Study of Emergency Vehicle Warning Lighting
Inferences about Emergency Vehicle Warning Lighting Systems from Crash Data
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Firefighters who are killed in the line of duty from road traffic crashes are a substantial fraction of all firefighters who die in the line of duty. Consequently, understanding and addressing the circumstances that lead to these crashes are major concerns for firefighter safety. By their nature, the activities involved in firefighting involve substantial risks, and activities involving traffic are not exempt from such risks. Warning lamps are used on emergency vehicles in order to reduce traffic risks by increasing the conspicuity of those vehicles, and they are probably very effective in doing that. However, there has been concern that, if they are too strong, warning lamps could also increase the risk of certain types of crashes. Thus far, empirical evidence on this issue from crash data has been limited. The purpose of this project is to examine several sources of information about emergency-vehicle crashes and to use that information to make tentative recommendations about how warning lamps could be modified to increase safety.

The effectiveness of warning lamps as alerting devices is probably determined by several variables: light intensity, flash rate, abruptness of flash onset and offset, color, number of lamps, and configuration of lamps. The ways in which each of these variables may be related to positive or negative effects on emergency vehicle safety are complex. However, it may be possible, for many purposes, to characterize warning lamps on a single dimension, which might be referred to as their overall *strength*. Stronger lamps may be more effective in getting drivers to notice emergency vehicles, and thereby avoid many potential crashes. However, there may also be some negative effects of warning lamps—including visual effects such as glare and masking; and cognitive effects such as distraction, confusion, and disorientation. If greater strength also increases negative effects of warning lamps, then optimizing the design of warning lamps may involve determining the strength of lamps that yields the best tradeoff between conspicuity and those negative effects.

The following three sources of data for emergency vehicle crashes were examined: (1) state databases, covering fatal and nonfatal crashes, from Missouri and Florida, (2) the U.S. Fatality Analysis Reporting System (FARS), which covers all fatal crashes, and (3) a specialized database for all fatal firefighter traffic crashes. The more general-purpose databases can be used to identify emergency vehicle crashes in which the emergency vehicle was a contact vehicle; the specialized database was used primarily to identify crashes in which a firefighter was killed as a pedestrian, but in which no emergency vehicle was a contact vehicle.

The crash data that were examined provide several findings with possible implications for the effectiveness of warning lamps. The state databases yielded the most directly applicable findings. Emergency vehicles are involved in fewer angle crashes in the dark, consistent with the hypothesis that warning lamps are effective in preventing those crashes because the lamps are more salient in darker ambient conditions. In addition, changes in the warning lamps on fire trucks with the 1998 model year may have improved their safety effectiveness, as suggested by reductions in the number of crashes on emergency runs relative to those not on emergency runs. Examination of police accident reports (PARs) for crashes involving firefighting vehicles in Florida suggested that there may be a substantial number of multiple-vehicle crashes (about 30% of the cases examined) in which drivers of the nonemergency vehicles did not detect the emergency vehicle. Stronger warning lamps might be able to address that problem. Information from the specialized database for fatal firefighter road traffic crashes indicated that firefighter pedestrian deaths are a substantial fraction of all incidents in which firefighters are killed in road traffic (25 of 98 incidents). There were suggestions that warning lamps may have sometimes reduced the likelihood of drivers detecting and avoiding the pedestrian, but the likelihood of detection in those cases may have been low even without any negative effects of warning lamps.

Although these results add to prior knowledge about how warning lamps may affect the risk of emergency vehicle crashes, such knowledge is still quite limited and suggestions for improvements in warning lamps must be considered tentative. For purposes of discussion and further investigation, more than for immediate action, we offer the following suggestions: (1) Given the considerations if the previous paragraph, stronger warning lamps might reduce the risk of crashes in which another driver fails to detect an emergency vehicle. There does not appear to be strong evidence that stronger lamps would result in significant negative effects. (2) Given the possibility that there is a tradeoff between the conspicuity of warning lamps and negative effects of those lamps, options for warning lamps that may change that tradeoff seem worth considering.

The results of this project lead to several possible approaches for further research to better understand how warning lamps affect emergency vehicle safety. First, in order to overcome the limits of existing crash databases, it may be valuable to directly observe the behavior of other vehicles around an emergency vehicle engaged in emergency operation, either while in transit or while parked at an emergency site. Second, the possibility that warning lamps at night reduce the visibility of emergency personnel as pedestrians should be directly studied with human-performance field work.