



U.S. Department  
of Transportation  
**National Highway  
Traffic Safety  
Administration**

www.nhtsa.dot.gov  
**nhtsa**  
people saving people

DOT HS 809 973

December 2005

# Assessment of Headlamp Glare and Potential Countermeasures

## Survey of Advanced Front Lighting System (AFS) Research and Technology

**This publication is distributed by the U.S. Department of Transportation, National Highway Traffic Safety Administration, in the interest of information exchange. The opinions, findings and conclusions expressed in this publication are those of the author(s) and not necessarily those of the Department of Transportation or the National Highway Traffic Safety Administration. The United States Government assumes no liability for its content or use thereof. If trade or manufacturer's names or products are mentioned, it is because they are considered essential to the object of the publication and should not be construed as an endorsement. The United States Government does not endorse products or manufacturers.**

**Technical Report Documentation Page**

|   |  |  |  |  |           |
|---|--|--|--|--|-----------|
| 1. Report No.<br>DOT HS 809 973   |  | 2. Government Accession No.                          |  | 3. Recipient's Catalog No.                                   |           |
| 4. Title and Subtitle<br>Assessment of Headlamp Glare and Potential Countermeasures:<br>Survey of Advanced Front Lighting System (AFS)  |  |  |  | 5. Report Date<br>December 2005                              |           |
|   |  |  |  | 6. Performing Organization Code                              |           |
| 7. Author(s)<br>Yukio Akashi, John Van Derlofske, Jennifer Watkinson, Charles Fay   |  |  |  | 8. Performing Organization Report No.                        |           |
| 9. Performing Organization Name and Address<br>Lighting Research Center, Rensselaer Polytechnic Institute<br>21 Union St<br>Troy, NY 12180  |  |  |  | 10. Work Unit No. (TRAIS)                                    |           |
|   |  |  |  | 11. Contract or Grant No.<br>DTNH22-99-D-07005               |           |
| 12. Sponsoring Agency Name and Address<br>National Highway Traffic Safety Administration<br>NHTSA, NRD-13<br>400 7th St SW<br>Washington, DC 20590  |  |  |  | 13. Type of Report and Period Covered<br>Task 7 Final Report |           |
|   |  |  |  | 14. Sponsoring Agency Code                                   |           |
| 15. Supplementary Notes<br>Michael Perel was the NHTSA COTR for this project.   |  |  |  |  |           |
| 16. Abstract<br>The goal of advanced front lighting systems (AFS) is to actively control headlamp beam patterns to meet the dynamic requirements of changing roadway geometries and visibility conditions. AFS is being rapidly introduced worldwide due to its attractive styling aspects and potential safety benefits. However, before AFS becomes more aggressively implemented, it is necessary to better understand the impacts of AFS on drivers, other vehicles, and pedestrians. To achieve this understanding, this survey investigated comments on AFS from the NHTSA database (Docket 13957), reviewed relevant literature, and held a phone conference with automobile and headlamp manufacturers for industry feedback. The detailed results of the survey are described in this report.<br>This survey led to a general conclusion that, although a significant number of studies on AFS have been done, due to inconsistency in metrics used and lack of information on experimental procedure and scenarios, further research is still needed to quantify the effectiveness of AFS. In order to evaluate AFS technology, it is important to first identify the appropriate visibility, glare, and safety metrics and test methods. Second, based on these common metrics and test methods, examine the effectiveness of AFS compared to other vehicle forward lighting systems. Based on these findings, two tasks are proposed as future NHTSA research: (1) identify appropriate metrics, performance measures, and test scenarios for AFS; and (2) develop an AFS prototype for evaluation. |  |  |  |  |           |
| 17. Key Words<br>headlamp, headlight, disability glare, discomfort glare, visibility, AFS, bending beam, town beam, motorway beam, adverse weather beam   |  |  |  | 18. Distribution Statement                                   |           |
| 19. Security Classif. (of this report)<br>Unclassified  |  | 20. Security Classif. (of this page)<br>Unclassified |  | 21. No. of Pages   | 22. Price |

Form DOT F 1700.7 (8-72)

Reproduction of completed page authorized



## Table of Contents

|   |     |
|---|-----|
| List of Tables .....                                | iii |
| List of Figures .....                               | iv  |
| Section 1: Executive Summary .....                  | 1   |
| Section 2: Introduction .....                       | 3   |
| 2.1: History of AFS .....                           | 3   |
| 2.2: Outline of the Eureka Project .....            | 4   |
| 2.3: Objectives and procedure of this study .....   | 4   |
| 2.4: Summary of findings .....                      | 5   |
| Section 3: Manufacturer Input .....                 | 7   |
| Section 4: NHTSA Docket Summary .....               | 10  |
| Section 5: AFS Literature Review .....              | 19  |
| 5.1: Relevant literature .....                      | 19  |
| 5.2: Reviewed literature and summary .....          | 19  |
| 5.3: Literature review and analysis .....           | 21  |
| 5.3.1: Overall benefits and acceptance of AFS ..... | 21  |
| 5.3.2: Bending beam .....                           | 22  |
| 5.3.3: Town beam .....                              | 42  |
| 5.3.4: Motorway beam .....                          | 47  |
| 5.3.5: Adverse weather light .....                  | 52  |
| 5.3.6: Regulations .....                            | 62  |
| 5.3.7: Technology .....                             | 65  |
| 5.3.8: Other applicable AFS research areas .....    | 68  |
| Section 6: Research Needs .....                     | 70  |
| Acknowledgements .....                              | 74  |
| Appendix A: Relevant Literature .....               | 75  |
| Appendix B: Reviewed Literature .....               | 79  |

# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

## LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

## FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

## E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.