RoadwayVR Course Hub

**RWR 4015 Traffic Simulation for Planning Applications**

**Course Outline – Fall Term (September - December 2026)**

**Instructor: Dr. Ahmad Mohammadi**

**Course Website: View Link**

## Course Overview

This 12-week course combines lecture-based instruction with hands-on workflows to build professional competency in transportation planning. Weekly modules introduce key capabilities: traffic simulation fundamentals, network modeling (GIS/OpenStreetMap), demand calibration, signal planning, mixed traffic scenarios (autonomous vehicles), environmental analysis (emissions and electric vehicles), intelligent transportation systems, and 3D visualization. Following UDL principles, content is delivered through multiple formats including lecture slides, hands-on slides, and video demonstrations, all accessible through the course website for self-paced learning. Weekly hands-on sessions build progressively from foundational skills to advanced applications, with each producing concrete deliverables. The course has a design project where students conduct a traffic impact study on a real intersection and conduct alternatives analysis with traffic simulation, 3D visualization, and professional deliverables (technical report and presentation). Students receive support through flexible office hours and an online peer learning community.

## Teaching Philosophy

This course is designed using Universal Design for Learning (UDL) principles to ensure all students can access, engage with, and demonstrate understanding of traffic simulation 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 through approaches that match their learning needs.
- **Multiple means of engagement:** Providing two support channels including Office Hours and Community Learning Platform. These support channels are designed 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 six complementary assessment structure: class participation and discussion, transportation news brief presentations, weekly in-class deliverables, weekly assignments, paper-based midterm with written reasoning, and the design project with professional deliverables (technical report, presentation).

## Course Learning Outcomes

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

1. **Develop foundational knowledge in transportation planning** topics including traffic simulation, signal planning, network/demand modeling, environmental analysis, artificial intelligence, and visualization
2. **Build and calibrate** traffic simulation models using professional open-source tools (SUMO, QGIS) alongside industry-standard methods.
3. **Analyze** transportation scenarios including signal timing, mixed traffic (AVs/manual vehicles), and environmental impacts
4. **Evaluate** planning alternatives using performance metrics (delay, emissions, level of service)
5. **Communicate** technical findings to diverse audiences through reports, visualizations, and presentations
6. **Apply** conceptual understanding to diagnose model issues and justify calibration decisions
7. **Integrate** emerging technologies (AI, 3D visualization) into transportation planning workflows

## 12 -Week Course Structure

| Week | Topic (Lecture + Hands-on) | Materials |
|---|---|---|
| 1 | **Introduction to Traffic Simulation**<br>**Lecture:** What is Traffic Simulation?; The Purpose of Traffic Simulation; Examples of Traffic Simulation Studies; Course Description<br>**Hands-on:** Install Simulation of Urban Mobility (SUMO); Set Up SUMO Environment Variables; Install Notepad++; SUMO Files and User Interface; Create a Simple Network with Car Traffic Demand; Add Opposite Traffic Flow | Video Tutorial 1<br>Video Tutorial 2 |
| 2 | **Fundamentals of Traffic Simulation**<br>**Lecture:** Road Network Development; Vehicles Characteristics; Vehicle Dynamics; Car Following and Lane Changing Models; Traffic Theory; Fundamental Diagram (Flow, Density, Speed)<br>**Hands-on:** Road Network Development in Traffic Simulation; Car Following and Lane Changing Models in Traffic Simulation | Video Tutorial 1<br>Video Tutorial 2 |
| 3 | **Network Modelling with GIS**<br>**Lecture:** Introduction to GIS; GIS in Planning Applications; Relationship between GIS and Simulation; What Network Details Matter<br>**Hands-on:** Geographic Information System (GIS); GIS Software; Download and Installing QGIS Software - Open Source and Free; Map Services; Imagery Map and Georeferencing; Create a Road Network on Top of GIS; Import a Road Network from OpenStreetMap into SUMO | Video Tutorial 1<br>Video Tutorial 2 |
| 4 | **Traffic Signal Planning in Simulation**<br>**Lecture:** Signalized and Unsignalized Intersections; Introduction to Traffic Signal Planning; Traffic Signal Planning Case Studies; Signal Elements (phases, cycle, lost time); Fixed-time vs. Actuated; Ring-barrier (conceptual); Basic Signal Optimization Concepts<br>**Hands-on:** Intersection - Unsignalized; Intersection - Signalized | Video Tutorial 1<br>Video Tutorial 2 |
| 5 | **Demand Modelling & Route Assignment**<br>**Lecture:** Elements of Demand Modelling and Route Assignment; Traffic Movement Calibration; Traffic Volume Calibration; Traffic Speed Calibration<br>**Hands-on:** Implementation of Traffic Movement/Volume Speed Calibration in Simulation | Video Tutorial 1<br>Video Tutorial 2 |

| Week | Topic (Lecture + Hands-on) | Materials |
|---|---|---|
| 6 | **Mixed Traffic Planning: Autonomous and Human-Driven Vehicles**<br>**Lecture:** Fundamentals of Connected and Autonomous Vehicles (CAVs); Automation Levels; Simulation Tools for CAVs; Impact of Mixed Traffic Planning<br>**Hands-on:** Develop Mixed Traffic Planning for AVs and Human-Driven Vehicles in Simulation; Analyze Impacts of Different AV Penetration Rates on Traffic Performance | Video Tutorial 1<br>Video Tutorial 2 |
| 7 | **Environmental Analysis (Energy, Emissions, Electric Vehicles)**<br>**Lecture:** Fundamental of Energy and Emission (Combustion Engine Vehicle and Electric Vehicles); Energy and Emission Definition and Impact of Different Vehicle Types; Internal Combustion Engine Vehicle and Electric Vehicle; SUMO Vehicle Supports; Energy Consumption and Emission Models<br>**Hands-on:** Energy Consumption and Emission Model (HBEFA Model); Emission Models in Simulation; Environmental Analysis in Simulation; Develop Mixed Traffic Planning Strategies of EVs and ICE in Simulation; Analyze Environmental Impacts of Different Scenarios | Video Tutorial 1<br>Video Tutorial 2 |
| 8 | **Midterm (Paper-Based): Model Reasoning**<br>**In-class assessment (no computer):** Students interpret printed outputs (traffic counts, speeds, travel times, queue plots, SUMO snapshots, signal timing diagrams, network diagrams, emission reports, AV penetration scenarios) and:<br>• Diagnose likely causes of simulation-reality mismatches (demand, speed parameters, signal timing, car-following/lane-changing behavior, network geometry)<br>• Propose calibration strategies with justification (what to adjust and why)<br>• Evaluate model quality and validation evidence<br>• Apply traffic theory to explain simulation behaviors (flow-density relationships, capacity, queuing)<br>• Analyze mixed traffic scenarios (compare impacts of different AV penetration rates on traffic performance)<br>• Evaluate environmental impacts (assess energy consumption and emissions across different vehicle mix scenarios)<br>• Compare design alternatives based on simulation outputs (intersections, signal timing, network changes, EV/ICE planning strategies | |
| 9 | **Artificial Intelligence in Intelligent Transportation Systems**<br>**Lecture:** Reviewing Intelligent Transportation Systems Case Studies and Explaining the Concept of ITS, Three Phases of Detection, Algorithms and Decisions in ITS; Explain Application of Artificial Intelligence in ITS<br>**Hands-on:** Fundamentals of Machine Learning Algorithms; Fundamentals of Reinforcement Learning Algorithms; Implement an Intelligent Traffic Signal; Analyze the Performance of Intelligent Traffic Signal | Video Tutorial 1<br>Video Tutorial 2 |
| 10 | **3D Simulation in Planning I**<br>**Lecture:** 3D Visualization in Planning; 3D Visualization Case Studies; 3D Simulation with Existing Game Engines; Unity Game Engine<br>**Hands-on:** Install Sumo2Unity Tool, Install Unity Game Engine; Visualize a Single Lane Road with one Unsignalized Intersection | Video Tutorial 1<br>Video Tutorial 2 |
| 11 | **3D Simulation in Planning II**<br>**Lecture:** Multi Lane Road with Signalized Intersection<br>**Hands-on:** Visualize Different Modes of Transportation (Bicycle, Scooters) | Video Tutorial 1<br>Video Tutorial 2 |
| 12 | **Final Project Report and Presentation**<br>**Lecture:** Writing A Final Project Report Including Analysis Results through Tables and Plots; Discuss Findings<br>**Hands-on:** Final Project Presentations | Video Tutorial 1<br>Video Tutorial 2 |

## Course Assessment

| Activity | Type | Frequency | Weight | What It Evaluates |
|---|---|---|---|---|
| Class participation | Participation | Weekly | 5% | Active engagement, peer learning, professional communication |
| In-class deliverables | Progressive | Weekly | 15% | Technical skills application, immediate feedback on modeling |
| Transportation News Brief presentation | Communication | Once per student | 10% | Ability to analyze current events and present to peers |
| Assignments | Practice | Throughout term | 10% | Concept reinforcement, preparation for midterm |
| Midterm examination (paper-based) | Summative | Week 8 | 25% | Conceptual understanding, calibration reasoning without software |
| Design project | Applied Project | Cumulative | 35% | End-to-end planning workflow, professional deliverables |

## Optional Course Materials

1. Federal Highway Administration. (2019). *Traffic analysis toolbox volume III: Guidelines for applying traffic microsimulation modeling software* (2019 update to the 2004 version). U.S. Department of Transportation. https://rosap.ntl.bts.gov/view/dot/43570

2. Dowling, R., Skabardonis, A., & Alexiadis, V. (2004). *Traffic analysis toolbox volume III: Guidelines for applying traffic microsimulation modeling software* (Publication No. FHWA-HRT-04-040). Federal Highway Administration. https://highways.dot.gov/media/6916

## Prerequisites

No prior traffic simulation experience required. Students should have:

- Basic understanding of transportation concepts (traffic flow, intersections, signals)
- Comfort with software installation and learning new tools
- Willingness to engage with technical material

**Recommended background:** Urban planning, Transportation planning or related field. Students from other disciplines (policy, design, data science) are welcome with instructor permission.

## Career Outcomes

The course provides a foundation for roles such as:

- **Traffic Simulation Modeler:** Builds/calibrates microsimulation models and tests alternatives for land-use and transportation planning scenarios.
- **Transportation Planner:** Analyzing and planning transportation systems at the intersection of land use, mobility, and policy - directly supporting municipal planning departments and consulting firms in development review and transportation studies.
- **Traffic Operations Analyst:** Operational performance analysis, diagnosis, and improvements for municipal and public-sector planning initiatives.

## 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

**Accessibility:** Students requiring accommodations should contact [Accessibility Services office] as early as possible. Course materials are provided in multiple formats (slides, videos, hands-on) to support diverse learning needs.

**Technical Support:** All required software (SUMO, QGIS, Unity) is free and open-source. Installation tutorials and troubleshooting guides provided.