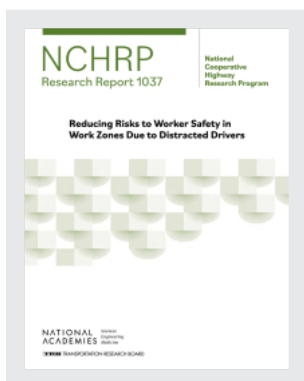


This PDF is available at <http://nap.nationalacademies.org/27009>



Reducing Risks to Worker Safety in Work Zones Due to Distracted Drivers (2023)

DETAILS

44 pages | 8.5 x 11 | PDF

ISBN 978-0-309-69830-6 | DOI 10.17226/27009

CONTRIBUTORS

LuAnn Theiss, Gerald L. Ullman; National Cooperative Highway Research Program; Transportation Research Board; National Academies of Sciences, Engineering, and Medicine

BUY THIS BOOK

FIND RELATED TITLES

SUGGESTED CITATION

National Academies of Sciences, Engineering, and Medicine. 2023. *Reducing Risks to Worker Safety in Work Zones Due to Distracted Drivers*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/27009>.

Visit the National Academies Press at nap.edu and login or register to get:

- Access to free PDF downloads of thousands of publications
- 10% off the price of print publications
- Email or social media notifications of new titles related to your interests
- Special offers and discounts



All downloadable National Academies titles are free to be used for personal and/or non-commercial academic use. Users may also freely post links to our titles on this website; non-commercial academic users are encouraged to link to the version on this website rather than distribute a downloaded PDF to ensure that all users are accessing the latest authoritative version of the work. All other uses require written permission. ([Request Permission](#))

This PDF is protected by copyright and owned by the National Academy of Sciences; unless otherwise indicated, the National Academy of Sciences retains copyright to all materials in this PDF with all rights reserved.



References

- Akepati, S. R., and S. Dissanayake. 2011. "Characteristics of Work Zone Crashes." In *Transportation and Development Institute Congress*, American Society of Civil Engineers, pp. 1286–1295. <https://ascelibrary.org/doi/pdf/10.1061/41167%28398%29122>. Accessed July 26, 2022.
- ALDOT. 2018. Special Project Detail, Drawing 2002-A "Details for Traffic Control for Two Lane Highways." Montgomery, AL. <https://www.dot.state.al.us/publications/Design/pdf/ETCL/2002a.pdf>. Accessed July 26, 2022.
- Alexander, G. J., and H. Lunenfeld. 1975. *Positive Guidance in Traffic Control*. Federal Highway Administration, U.S. Department of Transportation, Washington, DC.
- Antonucci, N. D., K. K. Hardy, J. E. Bryden, T. R. Neuman, R. Pfefer, and K. Slack. 2006. *NCHRP Report 500: Guidance for Implementation of the AASHTO Strategic Highway Safety Plan, Volume 17: A Guide for Reducing Work Zone Collisions*. National Cooperative Highway Research Program, Transportation Research Board, Washington, DC. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_500v17.pdf. Accessed July 26, 2022.
- AsphaltPro. n.d. "Oldcastle's AWARE System Makes Every Second Count." <https://theasphaltpro.com/articles/oldcastle-aware-system/>. Accessed July 26, 2022.
- Bai, Y., and Y. Li. 2006. *Determining Major Causes of Highway Work Zone Accidents in Kansas*. Report No. K-Tran: KU-05-1. University of Kansas, Lawrence, KS. <https://kuscholarworks.ku.edu/handle/1808/20081>. Accessed July 26, 2022.
- Benekohal, R. F., and J. F. Linkenheld. 1990. *Evaluation of a Radar Activated Horn System for Speed Control in Highway Maintenance Operations*. Report No. FHWA-IL-UI-235. Department of Civil Engineering, University of Illinois at Urbana-Champaign, Urbana, IL. <https://apps.ict.illinois.edu/projects/getfile.asp?id=2889>. Accessed July 26, 2022.
- Brown, H., C. Sun, and T. Cope. 2015a. *Evaluation of Mobile Work Zone Alarm Systems*. Research Report CMR 15-011. Missouri Department of Transportation, Jefferson City, MO. <https://spexternal.modot.mo.gov/sites/cm/CORDT/cmr15-011.pdf>. Accessed July 26, 2022.
- Brown, H., C. Sun, and T. Cope. 2015b. Evaluation of Mobile Work Zone Alarm Systems. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2485, pp. 42–50.
- Caltrans. 2014. "Maintenance Manual." <https://dot.ca.gov/programs/maintenance/maintenance-manual>. Accessed July 26, 2022.
- Caltrans. 2021. "Pilot Testing of Work Zone Intrusion Alarms." Research Notes. Division of Research, Innovation and System Information. <https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/research-notes/task3875-rns-3-21-a11y.pdf>. Accessed July 26, 2022.
- CDOT. 2019. "S-630-5 Portable Rumble Strips (Temporary)." *CDOT Traffic S-Standard Plan*, Denver, CO. <https://www.codot.gov/safety/traffic-safety/assets/s-standard-plans/2019/s-630-5/S-630-05%20-2-Page%20Set.pdf>. Accessed July 26, 2022.
- Chen, E., and A. P. Tarko. 2012. Analysis of Crash Frequency in Work Zones with Focus on Police Enforcement. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2280, pp.127–134.
- Daniel, J., K. Dixon, and D. Jared. 2000. Analysis of Fatal Crashes in Georgia Work Zones. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1715, pp. 18–23.
- El-Rayes, K., L. Liu, and T. Elghamrawy. 2013. *Minimizing Traffic-Related Work Zone Crashes in Illinois*. Research Report FHWA-ICT-12-017. Illinois Center for Transportation, University of Illinois at Urbana-Champaign, Urbana, IL. <https://apps.ict.illinois.edu/projects/getfile.asp?id=3078>. Accessed July 26, 2022.
- El-Rayes, K., L. Liu, N. El-Gohary, and A. Abdelmohsen. 2014. *Effect of Flaggers and Spotters in Directing Work Zone Traffic for Illinois Expressways and Freeways*. University of Illinois at Urbana-Champaign, Urbana, IL. <https://www.ideals.illinois.edu/handle/2142/46994>. Accessed July 26, 2022.

- Erie Insurance. 2018. "Erie Insurance Releases Police Data Showing Daydreaming #1 on Top 10 List of Fatal Distracted Driving Behaviors." <https://www.erieinsurance.com/news-room/press-releases/2018/distracted-driving-survey>. Accessed July 26, 2022.
- FHWA. 2012. *Manual on Uniform Traffic Control Devices*. U.S. Department of Transportation, Washington, DC. <https://mutcd.fhwa.dot.gov/>. Accessed July 26, 2022.
- Finley, M. D., L. Theiss, N. Trout, and G. L. Ullman. 2008. *Studies to Improve the Management of Regulatory Speed Limits in Texas Work Zones*. Report FHWA/TX-09/0-5561-1. Texas Transportation Institute, College Station, TX. <http://tti.tamu.edu/documents/0-5561-1.pdf>. Accessed July 26, 2022.
- Finley, M. D., J. Jenkins, and D. McAvoy. 2014. *Evaluation of Ohio Work Zone Speed Zones Process*. Report FHWA/OH-2014/10. Ohio Department of Transportation, Columbus, OH. https://www.dot.state.oh.us/Divisions/Planning/SPR/Research/reportsandplans/Reports/2014/Roadway/134716_FR.pdf. Accessed July 26, 2022.
- Finley, M. D., L. Ruback, and F. Ye. 2020. *Evaluate the Uses and Technology for Autonomous Truck-Mounted Attenuators*. Report No. 107305. Texas A&M Transportation Institute, College Station, TX.
- Fyhrie, P. B. 2016. *Work Zone Intrusion Alarms for Highway Workers*. Division of Research, Innovation and System Information, California Department of Transportation, Sacramento, CA. <https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/preliminary-investigations/work-zone-warning-pi-a11y.pdf>. Accessed August 2, 2021.
- Gambatese, J. A., H. W. Less, and C. A. Nnaji. 2017. *Work Zone Intrusion Alert Technologies: Assessment and Practical Guidance*. Report No. FHWA-OR-RD-17-14. Oregon State University, Corvallis, OR. https://www.oregon.gov/ODOT/Programs/ResearchDocuments/SPR790_IntrusionAlertTech.pdf. Accessed July 26, 2022.
- Garber, N. J., and M. Zhao. 2002. *Crash Characteristics at Work Zones*. Report No. VTRC-02-R12. Virginia Transportation Research Council, Charlottesville, VA. https://rosap.ntl.bts.gov/view/dot/20448/dot_20448_DS1.pdf. Accessed July 26, 2022.
- Graham, J. L., J. Migletz, J. R. Loumiet, J. Hinch, D. Stout, and N. Lerner. 1989. *Maintenance Work Zone Safety*. Report No. SHRP-M/FR-89-001. Unpublished report from the Strategic Highway Research Program, National Research Council, Washington, DC. <http://onlinepubs.trb.org/onlinepubs/shrp/SHRP-89-001.pdf>. Accessed July 26, 2022.
- Ha, T.-J., and Z. A. Nemeth. 1995. Detailed Study of Accident Experience in Construction and Maintenance Zones. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1509, pp. 38–45. <http://onlinepubs.trb.org/Onlinepubs/trr/1995/1509/1509-006.pdf>. Accessed July 26, 2022.
- Hall, J. M., and V. M. Lorenz. 1989. Characteristics of Construction-Zone Accidents. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1230, pp. 20–27. <http://onlinepubs.trb.org/Onlinepubs/trr/1989/1230/1230-003.pdf>. Accessed July 26, 2022.
- Hall, J. W., and E. W. Rutman. 2003. *Work Zone Safety: Analysis of Crashes, Speeds, and Traffic Flow During the Reconstruction of the I-25/I-40 Interchange*. Report No. NM00SAF-01. University of New Mexico, Albuquerque, NM.
- Hargroves, B. T., and M. R. Martin. 1980. *Vehicle Accidents in Highway Work Zones*. Report No. FHWA/RD-80/063. Federal Highway Administration, U.S. Department of Transportation, Washington, DC. <https://rosap.ntl.bts.gov/view/dot/18973>. Accessed July 26, 2022.
- Hawkins, N., and S. Knickerbocker. 2017. *Field Measurements on the Effect of Temporary Rumble Strips in Work Zone Flagging Operations*. Center for Transportation Research and Education, Iowa State University, Ames, IA. https://intrans.iastate.edu/app/uploads/2018/03/temp_rumble_strips_in_work_zone_flagging_ops_w_cvr.pdf. Accessed July 26, 2022.
- Hildebrand, E. D., F. R. Wilson, and J. J. Copeland. 2003. "Speed Management Strategies for Rural Temporary Work Zone." In *Proceedings from the Canadian Multidisciplinary Road Safety Conf. XIII*, Canadian Association of Road Safety Professionals, Ottawa, Canada.
- Hostetter, R. S., K. W. Crowley, G. W. Dauber, L. E. Pollack, and S. Levine. 1982. *Determination of Driver Needs in Work Zones*. Report No. FHWA-RD-82-117. Federal Highway Administration, U.S. Department of Transportation, Washington, DC. <https://babel.hathitrust.org/cgi/pt?id=mdp.39015075546385;view=1up;seq=5>. Accessed July 26, 2022.
- Huchingson, R. D. 1981. *New Horizons for Human Factors Design*. McGraw Hill Book Company, New York, NY.
- Hummer, J. E., and C. R. Scheffler. 1998. *Driver Performance Comparison of Fluorescent Orange to Standard Orange Work Zone Traffic Signs*. Final Report. 3M Traffic Control Materials Division, St. Paul, MN. <http://apps.usd.edu/coglab/schieber/pdf/Hummer-Scheffler-99.pdf>. Accessed July 26, 2022.
- IDOT. 2016. *Work Zone Fact Sheet*. <https://idot.illinois.gov/Assets/uploads/files/Travel-Information/Pamphlets-&-Brochures/WorkZone%20IL%20Fact%20Sheet.pdf>. Accessed September 20, 2022.
- IDOT. 2017. *Illinois Highway Standards for Traffic Control*. https://idot.illinois.gov/Assets/uploads/files/Doing-Business/Standards/Highway-Standards/PDF/226-701316-13_LnClosure2L2W-BridgeRepair45MPH or More.pdf. Accessed September 20, 2022.
- Iowa DOT. 2020. "Standard Road Plan TC-214." https://www.iowadot.gov/erl/current/RS/content_eng/tc214.pdf. Accessed July 26, 2022.

- Khan, G., S. Sanni, S. Berr, K. Shafizadeh. 2019. *Evaluation of Work Zone Intrusion Alarms*. Report No. CA19-3038. California Department of Transportation, Sacramento, CA. <https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/final-reports/ca19-3038-finalreport-a11y.pdf>. Accessed July 26, 2022.
- Krupa, C. 2010. *Work Zone Intrusion Alarm Effectiveness*. Report No. NJ-2010-004. New Jersey Department of Transportation, Trenton, NJ. <https://www.nj.gov/transportation/business/research/reports/NJ-2010-004.pdf>. Accessed July 26, 2022.
- Kuhn, B., K. Balke, R. Brydia, L. Theiss, I. Tsapakis, L. Ruback, and M. Le. 2015. *Evaluation of TxDOT Variable Speed Limit Pilot Projects*. Final Report. Texas A&M Transportation Institute, College Station, TX. <http://tti.tamu.edu/documents/TTI-2015-10.pdf>. Accessed July 26, 2022.
- Kuta, B. 2009. *Work Zone Intrusion Alarm Demonstration*. Interim Report. Federal Highway Administration, U.S. Department of Transportation, Washington, DC.
- Kwon, E., D. Brannan, K. Shouman, C. Isackson, and B. Arseneau. 2007. Development and Field Evaluation of Variable Advisory Speed Limit System for Work Zones. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2015, pp. 12–18. <https://www.dot.state.mn.us/trafficeng/workzone/doc/Var-Adv-SpeedSystem-WZ-Report.pdf>. Accessed July 26, 2022.
- Lee, J. D., D.V. McGehee, T. Brown, and M. L. Reyes. 2002. “Collision Warning, Driver Distraction, and Driver Response to Rear-End Collisions in a High-Fidelity Driving Simulator.” *Human Factors*, Vol. 44, No. 2, pp. 314–334. <http://journals.sagepub.com/doi/pdf/10.1518/0018720024497844>. Accessed July 26, 2022.
- MaineDOT. 2017. *Temporary Traffic Control Zones*.
- Maryland SHA. 2005. “Use of Temporary Transverse Rumble Strips in Work Zones.” Baltimore, MD. <https://www.roads.maryland.gov/OOTS/04RumbleStrips.pdf>. September 20, 2022.
- MassDOT. n.d. “Road Flaggers and Police Detail.” Boston, MA. <https://www.mass.gov/road-flaggers-and-police-detail>. Accessed July 26, 2022.
- Mohan, S. B., and P. Gautam. 2002. “Cost of Highway Work Zone Injuries.” *ASCE Practice Periodical on Structural Design and Construction*, Vol. 7, No. 2, pp. 68–73.
- NCDOT. n.d. “Technology Transfer for RP2019-24—Work Zone Intrusion Alert System Technology Tests.” NCDOT Research Project Number 2021-22. Raleigh, NC. <https://connect.ncdot.gov/projects/research/Pages/ProjDetails.aspx?ProjectID=2021-22>. Accessed July 26, 2022.
- Neale, V. L., T. A. Dingus, S. G. Klauer, J. Sudweeks, and M. Goodman. 2005. “An Overview of the 100-Car Naturalistic Study and Findings.” Paper No. 05-0400. In *Proceeding 19th International Technical Conference on the Enhanced Safety of Vehicles (CD-ROM)*, National Highway Traffic Safety Administration, Washington, DC. <https://pdfs.semanticscholar.org/7b74/1bbe1a4da54c48e235b2cfd33c8df8f0b28b.pdf>. Accessed July 26, 2022.
- NHTSA. n.d. Fatal Analysis Reporting System [website]. U.S. Department of Transportation, Washington, DC. <https://www.nhtsa.gov/research-data/fatality-analysis-reporting-system-fars>. Accessed July 26, 2022.
- Olson, P. L. 2002. “Driver Perception-Response Time.” In *Human Factors in Traffic Safety*, R. E. Dewar and P. L. Olson (eds.), Lawyers and Judges Publishing Company, Inc., Tucson, AZ, pp. 43–76.
- Ozan, E., Y. Fu, and B. Dunn. 2020. *Using IoT Technology to Create Smart Work Zones*. Report No. FHWA/NC/2019-24. North Carolina Department of Transportation, Raleigh, NC. <https://connect.ncdot.gov/projects/research/RNAProjDocs/Final%20Report%202019-24.pdf>. Accessed July 26, 2022.
- Phanomchoeng, G., R. Rajamani, and J. Hourdos. 2008. *Directional Sound for Long Distance Auditory Warnings from a Highway Construction Work Zone*. Report No. CTS 08-20. Department of Civil and Mechanical Engineering, University of Minnesota, Minneapolis, MN. <https://www.cts.umn.edu/publications/report/directional-sound-for-long-distance-auditory-warnings-from-a-highway-construction-work-zone>. Accessed July 26, 2022.
- Pigman, J., and K. Agent. 1990. Highway Accidents in Construction and Maintenance Work Zones. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1270, pp. 12–21. <http://onlinepubs.trb.org/Onlinepubs/trr/1990/1270/1270-002.pdf>. Accessed July 26, 2022.
- Qin, X., Y. Chen, and D. A. Noyce. 2007. “Anatomy of Wisconsin Work Zone Crashes.” In *CD-ROM Compendium, Institute of Transportation Engineers Annual Meeting*, Pittsburgh, PA.
- Raub, R. A., O. B. Sawaya, J. L. Schofer, and A. Ziliaskopoulos. 2001. “Enhanced Crash Reporting to Explore Work Zone Crash Patterns.” In *CD-ROM Proceedings, 80th Annual Meeting of the Transportation Research Board*, Washington, DC. <https://pdfs.semanticscholar.org/fc19/bd629f70fd9bdf53598fa475ab51263fa113.pdf>. Accessed July 26, 2022.
- Regan, M. A., J. D. Lee, and K. Young (eds.). 2008. *Driver Distraction: Theory, Effects, and Mitigation*, First Edition. CRC Press, Boca Raton, FL. <https://doi.org/10.1201/9781420007497>.
- Roofigari-Esfahan, N., E. White, M. Mollenhauer, and J. P. Talledo Vilela. 2021. *Development of a Connected Smart Vest for Improved Roadside Work Zone Safety*. Report No. 04-104. Safe-D National UTC (Virginia Tech Transportation Institute). <https://safed.vtti.vt.edu/wp-content/uploads/2021/06/Safe-D-Final-Report-Smart-Vest-04-104-Final-Updated-FixedV1.pdf>. Accessed September 20, 2022.

- Rouphail, N. M., Z. S. Yang, and J. Fazio. 1988. Comparative Study of Short- and Long-Term Urban Freeway Work Zones. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1163, Washington, DC, pp. 4–14.
- Saito, M., and A. B. Wilson. 2011. *Evaluation of the Effectiveness of a Variable Advisory Speed Systems on Queue Mitigation in Work Zones*. Report No. UT-22.04. Brigham Young University, Provo, UT. <https://scholarsarchive.byu.edu/cgi/viewcontent.cgi?article=3503&context=etd>. Accessed July 26, 2022.
- Sakhare, R.S., J. C. Desai, J. Mahlberg, J. K. Mathew, W. Kim, H. Li, J. D. McGregor, and D.M. Bullock. 2021. Evaluation of the Impact of Queue Trucks with Navigation Alerts Using Connected Vehicle Data. *Journal of Transportation Technologies*, 11, 561–576. <https://doi.org/10.4236/jtts.2021.114035>. Accessed September 20, 2022.
- Salem, O. M., A. M. Genaidy, H. Wei, and N. Deshpande. 2006. “Spatial Distribution and Characteristics of Accident Crashes at Work Zones of Interstate Freeways in Ohio.” In *2006 IEEE Intelligent Transportation Systems Conference*, pp. 1632–1647. <https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1707460>. Accessed July 26, 2022.
- Schrock, S. D., G. L. Ullman, A. S. Cothron, E. Kraus, and A. P. Voigt. 2004. *An Analysis of Fatal Work Zone Crashes in Texas*. Report No. FHWA/TX-05/0-4028-1. Texas Transportation Institute, College Station, TX. <http://tti.tamu.edu/documents/0-4028-1.pdf>. Accessed July 26, 2022.
- Strayer, D. L., F. A. Drews, and D. J. Crouch. 2006. “A Comparison of the Cell Phone Driver and the Drunk Driver.” *Human Factors*, Vol. 48, No. 2, p. 381. <http://journals.sagepub.com/doi/10.1518/00187200677724471>. Accessed July 26, 2022.
- Stutts, J. C., D. W. Reinfurt, L. Staplin, and E. A. Rodgman. 2001. *The Role of Driver Distraction in Traffic Crashes*. Report 202/638-5944. AAA Foundation for Traffic Safety, Washington, DC. <https://www.forces-nl.org/download/distraction.pdf>. Accessed July 26, 2022.
- Stutts, J., R. R. Knipling, R. Pfefer, T. R. Neuman, K. L. Slack, and K. K. Hardy. 2005. *NCHRP Report 500: Guidance for the Implementation of the AASHTO Strategic Highway Safety Plan, Volume 14: A Guide for Reducing Crashes Involving Drowsy and Distracted Drivers*. National Cooperative Highway Research Program, Transportation Research Board, Washington, DC. <http://www.nap.edu/download/23420>. Accessed July 26, 2022.
- Sun, C., P. Edara, and K. Ervin. 2011. “Elevated-Risk Work Zone Evaluation of Temporary Rumble Strips.” *Journal of Transportation Safety and Security*, pp. 157–173.
- Swansen, E. L. 2012. *Varied Applications of Work Zone Safety Analysis through the Investigation of Crash Data, Design, and Field Studies*. M.S. Thesis, Department of Civil and Environmental Engineering, University of Massachusetts Amherst, Amherst, MA. <https://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1874&context=theses>. Accessed July 26, 2022.
- Theiss, L., G. L. Ullman, and T. Lindheimer. 2017. *Closed Course Performance Testing of the AWARE Intrusion Alarm System*. Texas A&M Transportation Institute, College Station, TX. <http://tti.tamu.edu/documents/TTI-2017-2.pdf>. Accessed July 26, 2022.
- Theiss, L., M. D. Finley, E. Rista, and G. L. Ullman. 2022. Evaluation of End-of-Queue Crash Mitigation Strategies at Flagging Stations on Two-Lane Roads. Report 0-6998-R1. Texas A&M Transportation Institute, College Station, TX. <https://static.tti.tamu.edu/tti.tamu.edu/documents/0-6998-R1.pdf>. Accessed July 26, 2022.
- Tsai, Y. 2011. *Development of a Sensing Methodology for Intelligent and Reliable Work-Zone Hazard Awareness*. Highway IDEA Project 139 Final Report. Transportation Research Board, Washington, DC. http://onlinepubs.trb.org/Onlinepubs/IDEA/FinalReports/Highway/NCHRP139_Final_Report.pdf. Accessed July 26, 2022.
- TxDOT. 2016. “Temporary Rumble Strips, WZ(RS)-16.” <https://ftp.dot.state.tx.us/pub/txdot-info/cmd/cserve/standard/traffic/wzrs16.pdf>. Accessed July 26, 2022.
- TxDOT. 2018. “Traffic Control Plan, Lane Closures for Divided Highways, TCP(1-5)-18.” Austin, TX. <https://ftp.dot.state.tx.us/pub/txdot-info/cmd/cserve/standard/traffic/tcp1-5.pdf>. Accessed July 26, 2022.
- TxDOT. 2019a. “Temporary Queue Detection System Type 1 (Queue <= 7.5 Miles), WZ-ITS(1)-19.” Austin, TX. [https://ftp.dot.state.tx.us/pub/txdot-info/cmd/cserve/standard/traffic/wz-its\(1\)-19.pdf](https://ftp.dot.state.tx.us/pub/txdot-info/cmd/cserve/standard/traffic/wz-its(1)-19.pdf). Accessed July 26, 2022.
- TxDOT. 2019b. “Temporary Queue Detection System Type 2 (Queue <= 3.5 Miles), WZ-ITS(3)-19.” Austin, TX. [https://ftp.dot.state.tx.us/pub/txdot-info/cmd/cserve/standard/traffic/wz-its\(3\)-19.pdf](https://ftp.dot.state.tx.us/pub/txdot-info/cmd/cserve/standard/traffic/wz-its(3)-19.pdf). Accessed July 26, 2022.
- Ukkusure, S. V., K. Gkritza, X. Qian, and A. M. Sadri. 2016. *Best Practices for Maximizing Driver Attention to Work Zone Warning Signs*. Report No. FHWA/IN/JTRP-2016/15. Joint Transportation Research Program, Purdue University, West Lafayette, IN. <https://docs.lib.purdue.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=3120&context=jtrp>. Accessed July 26, 2022.
- Ullman, G. L. 2020. *Portable Rumble Strips: Placement Recommendations for Back-of-Queue Protection and Assessment of Driver Distraction-Reducing Effects*. Texas A&M Transportation Institute, College Station, TX. <https://tti.tamu.edu/documents/TTI-2020-12.pdf>. Accessed July 26, 2022.
- Ullman, G. L., and R. A. Krammes. 1991. *Analysis of Accidents at Long-Term Construction Projects in Texas*. Report No. FHWA/TX-90/1108-2. Texas Transportation Institute, College Station, TX. <http://tti.tamu.edu/documents/1108-2.pdf>. Accessed July 26, 2022.

- Ullman, G. L., and S. D. Schrock. 2001. *Feasibility and Design of Enforcement Pullout Areas for Work Zones*. Research Report FHWA/TX-02/2137-2. Texas Transportation Institute, College Station, TX. <http://tti.tamu.edu/documents/2137-2.pdf>. Accessed July 26, 2022.
- Ullman, G. L., and L. Theiss. 2019. *Personal Warning Sensor for Road Construction Workers*. Report No. MN/RC 2019-08. Minnesota Department of Transportation, St. Paul, MN. <http://www.dot.state.mn.us/research/reports/2019/201908.pdf>. Accessed July 26, 2022.
- Ullman, G. L., B. R. Ullman, C. L. Dudek, A. Williams, and G. Pesti. 2005. *Advanced Notification Messages and Use of Sequential Portable Changeable Message Signs in Work Zones*. Report No. FHWA/TX-05/0-4748-1. Texas Transportation Institute, College Station, TX. <https://tti.tamu.edu/documents/0-4748-1.pdf>. Accessed July 26, 2022.
- Ullman, G. L., M. D. Finley, J. E. Bryden, R. Srinivasan, and F. M. Council. 2008. *NCHRP Report 627: Traffic Safety Evaluation of Nighttime and Daytime Work Zones*. Transportation Research Board, Washington, DC. <https://www.nap.edu/download/14196>. Accessed July 26, 2022.
- Ullman, G. L., M. D. Finley, and L. A. Theiss. 2011. Categorization of Work Zone Intrusion Crashes. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2258, pp. 57–63.
- Ullman, G. L., M. A. Brewer, J. E. Bryden, M. O. Corkran, C. W. Hubbs, A. K. Chandra, and K. L. Jeannotte. 2013. *NCHRP Report 746: Traffic Law Enforcement Strategies for Work Zones*. Transportation Research Board, Washington, DC. <http://www.trb.org/Publications/Blurbs/168956.aspx>. Accessed July 26, 2022.
- Ullman, G. L., V. Iragavarapu, and R. E. Brydia. 2016a. Safety Effects of Portable End-of-Queue Warning System Deployments at Texas Work Zones. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2555, pp. 46–52.
- Ullman, G. L., N. Trout, and L. Theiss. 2016b, April. *Driver Responses to the AWARE Intrusion Alarm System*. Texas A&M Transportation Institute, College Station, TX. <http://tti.tamu.edu/documents/TTI-2016-19.pdf>. Accessed July 26, 2022.
- Ullman, G. L., M. Pratt, M. D. Fontaine, R. J. Porter, and J. Medina. 2018b. *NCHRP Report 869: Estimating the Safety Effects of Work Zone Characteristics and Countermeasures: A Guidebook*. Transportation Research Board, Washington, DC. <https://www.nap.edu/download/25007#>. Accessed July 26, 2022.
- Ullman, G. L., M. Pratt, S. Geedipally, B. Dadashova, R. J. Porter, J. Medina, and M. D. Fontaine. 2018a. *NCHRP Web-Only Document 240: Analysis of Work Zone Crash Characteristics and Countermeasures*. Transportation Research Board, Washington, DC. <http://www.trb.org/main/blurbs/177155.aspx>. Accessed July 26, 2022.
- U.S. DOT. 2022. “WZDx Demonstration Grants.” *Work Zone Management Program, Federal Highway Administration*. https://ops.fhwa.dot.gov/wz/wzdx/demonstration_grants.htm.
- Van Jura, J., D. Haines, and A. Gemperline. 2018. Use of Portable and Dynamic Variable Speed Limits in Construction Zones. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2672, Issue 16, pp. 35–45.
- VDOT. 2011. *Work Area Protection Manual, 2011 Revision 2.1 Edition*. https://www.virginiadot.org/business/resources/traffic_engineering/workzone/wapm/2011_WAPM_REV_2_1.pdf. Accessed September 20, 2022.
- VDOT. 2018. *Portable Temporary Rumble Strips (PTRS)*. Instructional and Information Memorandum. https://www.virginiadot.org/business/resources/IIM/TE-386_USE_OF_PTRS.pdf. Accessed July 26, 2022.
- Wang, J., W. E. Hughes, F. M. Council, and J. F. Paniati. 1995. Investigation of Highway Work Zone Crashes: What We Know and What We Don't Know. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1529, pp. 38–45.
- Wang, J.-S., Knipling, R. R., and Goodman, M. J. 1996. “The Role of Driver Inattention in Crashes: New Statistics from the 1995 Crashworthiness Data System.” In *40th Annual Proceedings of the Association for the Advancement of Automotive Medicine*, Vancouver, BC, October 7–9.
- Wang, M.-H., S. D. Schrock, C. Bornheimer, and R. Rescot. 2013. “Effects of Innovative Portable Plastic Rumble Strips at Flagger-Controlled Temporary Maintenance Work Zones.” *Journal of Transportation Engineering*, Vol. 139, No. 2, pp. 156–164.
- Welch, D. J., R. L. Vecellio, and J. R. McCarthy. 2003, May. *Methods to Improve the Effectiveness of Advance Warning Signs in Alabama Construction Work Zones*. Report IR-03-01. Highway Research Center, Auburn University, Auburn, AL. <https://eng.auburn.edu/files/centers/hrc/IR-03-01.pdf>. Accessed July 26, 2022.
- Zockaie, A., R. Saedi, T. Gates, P. Savolainen, B. Schneider, M. Ghamami, R. Verma, F. Fakhrmoosavi, M. Kaviani-pour, M. Shojaei, H. Singh, J. Warner, and C. Zhou. 2018. *Evaluation of a Collision Avoidance and Mitigation System (CAMS) on Winter Maintenance Trucks*. Report OR 17-103. Michigan Department of Transportation, Lansing, MI. https://rosap.nhtl.gov/view/dot/42752/dot_42752_DS1.pdf. Accessed September 20, 2022.
- Zwahlen, H., and T. Schnell. 1997. Visual Detection and Recognition of Fluorescent Color Targets versus Non-fluorescent Color Targets as a Function of Peripheral Viewing Angle and Target Size. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1605, pp. 28–40.

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI-NA	Airports Council International-North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FAST	Fixing America's Surface Transportation Act (2015)
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GHSA	Governors Highway Safety Association
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S. DOT	United States Department of Transportation

Transportation Research Board
500 Fifth Street, NW
Washington, DC 20001

ADDRESS SERVICE REQUESTED

**NATIONAL
ACADEMIES** *Sciences
Engineering
Medicine*

The National Academies provide independent, trustworthy advice that advances solutions to society's most complex challenges.

www.nationalacademies.org

ISBN 978-0-309-69830-6



9 780309 698306