Modified Asphalt Research Center (MARC)
Future Research Focus Workshop

Hussain Bahia

Xiaopeng (Shaw) Li

Sikai (Sky) Chen

Runhua Zhang

University of Wisconsin-Madison

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1. Executive Summary

The landscape of road infrastructure is evolving rapidly, driven by the pressing need for innovation in pavement design, construction, operation, and maintenance. Traditional methods and practices have been facing many challenges raised by the demands for improved performance, increased efficiency, better environmental sustainability, and resilience against the changing climate, which can be achieved by means of emerging technologies including artificial intelligence (AI), sensing techniques, and automation technologies. These newer technologies promise to streamline the material design and testing process, enhance the safety of road inspection and maintenance activities, improve the efficiency and effectiveness of pavement management systems, and reduce both the environmental footprint and costs from material production and construction projects, potentially revolutionizing existing methods and practices in the traditional pavement engineering field.

To timely respond to and capitalize on these opportunities, a collaborative workshop was convened by drawing participants from academia, industry, and government. The focus was to (1) identify the imminent challenges and urgent research needs in the pavement engineering field; (2) develop a new research agenda for MARC incorporating the recent advancement in emerging technologies, and; (3) find potential resources to support and address the identified challenges and needs. The one-day workshop was comprised of keynote presentations from the MARC researchers and invited speakers from industry and transportation agencies, and a discussion section for interaction and knowledge exchange among participants.

2. Workshop Overview

The workshop took place on February 21st, 2024, at the Fifth Quarter Studio, Union South, organized by the Modified Asphalt Research Center (MARC) at the University of Wisconsin-Madison (UW-Madison). The workshop was hosted by Dr. Hussain Bahia, Dr. Xiaopeng (Shaw) Li, Dr. Sikai (Sky) Chen, and Dr. Runhua Zhang.

2.1. Participants

Participants from academia, industry, and government sectors, along with numerous interested students from UW-Madison, registered to attend this workshop. Below is a list of the workshop attendees.

Name	Affiliation
Andrew Hanz	MTE Services
Ben Worel	Minnesota Department of Transportation
Carl Johnson	Stark Pavement Corporation
Cheng Ling	Pike Industries, Inc.
Chengyuan Ma	University of Wisconsin-Madison

Danial Mirzaiyan	*Solmax*
Danielle Knudtson	*MTE Services, Inc*
David Mensching	*Federal Highway Administration*
Debbie Schwerman	*Wisconsin Asphalt Pavement Association*
Erik Lyngdal	*Wisconsin Department of Transportation*
Eshan Dave	*University of New Hampshire*
Greg Harrington	*University of Wisconsin-Madison*
Gurdip Brar	*G2DVTechnologies, LLC/Mayor of Middleton (2017-23)*
Haotian Shi	*University of Wisconsin-Madison*
Humberto Flores	*UNSA*
Hussain Bahia	*University of Wisconsin-Madison*
Jacob Hehir	*MTE Services*
Jiarui Wang	*University of Wisconsin-Madison*
John Carbin	*Federal Highway Administration*
Keke Long	*University of Wisconsin-Madison*
Lei Shi	*University of Wisconsin-Madison*
Marvin James	*Wis-Coat, LLC*
Michael Vrtis	*Minnesota Department of Transportation*
Rui Wang	*University of Wisconsin-Madison*
Ruitao Xie	*University of Wisconsin-Madison*
Runhua Zhang	*University of Wisconsin-Madison*
Sally Gillan	*Cenovus Asphalt*
Sepehr Mohammadi	*Michigan Tech*
Sikai (Sky) Chen	*University of Wisconsin-Madison*
Tirupan Mandal	*Wisconsin Department of Transportation*
Xiaopeng Li	*University of Wisconsin-Madison*
Xiujuan Zhang	*UW-Madison College of Engineering*
Zhaohui (Vito) Liang	*University of Wisconsin-Madison*
Zilin Huang	*University of Wisconsin-Madison*

2.2. Proceedings Summary

The workshop commenced with Dr. Runhua Zhang extending a warm welcome and opening remarks to the attendees, setting the tone for a day of insightful discussions. Dr. Hussain Bahia then took the stage to delve into the history and achievements of MARC, articulating the necessity for evolution in the face of new research demands with a compelling call to action. This was followed by Dr. Xiaopeng Li's presentation on the team's pioneering work in the realms of Artificial Intelligence (AI) and automation and sensing, outlining the exciting potential for these technologies in transforming current practices in the road

infrastructure sector.

The dialogue then expanded to include perspectives from government agencies and industry representatives, with presentations from David Mensching (Asphalt Materials Research Program Manager for the Federal Highway Administration (FHWA)) and John Carbin (Transportation Automation Program Manager at FHWA), Erik Lyngdal (Chief Materials and Pavement Engineer for Wisconsin DOT), and Andrew Hanz (Director of MTE Services, a division of Mathy Construction) and Cheng Ling (Director of Engineering & Sustainability at Pike Industries, A CRH Company). These talks described the imminent challenges the road infrastructure system is currently facing and the potential research directions that the MARC and UW-Madison experts with various specialties could lead to address these challenges. The presentations also highlighted the urgent need for leveraging and integrating AI, sensing, and automation techniques and tools into the traditional pavement engineering field.

Figure   Glimpses from the MARC Workshop

Dr. Sikai Chen spearheaded a dynamic discussion session on identifying specific research areas for the development of MARC's new research agenda and exploring collaboration opportunities and available resources to support research in these areas. This forum became a melting pot of ideas, with participants eagerly sharing their insights and aligning their visions with potential funding opportunities to craft forward-looking research scopes and collaboration models

The workshop concluded with a comprehensive summary and reflective discussion, led by Dr. Li, who then guided attendees through a tour of the MARC and CATS Labs to briefly demonstrate the ongoing projects and exhibit the group's research capability to attendees.

3. Discussions and Key Insights

The discussion session focused on the development of the new MARC research agenda incorporating emerging technologies. The MARC researchers aimed to solicit ideas and insights from the workshop participants on the following four key topics:

Topic 1. AI for Structure & Material Design: Participants emphasized the use of AI and data science for AI-enhanced and data-driven material selection, mixture, and structure design methods. This includes: (1) incorporating the AI and sensing tools in the traditional design process to learn from the data and promote the design; (2) standardizing the data structure or developing the general data schema to improve the compatibility and interoperability of the data from different sources; (3) streamlining the project deliverables, and; (4) linking continuous lab/field measurements (e.g., material properties, traffic, and climatic conditions) to long-term field performance.

Topic 2. Autonomy for Testing: Autonomy holds the potential to significantly reduce the burden and cost associated with laboratory tests. This includes: (1) developing autonomous equipment for sample preparation (e.g., gyratory compaction and specific gravity measurement) and material testing (e.g., Quality Assurance (QA) and Quality Control (QC) and Balanced Mix Design (BMD) tests); (2) automating the plant production and construction equipment, and (3) contributing to workforce development by introducing new skills and methodologies.

Topic 3. AI & Autonomy for Inspection: The discussion explored the potential application of AI and autonomy in the pavement condition inspection process, including: (1) using remote automated sampling equipment to reduce the cost of data collection; (2) integrating fleet vehicles as mobile data collection units, presenting a unique opportunity to gather extensive and valuable roadway information without significant disruptions to traffic; (3) standardizing inspection data, ensuring that the information gathered is both reliable and comparable across different regions and projects, and; (4) developing and providing the low-cost inspection tools for counties and cities.

Topic 4. AI, Autonomy, and Digital Infrastructure for Construction & Maintenance: The MARC researchers are expected to research on: (1) developing the smart plants to improve efficiency, quality, and consistency for material production; (2) merging pavement data into BIM and GIS models for the digital twin of road infrastructure system; (3) proposing methods/tools to support agencies planning and autonomous testing processes, and; (4) developing the low-cost testing and construction equipment while assuring the quality.

4. Conclusions and Recommendations

Based on the comprehensive deliberations and research topics prioritization through voting among participants, MARC is recommended to focus on the following new research directions:

1. **Enhancing QA and QC Testing and Plant Monitoring through Automation**: The automation of QA/QC testing and plant monitoring stands out as a pivotal

area for immediate attention. Implementing automated systems and AI algorithms can significantly improve the accuracy, efficiency, and reliability of testing procedures and plant operations.

2. **Development of Interfacing Tools for Data Unification**: There's a critical need for developing tools that can interface and convert disparate data types into a unified structure, such as Geographic Information Systems (GIS) and Building Information Modeling (BIM). This will facilitate better data analysis, decision-making, and interoperability across different platforms and stakeholders.

3. **Optimizing Network Asset Management within Budget Constraints**: Research should focus on developing models and tools for more effective asset management, especially under limited budget scenarios. This involves leveraging AI and data analytics to prioritize maintenance and investment decisions for maximum impact.

4. **Integration of Low-Cost Sensors for Enhanced Inspection**: The deployment of low-cost sensors on fleet vehicles for real-time inspection and routine data collection presents a promising avenue for improving road infrastructure monitoring and maintenance strategies.

Identifying and securing funding is crucial for advancing these research areas. During the workshop, several potential funding opportunities were introduced, spanning governmental, private sector, and academic sources. MARC researchers are encouraged to explore the following programs:

1. USDOT Strengthening Mobility and Revolutionizing Transportation (SMART) Grants Program
2. USDOT Advanced Transportation Technologies and Innovative Mobility Deployment
3. USDOT Advanced Research Projects Agency - Infrastructure (ARPA-I)
4. USDOT Innovative Technology Deployment (ITD) Program
5. DOE Low Carbon Pavement
6. DOE EERE Funding Opportunity Exchange
7. FHWA BAA Digital Instruction — Pavement, Automation
8. NCHRP Highway, Pavement

To realize the potential of AI, sensing, and automation in transforming the existing paradigms of road infrastructure design, construction, operation, and maintenance, a collective effort from all stakeholders is essential. MARC calls on government agencies, industry partners, academic institutions, and funding bodies to engage in Collaborative Research and Knowledge Sharing.

5. Next Steps

Continued Research Directions and Collaborations: The MARC will continue to leverage its strengths in pavement materials, automation, and artificial intelligence to further research in the identified critical areas. By utilizing the MARC platform, we aim to foster collaboration with partners across various sectors to secure above mentioned funding opportunities for relevant research projects. This collaborative effort is expected to advance the development of innovative solutions to the technical challenges faced in the field of road infrastructure.

Establishment of an Advisory Board: In 2024, the center plans to establish an advisory board comprising experts from academia, industry, and government. This board will provide strategic guidance, facilitate knowledge exchange, and strengthen the center's connections with key stakeholders. The formation of this advisory board is a step towards ensuring that MARC's research and initiatives are aligned with current needs and future directions as highlighted during the workshop.

Periodic Workshops and Online Forums: MARC intends to host periodic workshops and online forums to encourage ongoing dialogue and collaboration among researchers, practitioners, and policymakers. These events will serve as platforms for sharing the latest advancements, discussing emerging challenges, and identifying opportunities for joint ventures. By maintaining a schedule of regular interactions, the center aims to foster a vibrant community of innovators committed to transforming the landscape of road infrastructure through cutting-edge research and technology.

Tentative Data for Next Year Workshop: Our 2025 MARC workshop is tentatively scheduled for the 20th of February.

Appendix

MARC Workshop Flyer

Modified Asphalt Research Center (MARC)
Future Research Focus Workshop

Purpose of the Workshop

This workshop aims to initiate discussions on emerging opportunities and challenges in road infrastructure. It will focus on setting a new research agenda, identifying potential resources, and fostering collaboration among stakeholders. The goal is to investigate existing challenges in road infrastructure and propose new solutions leveraging automation and AI. This includes creating efficient and reliable virtual platforms for design and optimization and developing automated construction and maintenance technologies to improve safety, efficiency, and cost-effectiveness.

Key Topics

- The impact of AI and automation in transforming material testing and structural design.
- Optimizing traffic operations and enhancing roadway construction and maintenance.
- Exploring interdisciplinary approaches for material and structural design.
- Strategies for monitoring and predicting smart traffic and pavement performance.
- Innovations in automating road construction and maintenance.

Agenda

Morning Session

Time	Session
8:50-9:00 a.m.	Welcome and Opening Remarks
9:00-9:30 a.m.	Review of MARC History, Highlights, and Collaborations, needs for change, New MARC
9:30-10:00 a.m.	Next generation center agenda – Project profile
10:00-10:30 a.m.	Break
10:30-11:10 a.m.	Updates from FHWA
11:10-11:30 a.m.	Updates from State DOT
11:30-12:10 p.m.	Industry Session

Afternoon Session

Time	Session
12:10-1:30 p.m.	Lunch
1:30-3:30 p.m.	Research Needs and Collaboration Discussion Session
3:30-4:00 p.m.	Break
4:00-5:00 p.m.	Summary and Tour of Center Labs, Automated Vehicle Demo

Attendees

The workshop will host stakeholders from the Federal Highway Administration (FHWA), state Departments of Transportation (DOTs), industry partners, and academic researchers.

Registration

https://forms.gle/fWGsUuEjnm8gVqis9

Parking (covered by UW-Madison): UW-Madison Union South Garage Lot 80, 1308-1398 W Dayton St, Madison, WI

Lodging: Wisconsin Union Hotel, Hilton Garden Inn, Hampton Inn, Hyatt Place Madison/Downtown

Date: February 21, 2024

Location: Union South Fifth Quarter Studio, 2nd Floor, 1308 W Dayton St, Madison, WI

Modified Asphalt Research Center (MARC) • Civil Engineering Department • University of Wisconsin-Madison
Contact: Dr. Runhua Zhang, rzhang478@wisc.edu

Rank Priorities of These Topics

Rank	Topic
1st	Automate QA/QC testing, plant monitoring
2nd	Advisory committee
3rd	Interfacing tool converting different data into a unified structure (e.g., GIS, BIM)
4th	Network asset management with a limited budget
5th	Add low cost sensors to fleet vehicle for inspection
6th	Introducing a standard AI approach for design & testing
7th	Policy and technical support for local agencies for adopting automated construction/maintenance
8th	Private car telematics data based inspection
9th	Different inspection data quality levels based on specific distress
10th	Develop niche automation technologies to complement major industry development.