# Impact of Traffic Dynamics on the Macroscopic Fundamental Diagram

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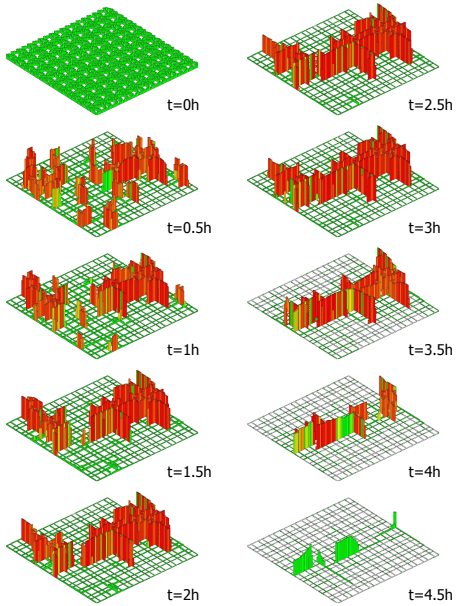
## Abstract

**The macroscopic fundamental diagram (MFD) relates the traffic production (average flow) in an area to the accumulation (average density), under the assumption of homogeneous traffic conditions. In real life, this assumption is not met. Using simulation we study the impact of inhomogeneous traffic conditions on the MFD, using a regular grid network. Due to inhomogeneous origins and destinations, traffic congestion occurs at some locations in the network, and then leads to more congestion. The points where congestion starts, are called *nucleation points*. Moreover, it is found that production is a continuous function of the accumulation (A) and the spatial spread of the density over the network (γ), expressed as the standard deviation of the densities at each location. This function is called the *generalised macroscopic fundamental diagram (GMFD)*.**

## Traffic states



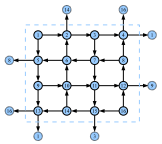

- Color indicates speed
- Height indicates density
- Traffic is initially distributed
- Near bottlenecks, traffic slows down
- This creates more congestion (*nucleation points*)

## Introduction

- Macroscopic Fundamental Diagram useful for area wide traffic description
- proven for "homogeneously congested areas"
- What is the influence of inhomogeneity?
- Expressed as standard deviation of density (γ)

## Periodic boundaries

- Traffic exiting the network at one side, re-enters at the opposite side



## Simulation

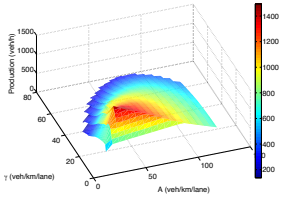
- 20 x 20 square grid network
- periodic boundaries
- 2 links per node
- 19 random destinations
- 1st order macroscopic traffic flow model (LWR)
- capacity restriction on node, no flow interruptions
- t=0-3h:
  redestination upon arrival => constant nr of vehicles
- t>3h: vehicles arrive

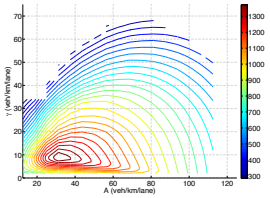
## Traffic dynamics and MFD

- Number of vehicles constant from t=0 to t=3
- Accumulation constant
- Inhomogeneity increases, production decreases
- Production is a decreasing function of inhomogeneity

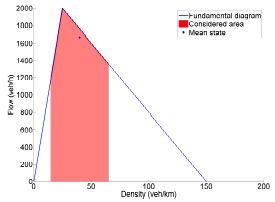
## Generalized Marcoscopic Fundamental Diagram

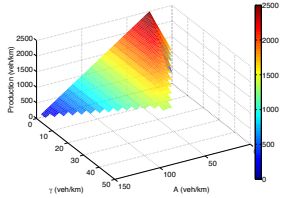
- Production is a *continuous* function of
  1) Accumulation
  2) Spatial inhomogeneity
- It increases and decreases with accumulation
- It decreases with inhomogeneity

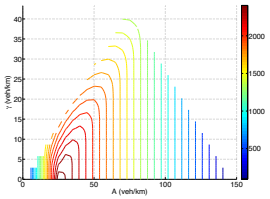



## Compared to random distribution of densities




**Methodology:**
- Select random states
- Uniform density
- Triangular FD

**Shape GMFD no interactions:**
- GMFD is less topped
- Variance less influence
- Variance less influence
- Isoproduction lines vertical

**Explanation:**
- In reality: traffic jams clustered
- More spread
- Production decreases more with variation in density

## Conclusions

The traffic state in an area can be described by two variables, the accumulation and the spatial variation of density; these can be related to the production by a Generalized Macroscopic Fundamental Diagram (GMFD). Traffic dynamics and in particular the way how traffic jams start, at the nucleation point, cause this relationship to differ from what is expected if random traffic states. The GMFD can be used in traffic state estimation or prediction, and hence for instance in optimal routing.

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