663	683	701	921
0.5D	14	25	31	62	140	190	330	491	530	651	790	806	831	885	995	1042	1055	1043	1000	1016	1233	1300	1400
	59	42	55	102	252	469	879	731	795	904	998	1065	1197	1250	1232	1275	1332	1265	1474	1605	1539	1710	2230
	5	5	6	59	112	232	465	1565	1887	1882	2164	2262	2380	2551	3048	3838	3897	4165	4426	4827	5297	5982	7132
1D	5	25	25	78	279	588	910	2364	2302	2603	3058	3422	3836	4012	4391	4391	5282	6335	6268	6260	7638	9481	10230
	44	40	44	169	446	828	1776	2650	3021	3768	4770	5582	6762	7106	6756	6877	7688	8144	9893	10967	10996	14012	15308
	5	5	6	50	151	373	973	2175	2539	2956	3574	4331	4916	5076	5342	5751	6171	6533	7576	7847	8179	8912	9168
1.5D	5	20	34	140	381	872	1551	3356	3764	4306	4989	6105	6689	7232	7884	7966	8589	9821	11037	11995	12856	15275	16940
	36	39	43	255	510	1057	2467	5431	5863	6019	6833	7454	8192	8995	9600	10306	11677	12943	14973	16361	17479	18800	19629
	5	5	5	37	177	523	1275	2363	2856	3496	4095	4568	4894	5065	5415	5974	6656	7440	7773	8153	8338	8523	8781
2D	5	10	27	194	420	897	1997	3843	4157	4252	4836	6360	7799	8158	8948	9851	10831	11964	12638	13192	13782	15423	17721
	26	32	66	260	636	1498	3303	6474	7935	8375	9394	10254	10916	11134	11486	12562	13913	16221	17072	19332	20239	20607	21608
	5	5	10	45	230	622	1350	2531	2931	3600	4159	4861	5444	5822	6079	6422	6683	7348	7039	6572	6984	7999	8819
2.5D	5	21	32	220	507	1057	2258	4169	4355	5082	5300	5782	7050	7912	8251	8513	9154	9887	10619	11202	12592	14124	14760
	43	30	136	295	743	1750	3806	7249	8700	9799	10215	10829	11371	12024	12368	12680	13481	14810	16491	17482	17378	17116	17296
	5	5	10	59	246	639	1452	2538	3008	3564	3782	4388	5085	5140	5293	5658	6478	6643	6481	6256	6290	6871	7517
3D	5	16	34	224	582	1328	2498	4151	4230	4693	5209	5944	6965	7626	8037	8077	8260	8949	9581	10248	10439	10839	11482
	35	32	158	318	878	2006	3645	6938	6721	7372	8571	9302	9970	10291	10505	10756	11587	12039	12156	12477	12846	13067	14101
	5	10	21	61	249	786	1495	2576	3113	3156	3449	3857	4709	4754	5088	5604	5704	5897	5856	5817	5867	5957	6184
3.5D	14	21	49	204	518	1410	2482	3778	3751	4191	4531	5006	5444	5809	6272	6445	7062	7457	7676	7980	7885	7895	8565
	41	39	166	386	954	1915	3490	5405	5955	6186	6618	7104	7659	8109	8446	8955	8866	8902	9005	9513	9891	10292	11507
	5	12	12	78	248	703	1358	2635	2666	2902	3151	3591	4162	4344	4601	4715	4760	5001	4976	5007	5119	5289	5593
4D	16	30	33	172	609	1320	2382	3095	3392	3639	3864	4337	4934	5057	5370	5769	6018	6248	6493	6540	6573	6553	6437
	47	56	196	421	1040	1862	3232	3894	4386	4951	5268	5728	6308	6515	6682	6901	7342	7699	8131	8580	8581	8844	8792
	5	11	11	80	260	675	1288	2331	2443	2614	2781	3143	3699	3947	4034	4119	4168	4208	4292	4404	4506	4511	4605
4.5D	18	31	36	158	504	1324	2182	2972	3139	3459	3489	3738	3901	4279	4443	4700	4986	5080	5201	5247	5248	5108	5364
	64	56	160	435	1063	1760	2975	3301	3694	3920	4189	4444	4693	4810	5293	5814	6415	6346	6565	6665	6930	6915	6847
	12	11	23	84	252	711	1488	2086	2245	2284	2304	2666	3101	3220	3298	3417	3777	3576	3571	3673	3971	3831	3838
5D	20	36	47	145	554	1317	2019	2698	2850	2971	3022	3267	3409	3542	3725	3809	3841	4011	4082	4133	4118	4364	4518
	56	56	133	434	996	1685	2690	3039	3321	3530	3699	3695	3799	4192	4684	4810	4550	4813	5039	5182	5279	5458	5552

	0.5R	1R	1.5R	2R	2.5R	3R	3.5R	4R	4.5R	5R	6R	7R	8R	9R	10R	15R	20R	25R	30R	35R	40R	45R
	44	44	45	45	46	47	46	47	46	45	43	45	45	43	40	31	27	20	11	8	6	3
7U	75	76	77	72	70	68	67	66	64	62	64	59	56	55	55	55	47	39	25	15	12	9
	125	124	124	122	121	109	108	107	108	115	121	106	105	101	101	100	68	58	40	30	24	31
	49	48	48	49	51	50	49	49	48	47	45	45	46	44	42	33	26	20	13	8	5	3
6.5U	75	82	80	79	79	76	72	71	69	69	67	64	62	61	60	58	47	37	24	18	13	9
	125	126	127	128	128	112	110	111	113	120	138	119	114	109	108	107	71	60	43	31	39	30
	55	53	53	54	56	56	54	54	52	51	52	49	48	45	43	35	27	21	18	9	5	4
6U	80	82	83	82	82	80	77	76	76	75	72	72	70	69	67	61	51	37	25	20	13	9
	125	126	126	123	116	116	116	118	118	120	141	128	129	126	124	112	72	63	45	49	46	25
	62	74	76	63	63	65	61	56	53	52	58	56	54	50	43	36	28	23	19	9	5	4
5.5U	79	81	81	84	83	82	83	83	82	79	78	76	75	75	75	65	53	37	31	18	13	9
	128	126	124	123	122	121	123	125	128	131	135	143	138	132	129	120	78	65	48	45	41	21
	59	58	62	62	62	60	57	56	54	53	60	58	60	60	56	38	30	28	20	9	5	4
5U	94	99	106	106	106	107	106	107	92	85	84	82	81	79	76	67	55	41	30	20	14	10
	137	136	135	133	131	131	133	136	140	142	144	152	142	140	130	126	84	68	57	53	37	19
	62	63	63	63	61	60	57	56	55	54	64	62	64	64	61	39	36	28	20	10	6	4
4.5U	119	117	117	118	118	118	118	120	122	122	93	89	92	97	85	73	57	45	31	20	14	10
	168	168	161	157	153	150	153	150	151	154	155	158	152	150	140	130	94	94	57	70	31	24
	68	67	69	67	65	61	59	58	57	60	70	66	69	68	60	42	42	29	20	11	7	4
4U	127	127	126	127	129	129	130	134	136	134	132	133	121	120	111	78	60	44	32	19	14	9
	187	185	181	178	174	171	172	176	181	187	172	164	161	164	161	135	104	105	61	60	27	32
	74	74	74	70	69	67	64	63	64	67	72	72	74	69	63	46	43	31	21	11	8	4
3.5U	141	140	131	133	144	145	147	150	147	148	148	149	148	149	137	90	70	42	34	18	14	9
	202	200	197	195	190	191	189	187	189	221	194	187	177	182	181	141	121	99	67	47	24	26
	82	82	80	79	75	73	73	73	71	76	86	84	87	73	80	54	46	31	24	12	8	4
3U	135	136	140	140	146	141	152	166	153	151	161	143	159	158	151	114	83	45	34	18	14	10
	212	212	209	211	209	210	209	208	203	198	198	193	197	206	197	158	136	96	81	54	30	17
	97	94	94	90	87	86	85	83	83	86	98	100	95	99	98	68	52	32	24	13	9	4
2.5U	158	156	158	157	158	161	161	163	165	171	164	153	160	175	174	141	92	52	37	18	15	12
	236	240	242	244	244	241	241	231	225	216	211	215	233	225	226	205	156	98	77	56	35	16
	109	107	105	104	103	103	101	100	100	104	119	121	120	107	102	87	59	34	24	14	9	4
2U	188	189	186	179	182	185	184	187	191	197	184	174	169	178	196	186	101	81	47	26	17	12
	276	285	290	291	289	284	281	273	263	256	250	263	281	264	256	267	171	101	79	59	37	19
	126	122	122	125	127	126	128	129	129	132	160	153	145	128	178	94	61	37	25	14	9	4
1.5U	231	233	227	219	223	214	211	213	213	214	227	217	255	287	287	225	151	95	46	25	19	11
	321	334	343	339	336	326	325	315	314	310	313	394	367	536	443	517	195	128	103	80	54	23
	145	148	151	159	165	166	167	172	194	198	243	296	364	331	314	99	67	40	26	15	9	4
1U	287	287	293	297	296	285	286	283	279	294	366	460	605	700	524	286	190	109	46	29	18	10
	384	403	414	417	420	423	430	460	453	564	584	1320	1396	1271	1431	564	221	128	102	62	74	32
	216	217	217	227	249	256	305	370	425	553	976	1426	598	769	643	123	70	49	30	15	10	3
0.5U	352	361	371	386	398	425	429	524	839	992	1858	1853	1771	1267	871	367	193	115	49	29	18	9
	473	485	520	587	699	739	846	904	1132	2119	3131	2946	2727	2319	2233	678	254	140	111	57	77	29
	404	404	403	529	599	900	1892	2326	2925	3189	2790	1956	1303	1206	801	259	120	44	25	11	5	5
0	569	700	698	856	1324	2127	3501	4008	3925	4345	4112	3274	2511	1722	1416	465	226	136	42	25	17	7
	778	968	1091	1446	2844	4854	5776	7092	7316	6455	4833	4151	3775	3187	2879	1070	314	186	129	63	82	24
	1113	1913	3418	4648	5568	5723	5638	5444	5063	4370	3375	2788	2007	1400	1013	348	152	45	22	10	5	3
0.5D	2299	3233	4718	6966	10118	11059	10659	9334	7103	6527	5310	4172	3083	2426	1690	579	326	138	66	24	10	5
	3218	6794	11218	13766	14165	14668	13011	11122	9535	8154	6359	5573	4324	3921	3284	1359	575	233	145	74	77	30
	8948	10139	10090	9582	9114	8719	8427	7870	6342	5560	4817	4249	2874	1853	1540	402	158	45	13	5	5	5
1D	12840	15806	16252	15554	15413	14431	12935	10875	9129	8183	6260	4886	3576	3221	2532	875	363	156	72	20	5	5
	16033	17246	18269	20066	19586	17771	15334	13579	11356	9946	7416	5471	4927	4055	3425	1520	707	390	204	84	67	31
	10424	11503	11666	12081	12290	11695	10705	9198	8025	7001	5705	5009	3268	2354	1897	557	231	89	18	10	5	5
1.5D	17526	17458	17327	16527	15764	15084	13951	11844	10391	9535	7775	5516	4702	3799	3168	1306	410	194	90	20	9	5
	24876	27934	26936	24681	20173	17754	15073	13788	12602	11492	9626	7305	5811	4585	3858	1670	830	417	200	128	69	26
	8840	9147	9440	9651	9978	10128	9270	8433	7784	7276	6018	5170	4164	3212	2648	900	391	132	20	9	5	5
2D	20389	19176	19473	18082	16720	14947	13768	11930	10195	9384	8085	6504	4839	4084	3398	1490	743	250	134	24	5	5
	22206	23280	22503	20369	19276	17018	15999	15018	14441	12678	9317	7820	6476	5898	4988	2319	916	446	227	148	77	20
	9147	8924	8524	9148	9351	9227	8741	8194	7738	7295	6020	4848	4082	3280	2770	1291	492	153	18	10	5	5
2.5D	15240	15504	15460	15317	13812	12409	11513	10487	9290	8142	6837	5509	4669	4158	4014	2137	901	317	148	36	5	5
	18676	19769	19521	17777	16642	15269	14110	13934	12985	12175	10153	8305	7457	6547	5945	2679	1345	518	359	160	81	43
	7908	8102	8100	8397	8513	8232	7798	7323	6830	6131	5158	4355	3981	3516	2649	1377	619	184	20	10	5	5
3D	11548	11360	11321	11268	10776	9776	9417	9056	8371	7464	6828	5617	4534	3795	3674	2503	885	334	160	52	5	5
	14232	14591	14201	13728	13488	12942	11755	11057	11087	11114	9761	8468	7410	6875	6238	3580	1752	761	337	170	83	44
	6605	6937	7128	7329	7008	7002	6939	6154	5682	5323	4813	4154	3694	3256	2860	1410	802	219	38	20	5	4
3.5D	8952	8731	8528	8565	8311	7800	7385	6821	6656	6525	6156	5548	4716	3986	3728	2543	997	360	166	78	10	5
	11146	11411	11093	10822	10760	10398	9981	9129	8550	8229	7458	7111	6999	6760	6088	4004	1686	852	386	157	84	41
	6012	6003	6046	6116	6149	5834	5572	5079	4663	4385	3998	3757	3418	2971	2666	1433	836	294	52	22	7	3
4D	6666	6976	7003	6849	6659	6242	6179	5969	5788	5547	5484	5039	4426	3928	3290	2669	1311	410	171	82	13	5
	8725	8671	8572	8593	8461	8445	8309	8150	7671	7473	6737	6289	5918	5758	5374	3941	1603	890	401	178	92	46
	4666	4680	4730	4722	4679	4737	4778	4637	4398	4253	3916	3503	3252	3069	2733	1439	896	333	65	23	7	2
4.5D	5340	5325	5394	5548	5573	5535	5355	5178	4994	4897	4824	4703	4223	3743	3184	2363	1431	461	156	90	22	7
	6859	6887	6888	6790	6806	6855	6744	6925	6744	6437	5898	5373	5102	4964	4759	3476	1803	967	419	182	104	51
	3861	3873	3816	3861	3911	4070	4098	4022	3861	3759	3466	3173	3014	2826	2580	1383	797	360	78	28	12	4
5D	4594	4691	4594	4555	4618	4556	4571	4534	4491	4475	4311	4102	3758	3705	3004	2088	1259	483	169	83	37	9
	5367	5476	5740	5944	5803	5697	5602	5400	5583	5569	5403	4757	4330	4041	3958	3088	1876	1044	366	162	89	40

DISCUSSION

The present analysis is not based on a complete census of current low-beam headlamps in Europe, but on a sample constituting 47% of all lamps for passenger vehicles sold in 17 European countries (all 15 members of the European Union, plus Norway and Switzerland). However, we do not have reasons to believe that there are any systematic differences between the lamps that were sampled and those that were not (with the possible exception of HID headlamps). We believe that the data presented in this report provide valid estimates of the luminous intensities that can be expected at various angles with respect to the headlamp axes of low-beam tungsten-halogen headlamps currently used in Europe. Thus, the data could be used to calculate the expected illuminance reaching targets with known geometric relationships to the headlamps, such as traffic signs, road delineation, the eyes of oncoming drivers, or rearview mirrors on preceding vehicles.

As we pointed out in our description of U.S. low beams (Sivak et al., 1997), data such as these should not be used to calculate gradients of luminous intensities for adjacent points in space (e.g., for estimating the sharpness of the cutoff that is important for visual aiming of the beam pattern). This is because the transitions from the more intense to the less intense parts of the beam pattern are not precisely in the same locations for all lamps. Consequently, although the present analysis provides valid estimates of luminous intensities for individual points, a computation of gradients between points based on the present analysis would underestimate the actual gradients. This caveat applies not only to the present data, but also to any aggregate data for nonidentical beam patterns.

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