



# **Driver Compliance in Daytime Headlights Zones in the U.S**

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### **Author's contribution**

*The sole author designed, analyzed, interpreted and prepared the manuscript.*

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## **ABSTRACT**

**Aims:** Observe driver compliance with daytime headlights requirements along two-lane highways in California and Arizona. Determine overall compliance rates, while identifying any statistical differences between highways.

**Study Design:** Travel along highways having daytime headlight use requirements during daylight hours, recording ambient conditions and compliance. Distinguish between cars, large commercial trucks, and motorcycles, and between manual (low-beam) and automated (very low-beam) headlights. Add supportive information from synergistic research.

**Place and Duration of Study:** California State Routes 4, 18, 74, 247, and U.S. Highway 95 in Arizona, during September 2010, and June and July 2015, over seven data collection days during the summer, and one on the first day of autumn.

**Methodology:** Calculate average driver headlight compliance rates and deviations to a 95% level of confidence. Assume that compliance follows a normal probability distribution pattern.

**Results:** A total of 758 motor vehicles were observed. Removing the 104 vehicles observed on a "cloudy" highway, 266 of the 654 drivers were using their headlights (40.7% ± 3.6% compliance). There was no difference between the proportions of compliant drivers on the six highways (95% level of confidence). A total of 66 of 104 drivers used their headlights under cloudy conditions (63.5% ± 9.6% compliance). A Facebook survey of 24 respondents found that 20% of drivers were unaware of daytime headlights zones (DHZs), and an additional 13% were deliberately noncompliant. Interviews of two California Highway Patrol officers revealed that citations for noncompliance were "not popular" (among the officers), and that there was some skepticism as to the effectiveness of the requirement.

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**Conclusions:** Further observation is needed under cloudy skies to develop a more precise proportion of compliance. The low compliance suggests that the effectiveness of DHZs cannot be truly assessed. Compliance might be improved with enhanced driver education, as to their existence and purpose, less reluctant enforcement, a revised headlight sign design, and more frequent signing.

*Keywords: Highway safety; traffic safety; driver safety; daytime headlights; driver compliance.*

## 1. INTRODUCTION

This study investigated motorist compliance with daytime headlights requirements along four California State Routes (CA 4, 18, 74, and 247) and one Arizona State Route (US 95). Headlights are mandatory within daytime headlights zones (DHZs), and non-compliance is subject to citation. Such zones are also referred to as “safety awareness zones” and “safety corridors.” The highways studied did not represent a complete inventory of DHZs, but were readily accessible to the research team. As of this writing, no known inventory of DHZs exists, but many others are located throughout the U.S., and worldwide.

### 1.1 Background: Running Lamps and Headlights

There are two ways in which a motor vehicle's headlights can be on during the daytime. With daytime running lamps (DRLs), the headlights are lit whenever the vehicle is running [1]. In 1993, the National Highway Traffic Safety Administration (NHTSA) permitted manufacturers to install low- and high-beam headlights on motor vehicles that automatically engage upon engine ignition. There is no requirement to purchase a vehicle with DRL capability in the U.S. [2], although some States were requiring insurance companies to offer discounts to drivers with DRLs [3]. As of 2005, DRLs were compulsory in Canada, Denmark, Finland, Hungary, Iceland, Norway and Sweden. In addition, DRLs were required under certain weather conditions in Israel and Italy [4]. European Union Directive 2008/89/EC required all new passenger cars and small delivery vans, starting in 2011, to come equipped with DRLs, with the mandate extended to trucks and buses in 2012 [5]. A number of eastern European countries, including Bulgaria, the Czech Republic, Estonia, Poland, Romania, and others, were requiring DRLs (or the use of low-beam headlights) [6]. Brazil was scheduled to enact mandatory DRLs for all new vehicles in 2021 [7]. The second way in which a motor vehicle's headlamps may be on during the

daytime is for the motorist to simply turn them on. A year 2010 research synthesis noted that DRLs and their impacts had been studied extensively, but that daytime use of low-beam headlights and their impacts had been studied “less frequently” [8]. One of the purposes of this study was to understand the extent to which drivers comply with daytime headlight zones. Note that this study did not examine the effects of daytime headlight use. Several studies have estimated the benefit-cost ratio of daytime headlight use, however. The ratios have ranged from a low of 1.18 in an Australian study [9] to a high of 1.96 in meta-analysis performed by Elvik et al. [10]. The current paper contends that these and even higher benefit-cost ratios cannot be realized without driver compliance.

Motor vehicle headlight use in the U.S. is regulated based on available sunlight and the time of day, and sight distance. For example, as of this writing, 20 States were requiring headlights to be on from sunset to sunrise, while 30 required them from one-half hour *after* sunset to one-half hour *before* sunrise. Thirty-five States were requiring headlights during inclement weather or when the windshield wipers were in use (and 15 States did *not* have this requirement). Notably, Bullough [11] found a statistically reliable reduction in fatal daytime motor vehicle crashes as a direct outcome of daytime headlight use. Maximum sight distance requirements for mandatory headlight use ranged from just 150 ft (45.7 m) in Vermont to 500 ft (152.4 m) in 22 States, and 1,000 ft (304.8 m) in 21 States [12]. The need for DRLs and daytime headlights along highways having poor sight distance is implied by these regulations. The need for DRLs along highways having adequate sight distance is less clear, although the need to heighten visibility is evident, at least from a safety improvement perspective.

### 1.2 Literature Review

Research on daytime headlights, and the impact on motor vehicle safety, has been limited and

conflicting. Henry and Phillips [13] claimed, based on European studies, that daytime running lights could “reduce accidents by up to 40%.” O’Donnell reported on a General Motors claim that DRLs had prevented 37,000 crashes since 1995 [14]. Williams [4] reported that a NHTSA study found that DRLs resulted in a 5% to 23% reduction in multivehicle daytime crashes. Williams also reported, however, on a study commissioned by the British Motorcyclists Federation in which DRLs *increased* collisions by 8%. Wald noted that daytime headlights had been associated with “annoying and unnecessary” glare by the U.S. Department of Transportation [15]. An extensive amount of research has emphasized daytime headlight use among motorcycles, assessing the conspicuity and safety effects (e.g., [16, 17, 18]). One concern is that the DRLs and daytime headlights may “compete” with those of motorcycles, potentially diminishing the conspicuity of the latter. One issue with DRLs, and daytime headlight use, is the impact of ambient lighting on their effectiveness. In countries located within the northerly latitudes, such as those listed earlier (e.g., Canada, Finland, Norway), the intensity of sunlight is reduced, compared to that in the U.S., by the angling away from the sun of the earth’s surface as the planet “crests” at the North Pole. The results of studies conducted in “Arctic” countries, therefore – many of which have demonstrated the effectiveness of DRLs [19,20] – may not be applicable in the U.S. Some studies have rejected the notion that there is a difference of effects between the “Arctic” nations and the U.S. regarding daytime headlights, however [21,22]. Also, a NHTSA study (23) found that DRLs generally had no effect on the frequency or severity of motor vehicle collisions. Pedestrian reaction times at intersections, to turning vehicles, may also be diminished, because the headlights “compete” with turn signals [24,25, 26]. Thus, despite the high level of investigation, the effectiveness of DRLs, and of daytime headlight use among cars, pickups and SUVs – particularly in the U.S. – is unclear.

## 2. DAYTIME HEADLIGHTS COMPLIANCE DATA

While the effectiveness of daytime headlights is not entirely clear, the literature does not address the level of compliance within DHZs. Compliance is a critical factor, since the effectiveness of daytime headlights cannot be realized without a high level of participation.

DHZs were in place along the following two-lane highway segments that were studied: an 11-km (7-mi) stretch of CA 4 in eastern Contra Costa County, about 80 km (50 mi) east of San Francisco (Fig. 1), a 56-km (35-mi) stretch of CA 247 in San Bernardino County, southeast of Barstow (Fig. 3), a 22.5-km (14-mi) stretch of CA 74 in southern Orange County (Fig. 5) and a 17-km (10.5-mi) stretch of CA 18 in San Bernardino County, between Lucerne Valley and Apple Valley (Fig. 3), all in California, and a 40-km (24.8-mi) stretch of US 95 between I-40 and Lake Havasu City in Arizona. Annual average daily traffic volumes (AADTs) in 2013 on the respective segments were 8,100 on CA 4, 9,500 on CA 18, 11,600 on CA 74, 2,800 on CA 247, and 7,070 on US 95 [27,28]. The dates of these traffic volume data were closest to the headlight data collection dates. As noted above, there are numerous other DHZs; a useful research study would be an inventory of DHZs in the U.S., and worldwide. The segments selected for the study included those that were easily accessible to the research team. Four survey runs were conducted on CA 4, and one each on the other highways. Limited data collection resources prevented additional survey runs. The primary objective of the data collection effort was to obtain a decent sample, substantial enough to accept or reject null hypothesis statements.

The compliance data were collected on the five highways during summertime days in 2010 and 2015, although one data run was conducted on the first day of autumn. The times of the day of the runs varied, but all were done during broad daylight hours. During each run, the author drove a motor vehicle at the speed limit in one direction, while observing and manually recording the motor vehicles traveling in the opposing direction. Since the author was “multitasking” (i.e., driving and writing), data items such as motor vehicle type, type of headlamp, and whether or not the vehicle was in a platoon were not recorded. Motorcycles were excluded from the count, since nearly all of them were observed to have their headlights on. A distinction was made between parking, low-beam and regular headlights. Parking and very low-beam headlights were recorded as “headlights off;” regular headlights and reasonably bright low-beams were recorded as “headlights on.” The sky conditions, time, length and date of the run, and number of motor vehicles observed are all presented in Table 1.



Fig. 1. CA 4 daylight headlight zone, eastern Contra Costa County, California  
(<http://ccmap.us/gis/>)



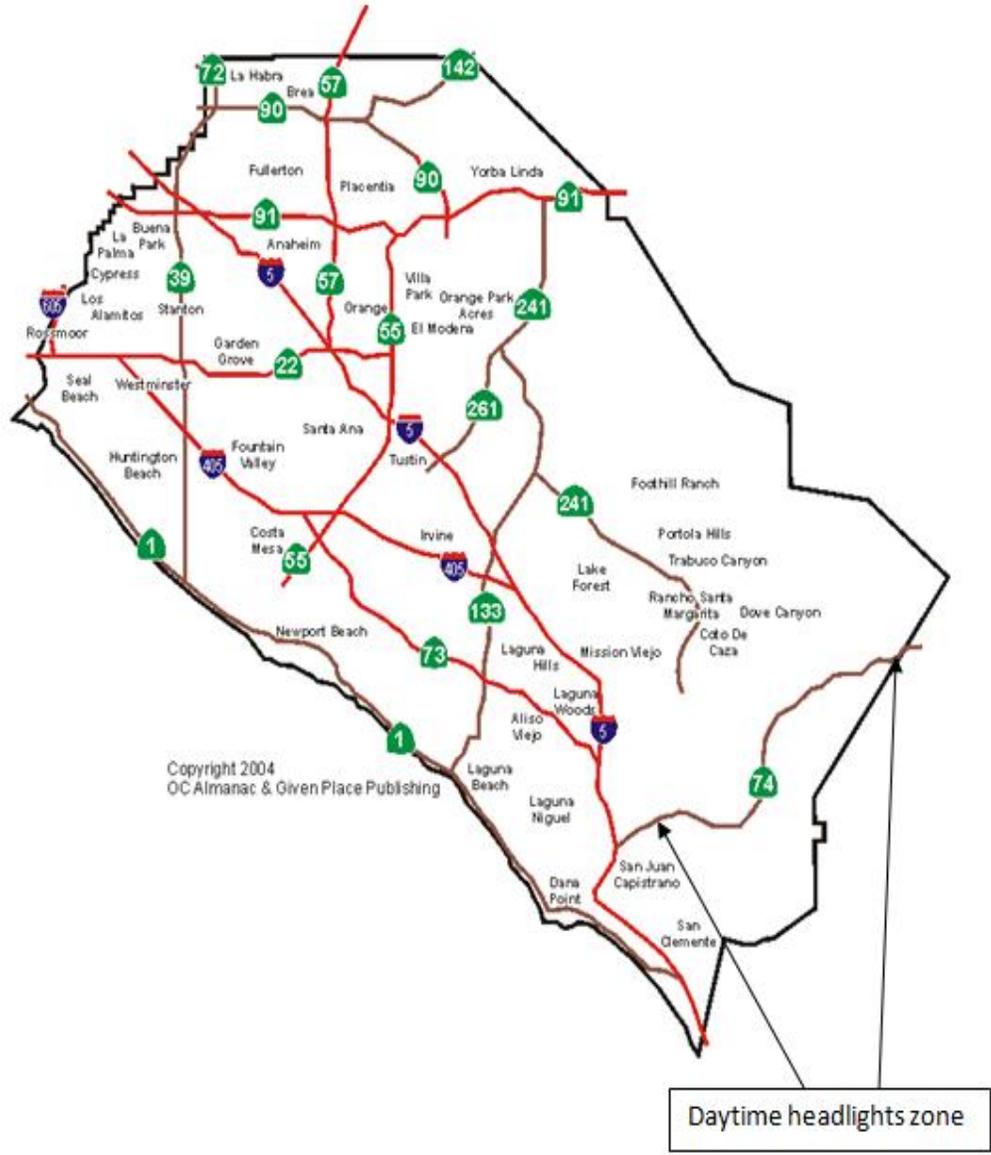
Fig. 2. CA 4 daylight headlight zone entry point near Brentwood, California  
([www.aaroads.com/california/images004/ca-004\\_eb\\_brentwood\\_18.jpg](http://www.aaroads.com/california/images004/ca-004_eb_brentwood_18.jpg))



Fig. 3. Daytime headlights zones in San Bernardino County, California: CA 18 & CA 247  
([www.sanbag.ca.gov/about/maps/sbmap.gif](http://www.sanbag.ca.gov/about/maps/sbmap.gif))



Fig. 4. Entrance to daytime headlights zone along CA 247  
([www.aaroads.com/california/ca-247.html](http://www.aaroads.com/california/ca-247.html))



**Fig. 5. Orange County, California Highways**  
 (www.ocalmanac.com/images/Map\_OC\_Hwys.gif)

**Table 1. Daytime headlights compliance data**

State	Highway	Date	Day	Time	Condition	On	Off
CA	CA 4	09.09.2010	Thu	3:35 pm	Sunny, dry	39	56
		14.09.2010	Tue	3:35 pm	Sunny, dry	31	65
		16.09.2010	Thu	3:35 pm	Sunny, dry	39	75
		21.09.2010	Tue	3:45 pm	Sunny, dry	37	59
	CA 18	28.06.2015	Sun	5:40 pm	Part sunny	19	24
	CA 74	06.07.2015	Mon	11:35 am	See note <sup>1</sup>	53	62
	CA 247	28.06.2015	Sun	4:55 pm	Clouds	66	38
AZ	US 95	27.06.2015	Sat	4:40 pm	Sunny, dry	48	47

<sup>1</sup> Marine layer for first third of route; partly sunny for middle third; sunny for final third of route

A total of 758 motor vehicles were observed during the data collection periods, with 332 (44%) complying, and 426 (56%) not complying. The 758 motor vehicles observed represented about 3% of all motor vehicles using those highways on those days, based on the following data and assumptions:

- The cumulative AADT on all five highways, including four days on CA 4, was 63,370 [27, 28].
- Each motor vehicle used the respective highway twice in one day (one trip in each direction).
- About 80% of the total daily vehicles used the respective highway during daylight hours.

### 3. ANALYSIS OF THE DATA AND RESULTS

As noted above, motor vehicle models and makes were not recorded during the data collection; thus, it was not possible to determine the exact proportion of vehicles with DRLs. Very low-beam headlights, as is characteristic of DRLs, were observed and noted, however. As of this research, DRLs were featured on some but not all makes of General Motors, Honda, Lexus, Saab, Subaru, Suzuki, Toyota, Volkswagen and Volvo [2]. NHTSA had been neutral on DRLs, as noted by the research above, and confirmed by the rescinding of a proposal for DRL intensity reduction in 2004. The responses from automakers were mixed: General Motors, for example, had requested a DRL mandate, while European makers offered no objection to proposals to either reduce DRL intensity, or even eliminate DRLs (on U.S. roads) altogether. Trucks were not distinguished during the data collection, although spot observations did not reveal any consistency in the use of daytime headlights by truck drivers.

Considering all 758 observations, the maximum error of the estimated proportion of vehicles with their headlights on was 3.6%. That is, the confidence level was 95% that the proportion of vehicles with their headlights on was within the range  $44.0\% \pm 3.6\%$  (i.e., 40.4 to 47.6%). However, the null hypothesis that the proportions of “headlights on” among the eight highway runs were equal was rejected with a 95% level of confidence. After removing CA 247 from the data set, and recomputing with 654 observations, the null hypothesis that the proportions of “headlights on” among the seven highway runs were equal was *not* rejected, with a 95% level of

confidence ( $\chi^2 = 10.40$ ). The overall level of compliance on the seven highways was 40.7% (266 of 654). The “odd highway out” was CA 247, which featured a 63.5% level of compliance. As indicated in Table 1, the sky conditions were partly cloudy; in fact, the author observed some light rain when heading westbound. The weather recap for the region, on the day of data collection (28 June 2015), indicated that light rain fell between 12 noon and 4 pm [29]. The survey was performed starting at 4:55 pm. Hence, there may have been a propensity among drivers to have used their windshield wipers and headlights for a period before the survey began, and then continued to use them under the cloudy skies.

To supplement the field observations, a survey of motorists was conducted using Facebook. The participants were limited to a group of Facebook “friends,” with the results potentially biased toward those that might be typical of drivers in their age range (18 to 50). There were 24 respondents. Twenty percent were unaware of the existence of DHZs, and 13% consciously did not follow daytime headlight instructions. Since 13% did not follow instructions, and presumably knew about DHZs, then only two-thirds knew about the zones *and* were compliant. Fifty percent of the respondents drove with their headlights on during the daytime; it is unknown how many of them had DRLs. One respondent suggested that daytime headlight use would be effective only during inclement weather, while another recommended that all motorists should drive with their headlights on to improve their visibility. DHZs are subject to enhanced enforcement, as suggested in the opening section of this paper, although the level of enforcement along the highways studied, and its impact on compliance and safety, was not known. As part of this study’s investigation, two California Highway Patrol officers were interviewed to obtain their insight. Officer A admitted to not having “much experience with this particular sign.” He had, however, stopped a couple of drivers to give warnings, but not citations. He stated that CA 4 in particular had “increased somewhat in safety, but not a whole lot where we see a huge change.” The officer estimated that his division was issuing about ten citations per month for non-compliance, and that it was “not a very popular citation” (among the officers). Officer B described CA 4 as a “bloody highway,” although he may have been referring to the entire highway, which has segments along which the AADT reaches 155,000. Yet, the officers’ statements indicated that it was not

possible to determine the impact of the daylight headlight section because of the lack of full compliance.

#### 4. DISCUSSION AND CONCLUSION

Compliance might improve with enhanced enforcement within any DHZ, given Officer A's implication that enforcement was not strong, at least along CA 4. The conjecture is in agreement with that of Shinar and MacKnight [30], in their study of the effects of enforcement. Those authors noted, however, that the true effects can be complex, but that desired levels of compliance can be achieved with an appearance of threat, as well as publicity provided, perhaps, by news coverage. The Facebook survey results suggest that education may also be useful, to make drivers more aware of the existence of and need for DHZs. After observing low driver compliance with stop signs at pedestrian crossings in a university campus environment, Brown et al. [31] similarly recommended education by college health personnel as an intervention to improve driver compliance. Gaweesh et al. [32] suggested that the design of the regulatory headlight sign could also be a factor in its interpretation by drivers. A new sign design was tested in a driver simulator environment, and was found to be preferred by the respondents. The new design – not shown here excusing permission from [31] and the Wyoming Department of Transportation – features similar wording as the original sign (see Figs 2 and 4), but with a yellow background behind “Turn Headlights On,” plus an internationally-recognizable headlight symbol on the sign. Increasing the frequency of DHZ signs along the highway was also recommended.

An average level of compliance of  $40.7\% \pm 3.6\%$ , with a 95% level of confidence, was observed on seven highways during sunny, dry conditions. The level of compliance increased to  $63.5\% \pm 9.6\%$ , with a 95% level of confidence, on a highway under clouds and light rain. The wide range around the compliant proportion on this highway indicated that a larger sample is needed to determine a more precise result. Overall, the level of compliance was determined to be between 37% and 44% when conditions are sunny and dry, and at least 54% when there are clouds and light precipitation. These results reflect a higher level of compliance than was identified in a study of three highways in Wyoming (US 287, WY 59, and WY 287) in June 2015 (33). An overall average compliance rate

of just 25.5% was observed among vehicles without DRLs. Standard deviations and the numbers of vehicles observed were not provided. Motorcycles, heavy trucks, and school buses were excluded from their observations. Despite the different results, both the current and the Wyoming studies corroborate the low compliance rates. Further studies along other DHZs, including different times of the day, days of the week, seasons, and weather conditions, are recommended. A compilation of DHZs, including their lengths and locations, would also be useful. It would subsequently be useful to determine if there are any regional variations in compliance.

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#### COMPETING INTERESTS

The author declares that no competing interests exist with the material in this article. The research expanded on a school term project, and was not funded. Hence, there is no allegiance to any organization or entity.

#### COMPETING INTERESTS

Author has declared that no competing interests exist.

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