UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Department of Civil and Environmental Engineering

**Francesc Soriguera**
*Associate Professor*

Jordi Girona 1-3, Office B1-111
08034 Barcelona (Spain)
Tel. (+34) 93 401 72 66
< francesc.soriguera@upc.edu >

**(250MUM023)**

# TRAFFIC

## Fall (S3)

*Format:* 5 ECTS – 3 hours of lecture per week

*General objectives:* The course will examine the attributes of highway transportation systems, including traffic flow features and theories. Emphasis will be given to principles and concepts and their application.

*Description:* The course will address issues regarding freeway/highway traffic operation (i.e. diagnosis). Our discussions will include methods of measuring traffic variables and of processing these measurements to evaluate prevailing conditions, to identify bottleneck locations, to uncover bivariate relations, etc. Considerable discussion will also be devoted to techniques for modeling and simulating traffic streams. This is only the first part of a traffic operations course. Freeway operation and management techniques and highway traffic control (e.g. signal systems) are out of the scope of the course.

*Methodology:* No textbook is assigned to this course. Rather, the background readings for the course (e.g. portions of monographs, journal publications, etc.) have been compiled into a reader that will be distributed among students. In general, the lectures will follow these materials closely. The professor will typically announce required reading assignments in advance. Ideally, you would bring the reader (or suitable portions of it) to each lecture.

The students will be assigned practical exercises (i.e. Graded Activities) to be solved during the course. These can be solved in pairs. Student pairs will be randomly allocated for each exercise. Failing to attend and work on the exercise during the "Discussion session" implies that the student will need to submit the exercise individually. The solution for each exercise will be presented in class by one (or several) students selected randomly.

- *Graded Activity 1* – Application of Edie's generalized definitions (from loop detector data of individual vehicles)
- *Graded Activity 2* – Bivariate Relations – Processing joint measurements and constructing diagrams.
- *Graded Activity 3* – Identification of freeway bottleneck location(s) and the estimation of bottleneck capacity from actual loop detector data on a freeway stretch.
- *Graded Activity 4* – Freeway queuing analysis. Application of the kinematic wave theory and BOQ cumulative count curve.
- *Graded Activity 5* – The Cell Transmission Model: coding the model for a simple freeway system.

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Department of Civil and Environmental Engineering

**Francesc Soriguera**
*Associate Professor*

Jordi Girona 1-3, Office B1-111
08034 Barcelona (Spain)
Tel. (+34) 93 401 72 66
< francesc.soriguera@upc.edu >

- *Graded Activity 6* – Simulation of a simple freeway system using a traffic simulation software.

*Digital Campus:* The course reader, the homework assignments, the mini-projects and some additional audiovisual support material will be accessible on the course web site in Atenea. (https://atenea.upc.edu). Those who have not officially enrolled the course yet, can access Atenea as guests. This course can be found at https://atenea.upc.edu/course/search.php with the Course code: 2024/25-01:ETSECCPB-250MUM023 – TRANSIT (Curs Total). Guest password: **Soriguera24**.

*Student Evaluation and Examination Norms:* The final course grade will be derived from the arithmetic average of the grades obtained in the course activities. All the activities have the same value. Re-submissions or late submissions (i.e. after the in class correction, whether or not there has been an on-time submission) are accepted until the last session of the course. Re-submissions must be individual. In this case, the final grade of the activity is obtained as the arithmetic average of the on-time and late submission grades. No on-time submission implies a zero grade for this part of the average. Failing to defend adequately the submitted solution, if asked to do so, implies a zero grade for the exercise and the requirement to go through the defense of all the submitted exercise solutions at the end of the course. There is no final exam.

*Additional Information:* The course is grounded on fundamental concepts from classical theories of traffic flow. The application of these theories requires making use of fundamental tools (graphical and analytical) regarding transportation operations (e.g. trajectories diagrams, cumulative curves and queuing theory, measurement and estimation). The development of the course takes this background for granted, as it is acquired in the 1$^{st}$ year of the masters' degree.

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Department of Civil and Environmental Engineering

**Francesc Soriguera**
*Associate Professor*

Jordi Girona 1-3, Office B1-111
08034 Barcelona (Spain)
Tel. (+34) 93 401 72 66
< francesc.soriguera@upc.edu >

*Tentative Schedule of Topics:*

| Date | Lec. | Prof. | TOPIC | Readings |
|---|---|---|---|---|
| 1/10 | 1 | FS | Introduction to the course. Traffic variables from trajectories. Edie's generalized definitions. Loop detectors. Discuss TRR 1232 vs 1591. Post GA#1. | 1, 2 |
| 8/10 | 2 | GSI | Discussion #1. Work on GA#1. | - |
| **15/10*** | 3 | FS | Bivariate relationships. Properties of the Fundamental Diagram. Problems when processing joint measurements. Estimating diagrams from data. Post GA#2. **GA#1 is due.** | 3 |
| 22/10 | 4 | GSI | Discussion #2. Work on GA#2. | - |
| **29/10*** | 5 | FS | N, T curves. Definitions. How to construct N, T curves. Oblique plot of N-Curves. Using N, T curves to diagnose traffic conditions. Identification of bottleneck location(s). Bottleneck capacity. Post GA#3. **GA#2 is due.** | 4, 5 (basics) 6 (application) |
| 5/11 | 6 | GSI | Discussion #3. Work on GA#3. | 7 |
| **12/11*** | 7 | FS | KWT Overview. Applying LWR to N-Curves. BOQ curve. Post GA#4. **GA#3 is due.** | 8 |
| 19/11 | 8 | GSI | Discussion #4. Work on GA#4. | - |
| **26/11*** | 9 | FS | CTM Overview. Regular segment. Merging CTM. Diverging CTM. Known turning ratios. Post GA#5. **GA#4 is due.** | 9, 10 |
| 3/12 | 10 | Guest | Traffic safety. In class activity. | - |
| 10/12 | 11 | GSI | Discussion #5. Work on GA#5. | - |
| **17/12*** | 12 | FS | Traffic simulation. Simulation levels. Review of available simulation software. General introduction to microsimulation and car-following models. In class activity. Hands on practice implementing the Gipps car-following mode in a spreadsheet. Car following dynamics demonstration and practical implications. Install Aimsun Next student version. Post GA#6. **GA#5 is due.** Computer Room D1-101. | 11, 12 |
| 7/01 | 13 | GSI | Introducing Aimsun Next simulation software. Showing the software basics, menus, panels, layers. Start introduction a network with node, links, centroids, and demand. Computer Room D1-101. | Aimsun tutorials |
| 14/01 | 14 | GSI | Tutorial on Aimsun Next microsimulation software. Showing incidents, calibration parameters, simulation randomness and view modes to produce outputs for a report. Training on Aimsun Next traffic simulation software. Solving students doubts when working on an academic assignment. Discussion #6. Work on GA#6. Computer Room B2-101. | Aimsun tutorials |
| **28/01*** | | | **GA#6 is due.** | |

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Department of Civil and Environmental Engineering

**Francesc Soriguera**
*Associate Professor*

Jordi Girona 1-3, Office B1-111
08034 Barcelona (Spain)
Tel. (+34) 93 401 72 66
< francesc.soriguera@upc.edu >

*Basic References:*

1. Hall, F. L. and B. N. Persaud. (1989). Evaluation of speed estimates made with single-detector data from freeway traffic management systems. *Transportation Research Record* 1232, 9-16.
2. Cassidy, M. J. and B. Coifman. (2007). Relation among average speed, flow and density and analogous relation between density and occupancy. *Transportation Research Record* 1591, 1-6.
3. Cassidy, M. J. (1998). Bivariate relations in nearly stationary highway traffic. *Transportation Research Part B* 32(1), 49-59.
4. Cassidy, M. J. and J. Windover. (1995). Methodology for assessing dynamics of freeway traffic flow. *Transportation Research Record* 1484, 73-79.
5. Muñoz, J. C. and C. F. Daganzo. (2000). Fingerprinting traffic from static freeway sensors. Unpublished.
6. Cassidy, M. J. and R. L. Bertini. (1999). Some traffic features at freeway bottlenecks. *Transportation Research Part B* 33(1), 25-42.
7. Cassidy, M. J. and M. Mauch. (2001). An observed traffic pattern in long freeway queues. *Transportation Research Part A* 35, 143-156.
8. Lawson, T.W., D.J. Lovell and C.F. Daganzo. (1997). Using the input–output diagram to determine the spatial and temporal extents of a queue upstream of a bottleneck. *Transportation Research Record* 1572, 140–147.
9. Daganzo, C. F. (1995). The cell transmission model. Part II: Network traffic. *Transportation Research Part B* 29(2), 79-93.
10. Daganzo, C. F. (Unknown). *Queuing of two conflicting traffic streams*. Unpublished notes from CE150. UC Berkeley.
11. Gipps, P. G. (1981). A Behavioural Car-Following Model for Computer Simulation. *Transportation Research Part B* 15(2), 105-111.
12. Milanés, V., S.E. Shladover, J. Spring, C. Nowakowski, H. Kawazoe and M. Nakamura. (2014). Cooperative adaptive cruise control in real traffic situations. *IEEE Transactions on Intelligent Transportation Systems*, 15(1), 296-305.
13. AIMSUN NEXT Tutorials: https://www.youtube.com/playlist?list=PLzpLQCnXvcIuGGBZhzPD7bLrHZxS6WSAc

*Additional References:*

– Cassidy, M.J. (1999). *Handbook of Transportation Science*. Chapter 6: Traffic Flow and Capacity. Springer.
– Daganzo, C.F. (1990). *Fundamentals of Transportation and Traffic Operations*. Prentice Hall.
– Homburger, W.S., J.W. Hall, W.R. Reilly and E.C. Sullivan. (2007). *Fundamentals of Traffic Engineering*. 16th Edition. Institute of Transportation Studies, University of California, Berkeley.
– Newell, G.F. (1982). *Applications of Queuing Theory*. Chapman & Hall.
– *Highway Capacity Manual*. (2000). Transportation Research Board. Washington D.C.
– May A.D. (1990). *Traffic Flow Fundamentals*. Prentice Hall.
– *Traffic Engineering Handbook*. 6th Edition (2009). Institute of Transportation Engineers. Washington D.C.
– Treiber, M., A. Kesting. (2013). *Traffic flow dynamics: data, models and simulation*. Springer Berlin, Heidelberg.
– Barceló, J. (2010). *Fundamentals of traffic simulation*. Springer New York, NY.