IEEE Toronto Section

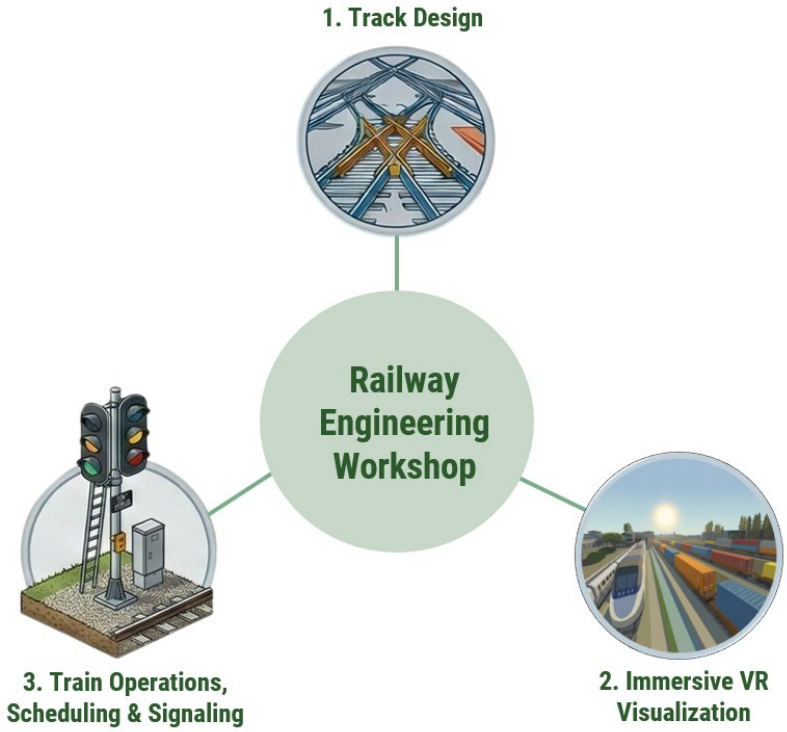
Railway Engineering: Design, Simulation & Immersive VR Visualization

(Hands-On Workshop)

Summer 2026

Workshop Organizers: Dr. Ahmad Mohammadi & Dr Marjan Alavi

Workshop Website: View Link



Course Overview

This workshop provides a hands-on, project-based introduction to railway engineering & simulation including three phases of a railway system:

1. Track Design (Bentley OpenRail): Create a real-world rail network on top of aerial imagery and elevation GIS maps including track geometry (horizontal, vertical, superelevation) and track layout (turnout, yard, bridge, and crossover).

2. 3D Visualization & Virtual Reality (LumenRT): Developing 3D environments including train stations, surrounding buildings, trees and develop VR 360 degree video.

3. Train Operations, Scheduling and Signaling (SUMO Traffic Simulation): Create a simulated rail network & rail signal in traffic simulation and conduct scheduling, operations and capacity analysis including number of trains, av dwell time in stations (fixed block)

Teaching Philosophy

This workshop is designed using Universal Design for Learning (UDL) principles to ensure all students can access, engage with, and demonstrate understanding of railway engineering concepts. The course provides:

- **Multiple means of representation:** Presenting the same concepts through text (lecture slides), hands-on (hands-on slides) formats, visual (video tutorial) and self-paced resources (website) to ensure students can access and understand key concepts.
- **Multiple means of engagement:** Providing two support channels including Office Hours and Community Learning Platform to reduce barriers, accommodate varied learning contexts, and maintain motivation through accessible and timely assistance.
- **Multiple means of expression:** Providing students with opportunities to demonstrate learning through complementary assessment structure: class participation and discussion and the design project with professional deliverables (project website + demo video).

Course Learning Outcomes

By the end of this course, students will be able to:

1. Develop a real-world railway corridor in OpenRail including essential track infrastructure elements such as alignments, turnouts, and crossovers.
2. Create 3D railway environments and VR/360-degree presentations using LumenRT.
3. Build a rail simulation model in SUMO including train scheduling and signaling.
4. Integrate railway design, visualization, and simulation workflows into a practical digital project (demo video + template website).

6 Hours - Workshop Structure

Day 1		
Hour	**Topic (Lecture + Hands-on)**	**Materials**
0:00-0:30	**Introduction to Railway Engineering** **Lecture:** • Introducing Workshop Organizers (Dr Marjan Alavi - MacMaster & Dr Ahmad Mohammadi - York University) • History of railways • What is railway system and railway engineering? • Railway engineering: Inputs, Sub-System, Outputs, Goals • Regulations and standards (e.g., Transport Canada, AREMA) • Hands on experiment (OpenRail Software, LumenRT & SUMO Simulation)	Preview
0:30 - 1:30	**Track Design I (Track Geometry)** **Hands-on:** • Introducing OpenRail ConceptStation • Create a New Project • Import Aerial and Elevation Maps • User Interface • Create a Real-World Rail Network	Preview

	• Vertical Alignment • Horizontal Alignment • Superelevation	
1:30- 1:45	**Break (Q&A)**	
1:45 - 2:45	**Track Design II (Track Layout)** **Hands-on:** • Railway Turnout Types • Insert Diverging Turnouts • Place Yards • Insert Merging Turnouts • Place Track Crossover • Bridge Clearance Analysis	Preview
2:45- 3:00	**Closing Remarks - Day 1 (Workshop Continues Day 2)**	
	Day 2	
Hour	**Topic (Lecture + Hands-on)**	**Materials**
0:00- 1:00	**3D Visualization & Virtual Reality** **Hands-on:** • Preparation & Quick Start on LumenRT • 3D Visualization Fundamental I: Light, Location, Eye, Time • 3D Visualization Fundamental II: Static Objects • 3D Visualization Fundamental III: Behaviors • Creating 3D Objects (Rail station, trees, buildings) Using Generative AI • Import, Place, and Adjust 3D Objects in LumenRT • Select Train Types (Electric or Diesel) • Virtual Reality: 360° VR Video	Preview
1:00- 2:00	**Train Scheduling & Signaling** **Hands-on:** • Fundamentals of Traffic Simulation • Simulation of Urban Mobility (SUMO) • SUMO Visualization Interface • Train Scheduling Mini Project - Assumptions • Develop a Simulated Rail Network • Set Corridor Operating Speed • Define Train Flows and Routes • Define Rail Signal Logic	Preview
1:30- 1:45	**Break (Q&A)**	
1:45- 2:45	**Operations & Capacity** **Hands-on:** • Fundamentals of Railway Operations and Capacity • Defining Train Stops and Stations • Timetable Scheduling I: Dwell Time • Timetable Scheduling II: Train Headway • Timetable Scheduling III: Departure and Arrival Times • Timetable Scheduling Analysis • Railway Network Capacity Analysis	Preview
2:45 - 3:00	**Final Remarks & Certificate Information** **Lecture:** • Summary of what was covered across all three phases • Overview of IEEE Participation & Completion Certificate criteria (see Certificate Assessment section) • Q&A and closing remarks	Preview

IEEE Certificate Assessment

Activity	Type	What It Evaluates
Participation Certificate	Attendance	Attended the live workshop session
Completion Certificate	Post-Workshop Submission	Attended the workshop and submitted the project showcase website within the deadline

Certificate Delivery: All certificates will be issued digitally in PDF format via email within 7 business days of the workshop (Participation) or submission deadline (Completion).

Completion Certificate Requirements:

- Attend the live workshop session
- Watch the post-workshop recorded tutorial
- Submit a showcase website including outputs from all three phases: track design screenshots, LumenRT VR video, and SUMO KPI tables/plots
- Submission deadline: 5 days after the workshop date

Issued by: IEEE Toronto Section and IEEE Industrial Applications Society.

Optional Course Materials

1. American Railway Engineering and Maintenance-of-Way Association. (2025). Manual for railway engineering. AREMA (Fall 2025): https://publications.arema.org/Publication/MRE_2025
2. American Railway Engineering and Maintenance-of-Way Association, Committee 24 Education and Training. (2003). Practical guide to railway engineering. AREMA. https://pdfcoffee.com/160988648-arema-practical-guidepdf-pdf-free.html
3.Metrolinx Track Standards (2025). Heavy Rail. Access: https://assets.metrolinx.com/image/upload/Documents/Engineering/Metrolinx_Track_Standards.pdf
4. Hansen, I. A., & Pachl, J. (2005). Railway Timetabling & Operations. Academic press.

Prerequisites

No prior experience in railway engineering, track design, or traffic simulation is required. This workshop is designed to be accessible to participants at all levels.

Participants should have:

- Comfort with installing and navigating desktop software
- A laptop capable of running OpenRail ConceptStation, LumenRT, and SUMO (Windows recommended)

Recommended background: Undergraduate or graduate students in engineering, computer science, urban planning, or related fields. Participants from adjacent disciplines including geography, data science, architecture, and public policy are equally welcome.

Student Support and Accessibility

Office Hours: By appointment via email (AhmadMohammadi1441@gmail.com) - flexible scheduling available to accommodate work/study commitments. Virtual meetings available.

Discord Community: Join our course Discord (https://discord.gg/8kPaECVzJY) for:

- Continuous support for Q&A (24-hour response time)
- Peer learning and study groups
- Archived resources and troubleshooting tips
- Community support outside scheduled hours

Technical Support: All required software must be installed prior to the workshop. SUMO is free and open-source. OpenRail ConceptStation and LumenRT are available as free student/trial versions. Installation tutorials and troubleshooting guides will be provided in advance.