

Christine E. Carrigan, P.E., Ph.D.



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Curriculum Vita

BIOGRAPHICAL SKETCH

Dr. Christine Carrigan received her undergraduate degree in Civil Engineering from Worcester Polytechnic Institute in 1997. She began her career in civil engineering as a highway designer joining a Massachusetts consulting firm where she was responsible for evaluating geometric design alternatives for corridors. Her responsibilities also included designing signalized and unsignalized intersections and roundabouts.

Dr. Carrigan later joined the Massachusetts Highway Department and another Massachusetts based consulting firm where she was responsible for geometric improvement, reconstruction, and maintenance projects; design of new intersections and interchanges; and construction inspection. Dr. Carrigan has designed a wide variety of highway and intersection improvements.

Dr. Carrigan gained close to ten years of design and construction experience before pursuing a PhD in Civil Engineering with a highway safety focus from Worcester Polytechnic Institute. While at Worcester Polytechnic Institute, Dr. Carrigan conducted research on performance-based highway design, cost-benefit analysis of roadside designs, and taught undergraduate and graduate classes in geometric design, construction management, and computer aided design.

Dr. Carrigan formed a research consulting business with two partners in 2010 and has subsequently been involved in a number of roadside safety research projects for the National Cooperative Highway Research Program and a variety of other government and industry sponsors. Dr. Carrigan's active research interests include the development of models from crash data to represent the impact of design changes on crash frequency and severity; the in-service performance of roadside features and hazards; the development of roadside design guidance; the risk-analysis of highway and roadside designs; and the development of cost-effective and risk analysis design tools.

Dr. Carrigan has consulted on the development of roadside design and policy development including bridge rail selection guidelines, median barrier selection and placement guidelines, and pier protection guidelines. She is a registered professional engineer the States of Maine and Massachusetts. She is active with all the major technical groups in roadside safety including the Transportation Research Board Committee on Roadside Design and the American Association of State Highway and Transportation Officials Task Force 13.

EXPERTISE

Probability concepts in roadside safety; development and use of crash-based and encroachment-based models in roadside safety; risk and cost effectiveness analysis of design alternatives; design and evaluation of geometric and roadside improvements; and development of roadside design guidance.

EDUCATION

- Ph.D in Civil Engineering, Worcester Polytechnic Institute, Worcester, Massachusetts (2010).
- MS in Civil Engineering, Worcester Polytechnic Institute, Worcester, Massachusetts (2008).
- BS in Civil Engineering, Worcester Polytechnic Institute, Worcester, Massachusetts (1997).

HONORS AND ACTIVITIES

- AFB20 Best Paper Award, *Using Risk Analysis to Minimize Adverse Consequences in Non-Standard Designs* by Malcolm H. Ray and Christine E. Carrigan (2015)
- AFB20 Volunteer of the Year (2014)
- Autodesk Developers Network (ADN) member
- Schroff Participation Grant from the ASEE/Engineering Design Graphics Division (2009)
- International Road Federation Student Essay Competition runner-up, Silvestri, C. and Conron, C. E., *Proposed Policy for Highway Design and Maintenance for the Reduction of Tree Crashes* (2008)
- Autodesk University Scholarship Recipient (2007 & 2008)
- Massachusetts Highway Department Pride in Performance (2000)

PROFESSIONAL REGISTRATION

- Massachusetts #49330
- Maine #13379
- South Carolina #33916

SERVICE

- Transportation Research Board – Geometric Design, Committee AFB10 (Member, 2012-2018).
- Transportation Research Board -- Roadside Safety, Committee AFB20 (Friend, 2009 – present).
- Transportation Research Board – Highway Safety Performance, Committee ANB25 (Friend, 2013 – present).
- Transportation Research Board – Standing Committee on Utilities, Committee AFB70, (Utility Task Group, 2014 – present).
- AASHTO-ARTBA-AGC Joint Subcommittee on New Materials, Task Force 13
- American Society of Civil Engineers (Member).
- Institute of Transportation Engineers (Member).

EXPERIENCE

- 2010-Present:** Partner, RoadSafe LLC, Canton, Maine: Perform research and consulting services in the areas of roadside safety, crash modeling, and risk assessment.
- 2007-2010:** Adjunct Instructor of Civil and Environmental Engineering at the Worcester Polytechnic Institute, Worcester, MA: Taught classes in the areas of transportation engineering, computer aided engineering, and construction management.
- 2001-2005:** Project Engineer at Vanasse, Hangen, Brustlin, Inc.: Designed highway improvement and signalization projects in rural, suburban, and urban areas, balancing the conflicting requirements of established design standards and limitations of available land. Prepared permit documents for new interchange construction. Conducted public meetings and hearings to inform the citizens of proposed roadway improvements and gain their feedback. Coordinated improvement project schedules with impacted groups, including municipalities, utility companies, and regulatory agencies. Trained staff on the use of computer aid design and drafting tools for improved performance of design tasks and plan production.
- 1998-2001:** Civil Engineer at the Massachusetts Highway Department, Worcester, MA: Designed signalized and unsignalized intersection reconstruction projects to improve traffic flow utilizing available traffic analysis software, including HCS, Syncro, and SimTraf. Developed conceptual designs for new interstate interchanges and new regional roadways. Conducted project reviews of consultant designs for adherence to design standards. Prepared construction bid documents. Prepared design plans using computer aiding drafting tools such as AutoCAD and Land Development Desktop. Prepared environmental regulatory agency filings. Conducted construction inspections of private contractors to assure compliance with the contract documents. Conducted public presentations utilizing digital and non-digital media to inform the citizens of proposed roadway improvements and gain their feedback.
- 1997-1998:** Project Engineer at Earth Tech, Inc, Concord, MA: Prepared timing and lane configuration plans for traffic signal improvement projects. Prepared traffic signal warrant analysis. Conducted roundabout and traffic signal capacity analysis. Prepared cost estimates. Prepared design plans using computer aiding drafting tools such as AutoCAD and Softdesk.

REFEREED PUBLICATIONS

Dr. Carrigan has been actively publishing the results of her scholarship for a number of years. A sample of her peer-reviewed scholarship is shown here.

1. C.E. Carrigan and M.H. Ray, “Consideration of Placement Criteria for Utility Poles to Minimize Crash Risk,” First International Roadside Safety Research Circular, Transportation Research Board, Washington, D.C., (in review).
2. M.H. Ray, C.E. Carrigan, and C.A. Plaxico, “Heavy Vehicle Encroachment Trajectories,” First International Roadside Safety Research Circular, Transportation Research Board, Washington, D.C., (in review).
3. C.E. Carrigan and N.M. Sheikh, “Proposed Modification Factors for Roadside Slopes,” Transportation Research Board Annual Meeting Compendium of Papers, Transportation Research Board, Washington, D.C., 2017.
4. C.E. Carrigan and M.H. Ray, “Assessment of the MASH Heavy Vehicles for Field Relevancy,” Transportation Research Board Annual Meeting Compendium of Papers, Transportation Research Board, Washington, D.C., 2017.
5. C.E. Carrigan, M.H. Ray, and A.M. Ray “Evaluating the Performance of Roadside Hardware,” Transportation Research Board Annual Meeting Compendium of Papers, Transportation Research Board, Washington, D.C., 2017.
6. C.E. Carrigan and M.H. Ray “A New Approach to Run-off-Road Crash Prediction,” Transportation Research Board Annual Meeting Compendium of Papers, Transportation Research Board, Washington, D.C., 2017.
7. C.E. Carrigan, T.O. Johnson, and M.H. Ray, “Tree Planting and Clearing Guidance with Consideration of Minimized Crash Risk,” Transportation Research Record: Journal of the Transportation Research Board, No. 2588 on pages 110–115, Washington, D.C., 2016.
8. C.E. Carrigan and M.H. Ray, “Practitioner’s Guide to the Analysis of In-Service Performance Evaluation Data,” Transportation Research Board Annual Meeting Compendium of Papers, Transportation Research Board, Washington, D.C., 2016.
9. M.H. Ray and C.E. Carrigan, “Using Risk Analysis to Minimize Adverse Consequences in Non-Standard Designs,” Transportation Research Record: Journal of the Transportation Research Board, No. 2521 on pages 109–114, Washington, D.C., 2015.
10. C.E. Carrigan and M.H. Ray, “Proposed Horizontal Curve and Vertical Grade Encroachment Adjustment Factors,” Transportation Research Record: Journal of the Transportation Research Board, No. 2521 on pages 94–100, Washington, D.C., 2015.
11. C.E. Carrigan and M.H. Ray, “Proposed Heavy Vehicle Encroachment Adjustment Factor,” Transportation Research Record: Journal of the Transportation Research Board, No. 2521 on pages 101–108, Washington, D.C., 2015.

12. M.H. Ray and C.E. Carrigan, "A Review of Bus Run-off-Road Crashes," Transportation Research Board Annual Meeting Compendium of Papers, Transportation Research Board, Washington, D.C., 2015.
13. C.E. Carrigan, M.H. Ray, T.O. Johnson, and A.M. Ray, "Run-off-road Crash Prediction Models for Each Edge of Undivided and Divided Roadways," Transportation Research Board Annual Meeting Compendium of Papers, Transportation Research Board, Washington, D.C., 2015.
14. C.E. Carrigan, M.H. Ray and T.O. Johnson, "Understanding Heavy Vehicle Encroachment Frequency," Transportation Research Record 2437, Transportation Research Board, Washington, D.C., pages 20-26, Washington, D.C., 2014.
15. M.H. Ray, C.E. Carrigan, and C.A. Plaxico, "Developing Selection Tables for Bridge Railing," Transportation Research Record 2437, Transportation Research Board, Washington, D.C., pages 10-19, 2014.
16. M.H. Ray, C.E. Carrigan, and C.A. Plaxico, "Method for Modeling Crash Severity with Observable Crash Data." Transportation Research Record 2437: Journal of the Transportation Research Board, pages 1-9, Washington, D.C., 2014.
17. M.H. Ray and C.E. Carrigan, "Methodology for Systematically Comparing Longitudinal Barrier Performance," Transportation Research Board Annual Meeting Compendium of Papers, Transportation Research Board, Washington, D.C., 2014.
18. M.H. Ray, C.E. Carrigan, and C.A. Plaxico, "Estimating Crash Costs in the Updated Roadside Safety Analysis Program," Transportation Research Board Annual Meeting Compendium of Papers, Transportation Research Board, Washington, D.C., 2012.
19. M.H. Ray, C. Silvestri, C.E. Conron, M. Mongiardini, "Experience With Cable Median Barriers in United States: Design Standards, Policies and Performance," Journal of Transportation, American Society of Civil Engineers, October 2009.

CONFERENCE PROCEEDINGS

Dr. Carrigan routinely presents her research at technical conferences. A sample of her work she has presented at conferences is shown here.

1. C.E. Carrigan and M.H. Ray, "Assessing the Field Performance of W-beam Terminals in Washington," Road Safety & Simulation International Conference Proceedings, Delft University of Technology and the Dutch Institute for Road Safety Research, The Hague, Netherlands, (In review).
2. M.H. Ray and C.E. Carrigan, "Meta-Analysis of the Risk of Fatal and Incapacitating Injury in Tangent W-Beam Guardrail Terminal Collisions," Road Safety & Simulation International Conference Proceedings, Delft University of Technology and the Dutch Institute for Road Safety Research, The Hague, Netherlands, (In review).

3. C.E. Carrigan, M.H. Ray and C.A. Plaxico, "Influence of Geometric Design on Roadside Encroachments," 4th Urban Street Symposium, Chicago, IL, 2012.
4. C.E. Carrigan, M.H. Ray, and C.A. Plaxico, "Modeling Urban and Suburban Run Off Road Crashes: A Comparison of the RSAP and the Highway Safety Manual," 4th Urban Street Symposium, Chicago, IL, 2012.
5. C.E. Carrigan and M.H. Ray, "Incorporating Measurable Outcomes into the Highway Design Process: A Case Study to Demonstrate Highway Safety Improvements," In Urban Transport XVII, Proceedings of the Urban Transport and Environment in the 21st Century Conference, Pisa, Italy, WIT Press, 2011.
6. C.E. Carrigan and M.H. Ray, "A Proposed Performance-Based Highway Design Process: Incorporating Safety Considerations," In Urban Transport XVII, Proceedings of the Urban Transport and Environment in the 21st Century Conference, Pisa, Italy, WIT Press, 2011.
7. C.E. Conron and M.H. Ray, "Incorporating Crash Costs into Highway Cost Analysis," American Association of State Highway and Transportation Officials, National Value Engineering Conference Proceedings, September 2009.
8. C.E. Conron, C. Silvestri, M.H. Ray, "A Policy Recommendation for the Reduction of Tree Crashes," Transportation Research Forum 50th Annual Forum Conference Proceedings, March, 2009.
9. C.E. Conron, "A Systematic Approach to Applying Seasonal Load Restrictions," Transportation Research Forum 50th Annual Forum Conference Proceedings, March, 2009.
10. C.E. Conron, C. Silvestri, A. Gagne, M.H. Ray, "Using Public Information and Graphics Software in Graduate Highway Safety Research at Worcester Polytechnic Institute," American Society for Engineering Education, Engineering Design Graphics Division, 63rd Annual Midyear Meeting Conference Proceedings, January 2009.
11. C.E. Conron, J.A. Bergendahl, "Bringing Graphics and Design to First Year Engineering Students," American Society for Engineering Education, Engineering Design Graphics Division, 63rd Annual Midyear Meeting Conference Proceedings, January 2009.
12. G.F. Salazar, C.E. Conron, "Introduction of Object-Oriented Software into Civil Engineering Curriculum through Undergraduate Projects at WPI," American Society for Engineering Education, Engineering Design Graphics Division, 63rd Annual Midyear Meeting Conference Proceedings, January 2009.
13. M.H. Ray, C. Silvestri, C.E. Conron, R.B. Albin, "Assessment of Fatality Risk in Collisions with Cable Median Barriers in the State of Washington," Risk Analysis VI: Simulation and Hazard Mitigation, WIT Press, 2008.

INVITED PRESENTATIONS

In addition of the publication listed above, Dr. Carrigan is often invited to speak at a variety of venues, including the business meetings of AASHTO and various trade groups as well as to lead training workshops. A sample of these efforts is provided here.

1. C.E. Carrigan, and M.H. Ray, “Selection and Placement Guidelines for Test Level 2 through Test Level 5 Median Barriers,” First International Roadside Safety Conference, San Francisco, CA, (expected 2017).
2. C.E. Carrigan, and M.H. Ray, “Selection and Placement Guidelines for Test Level 2 through Test Level 5 Median Barriers,” First International Roadside Safety Conference, San Francisco, CA, (expected 2017).
3. C.E. Carrigan, and M.H. Ray, “Benchmarking the Risks of Roadside Hazards,” First International Roadside Safety Conference, San Francisco, CA, (expected 2017).
4. C.E. Carrigan “In-Field Evaluation of MASH Hardware,” 2016 Joint Meeting of the TRB AFB20 Committee and the AASHTO Technical Committee on Roadside Safety (TCRS), Baltimore, Maryland, June 22, 2016.
5. C.E. Carrigan and M.H. Ray “Leveraging New Software to Quantify the Crash Risk of Roadside Hazards,” 2016 WTS Annual Conference, Austin, Texas, May 18-20, 2016.
6. C.E. Carrigan and M.H. Ray “Roadside Safety Analysis Program (RSAPv3),” 2016 ITE Northeastern District Annual Meeting, Portsmouth, New Hampshire, May 11, 2016.
7. C.E. Carrigan and M.H. Ray “In-Service Performance Evaluations (ISPEs) of W-beam Terminals,” Maine Section ASCE Annual Technical Seminar, Lewiston, Maine, May 24, 2016.
8. C.E. Carrigan, “TCRS Strategic Plan for RDG” 2015 Joint Meeting of the TRB AFB20 Committee and the AASHTO Technical Committee on Roadside Safety (TCRS), Chicago, Illinois, July 12-15, 2015.
9. C.E. Carrigan, “Consideration of Roadside Features in HSM (17-54)” 2015 Joint Meeting of the TRB AFB20 Committee and the AASHTO Technical Committee on Roadside Safety (TCRS), Chicago Illinois, July 12-15, 2015.
10. C.E. Carrigan, “Discussion of TCRS Strategic Plan Development” AASHTO Technical Committee on Roadside Safety (TCRS) Business Meeting, Chicago, Illinois, July 15, 2015.
11. C.E. Carrigan, “To Tree or Not To Tree — Strategies for Answering a Roadside Question” Workshop SMW15-005 of the 2015 Transportation Research Board Annual Meeting, Washington, D.C., 2015.
12. M.H. Ray, Carrigan, C.E., Plaxico, C.A., “Using the Roadside Safety Analysis Program, Part 1: Tutorial” Workshop 117 of the 2014 Transportation Research Board Annual Meeting, Washington, D.C., 2014.
13. M.H. Ray, Carrigan, C.E., Plaxico, C.A., “Using the Roadside Safety Analysis Program, Part 2: Workshop” Workshop 176 of the 2014 Transportation Research Board Annual Meeting, Washington, D.C., 2014.

14. C.E. Carrigan, "Summary of NCHRP 17-54" AASHTO Technical Committee on Roadside Safety (TCRS) Business Meeting, Portland, Maine, July 17, 2014.
15. C.E. Carrigan, "Summary of NCHRP 12-90" AASHTO Technical Committee on Roadside Safety (TCRS) Business Meeting, Portland, Maine, July 17, 2014.
16. C.E. Carrigan, "Summary of NCHRP 22-12(03)" AASHTO Technical Committee on Roadside Safety (TCRS) Business Meeting, Portland, Maine, July 17, 2014.
17. C.E. Carrigan, "Discussion of TCRS Strategic Plan Development" AASHTO Technical Committee on Roadside Safety (TCRS) Business Meeting, Portland, Maine, July 17, 2014.
18. C.E. Carrigan, "SPF's for the Roadside – What Affects the encroachment rate?" 2013 Joint Meeting of the TRB AFB20 Committee and the AASHTO Technical Committee on Roadside Safety (TCRS), New Orleans, Louisiana, July 7-12, 2013.
19. C.E. Carrigan, "Using the New and Improved Roadside Safety Analysis Program" Workshop 163 of the 2012 Transportation Research Board Annual Meeting, 2012.

TRADE PUBLICATIONS

1. M.H. Ray, C.E. Carrigan, C.A. Plaxico, "Roadside Safety Analysis Program, Version 3: Upgrading a Tool for Roadside Safety Design," TR News, page 12-13, October 2012.
2. C. Silvestri and C.E. Conron, "Proposed Policy for Highway Design and Maintenance for the Reduction of Tree Crashes," IRF Examiner, January 2009.

SPONSORED RESEARCH PROJECTS

Dr. Carrigan has participated in research sponsored by the National Cooperative Highway Research Program as well as many State Departments of Transportation.

1. "Recommended Guidelines for the Selection and Placement of Test Levels 2 through 5 Median Barriers," National Cooperative Highway Research Program (NCHRP) Project 22-31, National Academy of Sciences, \$300,000.
2. "Development of a Strategic Plan for the AASHTO SCOD Technical Committee on Roadside Safety," National Cooperative Highway Research Program (NCHRP) Project 20-07(360), National Academy of Sciences, \$75,000.
3. "Guidelines for Shielding Bridge Piers," National Cooperative Highway Research Program (NCHRP) Project 12-90, National Academy of Sciences, \$450,000.
4. "Consideration of Roadside Features in the Highway Safety Manual," National Cooperative Highway Research Program (NCHRP) Project 17-54, National Academy of Sciences, \$1,140,000.
5. "Recommended Guidelines for the Selection of Test Level 2 through 5 Bridge Railings," National Cooperative Highway Research Program (NCHRP) Project 22-12(03), National Academy of Sciences, \$250,000, 2014.

6. "Update of the Roadside Safety Analysis Program (RSAP)," National Cooperative Highway Research Program (NCHRP) Project 22-27, National Academy of Sciences, \$600,000, 2012.
7. "In-Service Evaluation of Flexible Pavement in Maine," Maine Department of Transportation, 2009.
8. "Development of an On-Line Guide to Luminaire Supports," Wyoming Department of Transportation Pooled Fund Study, 2007.
9. Development of an On-Line Guide to Small Sign Support Hardware, National Cooperative Highway Research Program, Project 20-7(214), 2006.
10. Development of an On-Line Guide to Bridge Railing Hardware, National Cooperative Highway Research Program, Project 20-7(196), 2006.

HIGHWAY IMPROVEMENT PROJECTS

Dr. Carrigan has experience throughout the various stages of highway infrastructure projects including the planning, design, construction, and maintenance of highway infrastructure. She has participated in a number of municipal, state, and federally funded improvement projects. An illustration of her experience is provided here.

1. Design and construction inspection of improvements for Staples Hill Road in Canton, Maine.
2. Design of roadway improvements and coordination of signal timing for eleven signalized intersections along US Route 20 and US Route 202 in Westfield, Massachusetts.
3. Design of roadway and intersection improvements along Route 12 in Auburn, Massachusetts.
4. Conceptual planning of improvements to the interchange of Interstate 495 and Interstate 290 in Marlboro, Massachusetts.
5. Conceptual planning of improvements for the installation of a barrier to separate the State Route 12 and US Route 20 overlap in Auburn, Massachusetts.
6. Construction inspection of the new Massachusetts Turnpike (Interstate 90) and State Route 146 interchange.
7. Development of construction bid documents for maintenance of pavement and concrete median barriers in Holden, West Boylston, Sterling, and Lancaster, Massachusetts along Interstate 190.