FOUNDATION FOR TRAFFIC SAFETY

Roadside Assistance Vehicle Lighting: Review of Scientific Research and State Regulations

INTRODUCTION

Tow trucks and other roadside service vehicles (RSVs) must safely operate in a wide range of roadway environments and conditions, from sunny afternoons to combinations of darkness, smoke, fog, rain, and snow. RSV visibility in these diverse operating conditions is paramount and static and flashing emergency or hazard vehicle lighting are common countermeasures to enhance the conspicuity of vehicles stopped or working on the roadside. Numerous factors related to lighting influence an approaching motorist's ability to distinguish operational personnel from the rest of the visual scene. There have been efforts to evaluate various aspects of service and emergency vehicle lighting (color, pattern, frequency, intensity); however, existing research does not clearly point to the best lighting solutions for safety, especially when considering limitations of individual studies as well as state laws or regulations that impose constraints on some aspects of lighting available for use on tow trucks and other roadside assistance vehicles. The current project aimed to (a) review and synthesize available studies on different properties of RSV lighting and (b) review state regulations that currently guide the selection of warning lights for roadside service vehicles.

METHODOLOGY

For the literature review, over 1200 articles were screened from scholarly databases and from the gray literature and 30 were deemed relevant to RSV lighting. Key outcomes were distilled according to the device type, number of lights and their mounting location, size and shape of the warning lights, warning light color, flash rate, flash pattern and modulation, lighting intensity, as well as vehicle markings. Overviews of the individual studies, their approach or design and limitations were noted, along with an assessment of critical knowledge gaps and areas where more research is merited.

Relevant laws and administrative rules (regulations) were reviewed for all 50 states, the District of Columbia, and Puerto Rico. For the purposes of this review, "warning lights" were defined as any type of light or beacon intended to warn road users of the presence of an RSV. In general, this means flashing beacons or light bars mounted high on the vehicle. Attempts were made to identify state statutes affecting the use of flood lights or work lights mounted on the RSV.

TECHNICAL REPORT:

Shaw, J. W., Ajibola, O. F., Lawrence, B., Kearney, J., Proud, J. K., & Wood, J. (2025). *Roadside Assistance Vehicle Lighting: Review of Scientific Research and State Regulations* (Technical Report). Washington, D.C.: AAA Foundation for Traffic Safety.

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607 14TH STREET, NW, STE 701
WASHINGTON, DC 20005
202-638-5944
AAAFOUNDATION.ORG

KEY FINDINGS

Although results from many of the studies reviewed are mixed, the preponderance of evidence suggests that several techniques are successful in drawing attention to a special-purpose vehicle, especially at night. These include using lightbars with LED lighting, using a faster flash rate (typically ~4 Hz), increasing the luminous intensity of the warning light(s), increasing the number of lights (2 to 4 lights per display), and increasing the amount of retroreflective sheeting on the vehicle. Replacing some of the amber lights with green or blue also appears to help draw attention to the vehicle, but it is unclear how much of this is a novelty effect. Increasing the complexity of flash patterns does not appear to be helpful to road users. Rather, alternating flash patterns (left/right "wig-wag") were generally found to be better detected by drivers than simultaneous flashing of two or more lights. Alternating patterns also appear to improve the ability for drivers to detect other objects in the scene compared to random flash patterns. Some selected outcomes are further described in the table below (see the report for full details).

Property	Key Findings
Device Type	• Studies investigating different light configurations in a roadside environment have increasingly used LED lights as the sole device type under study, making it challenging to interpret effects. • There is some evidence that LED lights are perceived as brighter than other common light types.
Number of Lights and Mounting Locations	• Light displays with two to four lights have been found to better alert drivers to the presence of a road event than displays with fewer lights. • There was evidence that displays with more than four lights may result in increased levels of discomfort glare. • Higher mounting positions on the vehicle (above the driver eye height) may improve visibility of the vehicle, provided there is consistent background contrast.
Warning Light Size and Shape	• The effect of warning light size and shape on alerting, informing, and managing drivers at roadside scenes requires further research.
Warning Light Color	• Although there were mixed results, the color of the light display may affect the ability of a driver to detect and identify conditions at a roadside scene. Warning lights in amber or green were found to be highly visible from a distance. However, compared to other colors, amber and green appear to result in more glare. • Much of the research appears to conflate the effects of warning light color and photometric output. • Consistent with historical practice, drivers strongly associate red or blue warning lights with fire or police, and strongly associate yellow/amber warning lights with road maintenance, construction, and towing. The color also influences driver perception of the level of urgency of the scene and how they may respond. • Short-term tests suggest color schemes other than amber alone might be perceived as indicating a somewhat more urgent scene, but long-term evaluations are required.
Flash Rate, Flash Pattern, and Modulation	• Faster flash rates convey greater urgency and are more attention-getting than slower flash frequencies. • Flash frequencies ranging from 1 to 4 Hz are recommended. • Alternating flash patterns (left/right) appear to be better detected by drivers than simultaneous flashing of two or more lights. Complex flash patterns such as double-flash or random patterns appear to make it more difficult for drivers to judge approach distance and detect workers near the vehicle. • There is limited evidence that flash modulation (dimming) to ~90% of peak luminance can improve warning light visibility compared to flash patterns that use full "off."

Property	Key Findings
Luminous Intensity	• Comparisons between studies tend to be confounded by differing test conditions. • Higher intensity warning light displays have greater attention-getting performance and are seen from a greater distance. However, in night conditions they have been found to increase disability glare. • Lower warning light intensity is recommended during nighttime to reduce discomfort glare and disability glare.
Vehicle Markings	• Most vehicle marking studies have been done on boxy vehicles such as dump trucks and fire apparatus. The applicability to tow vehicles may be limited. • Compared to checkerboard patterns, inverted V (stripe) patterns appear to have less adverse impact on night visibility of personnel on foot behind the vehicle. • There is some evidence that red+white markings are more distracting than black+yellow markings. • The use of retroreflective vehicle markings has been shown to make the vehicle more visible at night.

The review of state regulations sought to identify statutes and administrative rules related to the color of RSV warning lights or other properties. Summary tables are provided for each state in the report. In contrast to the extensive efforts that have been made to standardize traffic signs and traffic signals over the past century, U.S. state laws and regulations related to RSV warning lights are remarkably inconsistent. States differ not only regarding the allowable warning light colors, but also regarding when warning lights are to be used. While amber lights are traditional in most states, several states have added additional colors such as blue or red—often with stipulations that these colors can only be used while standing at the roadside, loading a disabled vehicle, or blocking a lane. In several states, white lights can be used under the same circumstances as amber lights; in some cases, it is legal for an RSV to be equipped only with flashing white warning lights.

IMPLICATIONS

The most important take-away from prior research is that interventions intended to improve the long-distance visibility of special-purpose vehicles often appear to have adverse effects on the visibility of personnel near the vehicles. For example, increased RSV lighting can increase glare, increase the time it takes for drivers to perceive the presence of a person on foot near the vehicle, and decrease the overall visibility of personnel on foot. Moreover, current work light practices in the towing industry potentially exacerbate the problem of nighttime glare at towing scenes.

With respect to regulations, most state statutes are silent about other key technical parameters such as luminous intensity, flash patterns, and mounting location. The variability of state requirements frequently results in situations where lighting equipment that is permissible in one state cannot be used legally in a neighboring state.