**“Road Traffic Engineering and Optimization”**

**Syllabus SCA.03/3**

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Version 1

# Name of the course

**Road Traffic Engineering and Optimization**

# ECTS credits

6 Credits, (**45 hours of Theory + 30 hours of Exercises & Lab**), 3rd semester

# Objectives

This course familiarizes students with the road traffic engineering fundamentals and their applications in transportation systems. The course introduces the concepts of characterizing traffic, various modeling approaches, and design of facilities to control and manage traffic. Within the module students will be introduced to fundamentals of traffic engineering, such as human factor design, geometric design and section design, traffic flow theory analysis, capacity analysis, traffic count methods, signalized intersection analysis; introduction of ITS (in the area of traffic control systems). The course will enable students to appreciate the traffic engineering as application of engineering techniques to achieve the safe and efficient movement of people and goods. Students will be familiarized with traffic control and management as well as traffic signals designing.

Overall, the lecture provides to students a solid background in the understanding the relationship between different parts of traffic engineering as well as practical skills of traffic analyses and designing of traffic control and management. .

# Learning outcomes

The general expectation regarding the knowledge to be provided/acquired is as follows:

* To explain the need for traffic engineering application in transport systems
* To identify the human and vehicle dynamics factors in traffic engineering design as well as relationships among human-vehicle-road
* To use an appropriate traffic flow theory for traffic characteristics
* To familiarise students with the traffic count methods
* To familiarize students with the the capacity and signalized intersection analysis as well as signal optimization at intersection and within traffic control system
* To familiarize students with the basic knowledge on traffic control systems as ITS service.

# Contents

1. **General introduction**
   1. Traffic engineering discipline
   2. Introduction to traffic engineering: Road user characteristics, human and vehicle characteristics (Vehicle motion and human factors)
   3. Road dependent factors, climatic and meteorological factors.
2. **Traffic stream characteristics**
   1. **Fundamental parameters and relations of traffic flow (**speed,density, volume, travel time, headway, spacing, time-space diagram, time mean speed, space mean speed and their relation, relation between speeds, flow, density, fundamental diagrams)
   2. **Traffic stream models** (e.g. Greenshield’s model, Greenberg’s logarithmic model, Underwood’s exponential model, pipe’s generalized model, multi-regime models, basic statistical concepts; traffic volume studies; speed, travel time & delay studies, queuing theory and traffic flow analysis, traffic analysis at motorway bottlenecks)
   3. **Adnanced Microscopic traffic flow modelling**
      1. Car-following models: Concept of stimulus-response, safety distance, pscho-physical, optimal velocity, fuzzy logic models, and applications;
      2. Lane changing models: Conceptual framework, lane selection model, gap acceptance models;
      3. Vehicle arrival models: Poisson distribution, headway modeling, random vehicle generation,
      4. Microscopic traffic simulation: Vehicle generation, design, calibration, validation, applications, operational models.
   4. **Macroscopic and mesoscopic traffic flow modelling**
      1. Traffic flow modeling analogies: Fluid flow analogy, heat flow analogy, granular flow, Lighthill-Withams theory, shock waves;
      2. Cell transmission models: Flow conservation, flow transmission;
      3. Traffic progression models: Robertson progression model, platoon movement, dispersion index, applications;
      4. Discrete simulation models: Cellular automata concepts, discretization of time and space, rules for acceleration, deceleration, randomization, and vehicle updation.
3. **Traffic measurement procedures and methods**
   1. **Measurement at a point:** Traffic volume and speed measurement, equipment for flow measurements, data analysis, concepts of ADT, AADT;
   2. **Measurement over a short section:** Speed measurements, 15th and 85th percentile speeds, design speed, speed distributions;
   3. **Measurement along a length of road:** Density measurement, travel time measurement;
   4. **Automated traffic measurement:** GPS devices, loop detectors, video analysis, and other technologies
4. **Road geometry basics**
5. **Capacity and level of service analysis. Measures of traffic effectiveness.** 
   1. **Capacity and Level of service LOS:** Definitions, highway capacity, factors affecting LOS, HCM methods;
   2. **Urban Streets:** Classification, operational performance measures, congestion management; MOEs
   3. **Multilane highways:** Characteristics, capacity and level of service;
   4. **Freeway operations:** Operational considerations, capacity and

level of service of a basic freeway segment, weaving and merging operations;

* 1. **Ramp metering:** Merging and diverging areas; gap acceptance, speed at ramps; fixed, reactive, and predictive systems;
  2. **Corridor analysis:** Segment capacity, free flow travel time, queue delay, transit corridor.

1. **Traffic control and management** 
   1. **Principles of traffic control:** Requirements, basic driving rules, priority movements, principles of traffic control, intersections conflicts**;**
   2. **Traffic signs and road markings:** Regulatory, warning, and

information signs; longitudinal, transverse, and object marking**;**

* 1. **Uncontrolled intersection:** Level of service, priority streams, conflicting traffic, critical gap and follow-up time, capacity, queue length, delays;
  2. **Assessment of the reasonableness of traffic signals introducing** (choice of intersection type) and links between geometrical solutions and traffic organisation in terms of signs and marking and signalling parameters
  3. **Traffic signal design**
     1. Elements of traffic signal: Definitions, basic parameters, analysis of saturation headway, saturation flow, lost time, critical flows, derivation of cycle length;
     2. Design principles of a traffic signal: Phase design, cycle time determination, green splitting, pedestrian phases, and performance measures;
     3. Evaluation of a traffic signal: Definitions and measurement of stopped and control delay, Webster’s delay model, oversaturated conditions;
     4. Capacity and LOS analysis of a signalized intersections: HCM 2010 method of analysis of a signalized intersection and determination of the level of service;
     5. Coordinated traffic signal: Concepts of offset, common cycle length bandwidth, offset for one-way and two way streets ;
     6. Vehicle actuated signals and area traffic control: Basic principles of vehicle actuation, collection of data, system architecture and algorithms
     7. Methods to optimise signals at intersection, along the streets and in the area.

# Teaching method

**Lectures, Case studies, Tutorials/exercises, ITS architecture creating with the FRAME Architecture tools.**

* The slides are available for the whole lecture. These slides are must be provided to students (or must be uploaded in the MOODLE system). The full content of each slide is systematically explained by the Lecturer. Additional examples which are not included in slides will be proposed by the Lecturer to allow good understanding of the information provided.
* The slides contain exercises with solutions for the good understanding of the content of each chapter. These solutions are systematically explained (during the lecture) by the Lecturer.
* The Slides contain exercises without solutions to be solved by students during the lecture (this is part of oral exam). The students are fully assisted by the Lecturer in order to obtain correct/exact solutions to the proposed exercises. This will help to check whether the students have understood the chapters or not.
* Several exercises will be proposed by the Lecturer to be solved by students as projects. This will help to test the self-learning potential of students.

# Assessment method

Mid-term and final oral and/or written examination, exercises from case studies.

# Textbooks - Publications - Software

**Textbooks**

* Principles of Highway Engineering and Traffic Analysis, by F L Mannering and W P Kilareski, Wiley, New York, September 2008
* Fundamentals of Transportation Engineering, by Jon D. Fricker and Robert K. Whitford , latest edition, Prentice Hall, New Jersey, 2004.
* Transportation Engineering: An Introduction, by C J Khisty & B K Lall, 3rd edition, Prentice Hall, New Jersey, 2002.
* Traffic-Flow Theory: State-ofthe-art: http://www.tfhrc.gov/its/tft/tft.htm.
* Highway Capacity Manual (2010), Transportation Research Board, USA.
* Traffic Engineering, 4/E. Roger P. Roess, Elena S. Prassas, and William R. McShane. Prentice Hall, 2009.

**Journals**

* Journal of Traffic and Transportation Engineering
* JOURNAL OF INTELLIGENT TRANSPORTATION SYSTEMS, TAYLOR & FRANCIS INC
* Traffic Engineering and Control (TEC) MAGAZINE

Software

**\*** tools for capacity estimating and designing traffic signals (e.g. OSCADY, ARCADY, CROSSIG, TRANSYT, HCS, CORSIM, SUMO)