**Assignment Traffic Flow Theory and Simulaton**

"De Golfbreker" (The "Breakwater")

Wide moving jams are a well-known phenomenon in traffic flow operations. They are short jams, in which the density is very high (nearly jam density). They move in the opposite direction of traffic at a nearly fixed speed (between 15 km/h and 20 km/h).

Wide moving jams are generally, but not always, generated in so-called standing queues. In these high-density areas, small disturbances grow as they move upstream in through the traffic flow, eventually turning into a region in which the density is nearly the jam density.

In turns out that the outflow of a wide moving jam is up to 30% lower than the free capacity of a road. Wide moving jams thus cause a substantial reduction of the freeway efficiency.

In this assignment, we will investigate wide moving jams as well as ways to resolve them. This is done in the following steps:

1. Data analysis
2. Theoretical analysis and application of shockwave theory and macroscopic models
3. Micro-simulation
4. Assessment and re-design

**Requirements and grading**

You are expected to hand in a report not later than the day before the exam. The questions below form a good starting point for the report, but other relevant analyses are also possible and appreciated. The report should have an introduction and conclusions on your opinion on proposed solution(s), and thus consist of more than answers to the questions posed below. The report will be graded based on the following items:

| | Points |
|---|---|
| **Data analysis** | 20 |
| Data handling | |
| Problem analysis | |
| **Theoretical analysis** | 25 |
| Statics (Fundamental diagrams, cap drop etc.) | |
| Shock wave analysis - speeds, variability | |
| Application of shock wave theory | |
| Discussion of design | |
| **Simulation** | 20 |
| Argumentation on set-up and reproducability | |
| Description of situation | |
| **Assessment and redesign** | 20 |
| Impact clearly described | |
| Handling of random errors | |
| Conclusions on benefits | |
| **Report:** | 5 |

Organisation of the report (structure)
Conciseness of report
Clarity of figures (captions, references in text)
Language

In total 90 points can be obtained, giving a grade between 1 and 10. The report counts for 30% of the final grade. The report can be handed in by groups of 2-3 students, which will all receive the same grade for the report. Handing in the report after the deadline will lead to 5 point penalty on the grade for the report, handing it in more than a week late 10 points, handing it in more than 2 weeks late results in 20 points penalty.

**1. Data analysis (week 1)**
In the first week, data from the A1 freeway in the Netherlands will be analyzed. The picture below shows an overview of the site. To find the distances along the road, you may use Google maps or check autosnelwegen.net/a1.html.

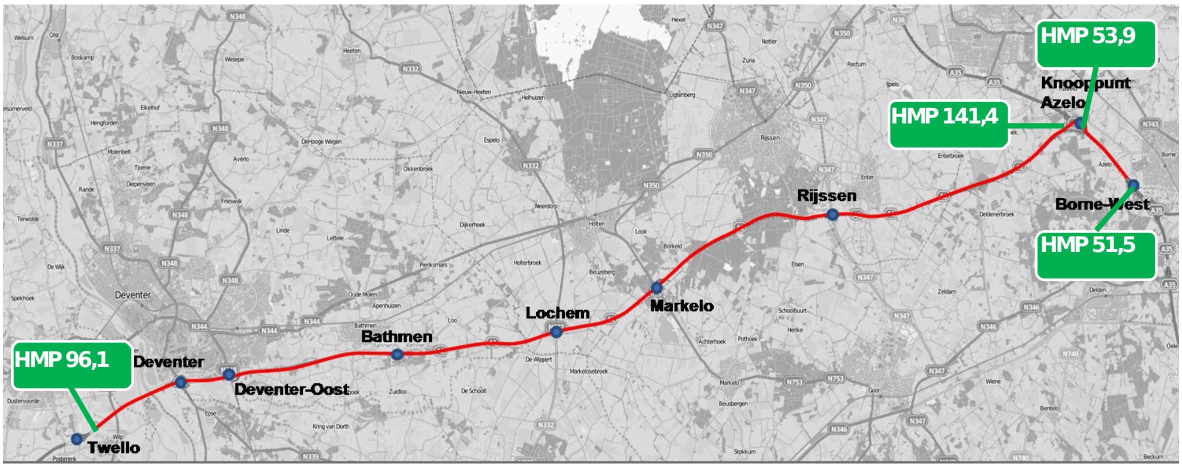

**Figure Overview of the A1 freeway section under consideration.**

On blackboard several so-called speed-contour plots are provided which show the traffic situation in March 2010.

a. Discuss what types of congestion you see and what the causes of the queues are (e.g. queues at on-ramps, queues due to incidents, etc.).

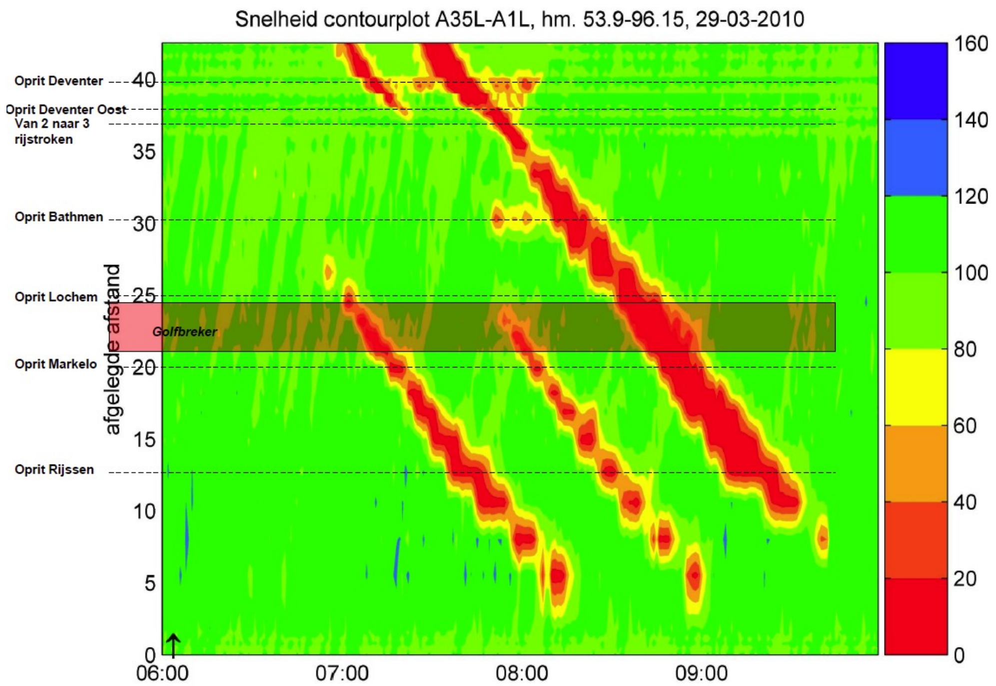

**Figure  Example of contour plot for (part of the) A1 section.**

b. Select one or more days (from the *March* dataset) in which wide-moving jams are clearly visible. Where do the wide moving jams originate from and what do you think is the main cause of the wide-moving jams?

Next, we focus on the wide moving jams. In particular, you are asked to investigate the main characteristics of the wide moving jams (in terms of delays, flows, etc.). To this end, you need to analyze these data. *The exercise can best be done using Matlab. Even students not familiar with Matlab can learn it on-the-fly, although the study load for the course will be exceeded in that case. Alternatively, Excel can be used.* On blackboard, also data files are provided, giving flows and speeds at detector locations. Notice that the March data is the data that you need to use for this exercise.

c. From the data, determine the flow downstream, in, and upstream of the wide-moving jam. Also determine the speed and the density at these locations. Interpret your findings.
d. What is the speed of the wide moving jam? What is the width of the wide-moving jam?
e. Determine the congestion characteristics (average travel time, average delay, average queue length, etc.).
f. What is the maximum flow in one minute in one lane? What average headway does that mean?

**2. Theoretical analysis (week 2 and 3)**
For the second week, consider the following:

g. Visualize the data in the flow-density plane and interpret the results. How does the capacity relate to the maximum flow in (f)
h. Identify the speed of the wide moving jam from the flow-density plots. How does this value compare to your findings under d?

i. What determines the speed of the wide-moving jam? To what extent does the traffic composition play a role (e.g. share of trucks) (*Hint: consider the microscopic derivation of the congestion branch of the fundamental diagram*).
j. What can you say about the free flow capacity, and the wide-moving-jam outflow?

The 'golfbreker' (breakwater or shock absorber) is a means to absorb the wide-moving jam. It provides additional storage capacity by means of an additional lane. Let us now consider the design of the shock absorber.

k. Use shockwave theory to explain the workings of the shock absorber. Will the shock absorber reduce travel time? Why?
l. Can you determine the required length of the shock absorber using shockwave theory? This will serve as your basic shock absorber design in the ensuing.

**3. Microscopic simulation (week 4 and 5)**
Let us now assess the design you came up with. To this end, FOSIM is used to simulate the freeway segment under consideration. A detailed reproduction of the situation may not be necessary, as long as the key characteristics of the situation are reproduced.

m. Set-up a simulation model to reproduce the phenomenon observed on the A1. In particular, assure that the wide moving jams are reproduced sufficiently accurate. Carefully describe and motivate your approach.

**4. Assessment and redesign (week 6 and 7)**
Finally, we use the simulation model to test the impact of the shock absorber.

n. Determine the impact of the shock observer in terms of delays and traffic patterns. What is the influence of different random seeds? Is this comparable with the observations?
o. Determine the sensitivity of your design for different truck shares, demand profiles, etc. How robust is your design?
p. Can you comment on the value of the shock absorber: what are the main benefits?

## Appendix: Data description

The two most important files are the files giving the data per time and detector location (DataComplete), and the file giving the detector position (BPScomplete). They give the data from 6-10 am aggregated per minute, yielding 301 measuring intervals. In the section of km 99-140 are 33 detectors. By the size, you can recognize the data formats.