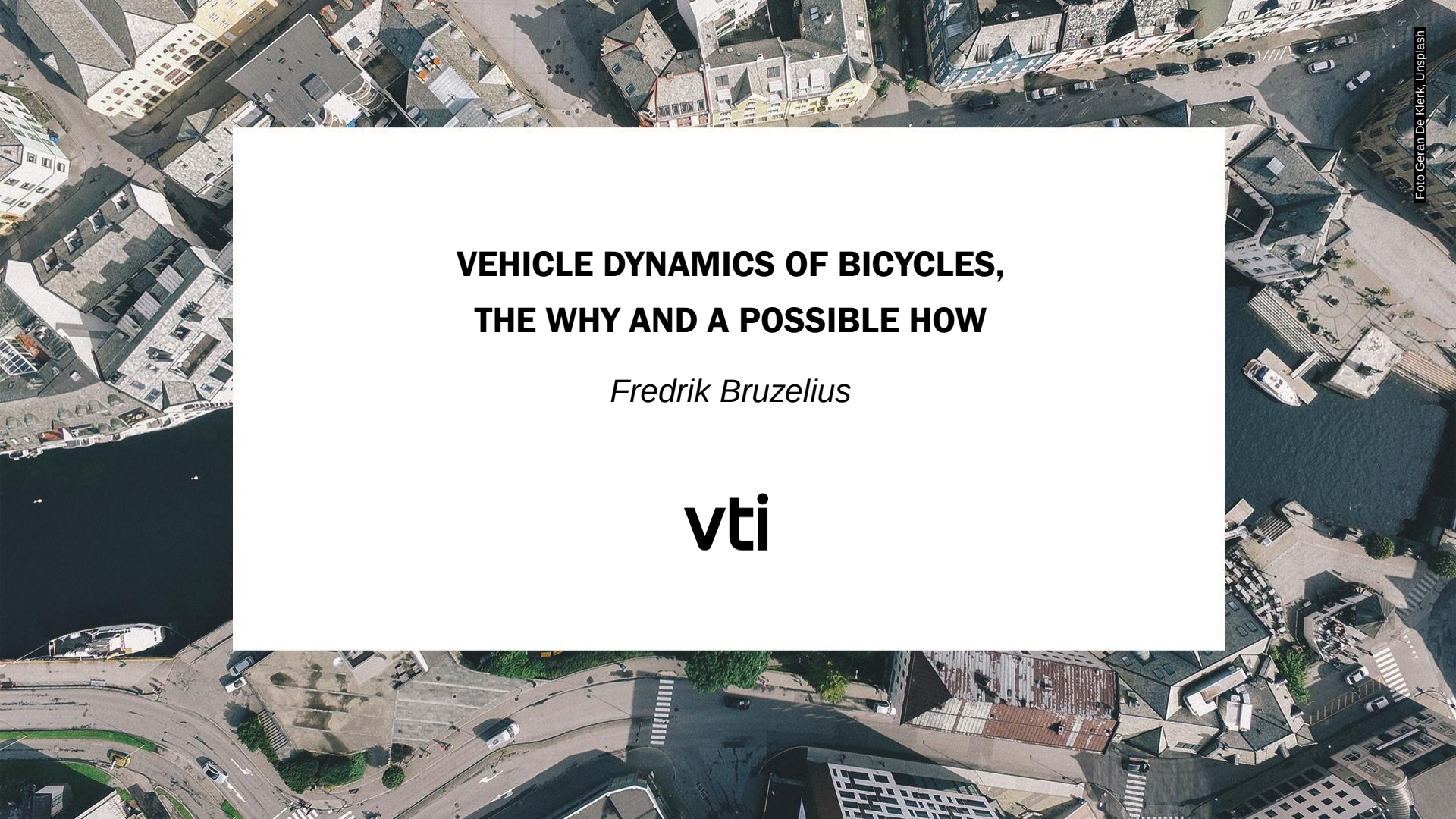

VEHICLE DYNAMICS OF BICYCLES, THE WHY AND A POSSIBLE HOW

Fredrik Bruzelius

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Foto Geran De Klerk, Unsplash

ABOUT ME

Major events

- 1974 Born and raised in Kristinehamn Värmland
- 1995, 1999, BSc in EE, MSc in Appl. Math
- 2004 PhD Control theory
- 2014 Docent in Vehicle dynamics at Chalmers

Employments

- 2004-2008 at Volvo Technology
- 2008- at VTI (Vehicle systems and Driving simulation
- 2014 - Adjunct professor at Chalmers

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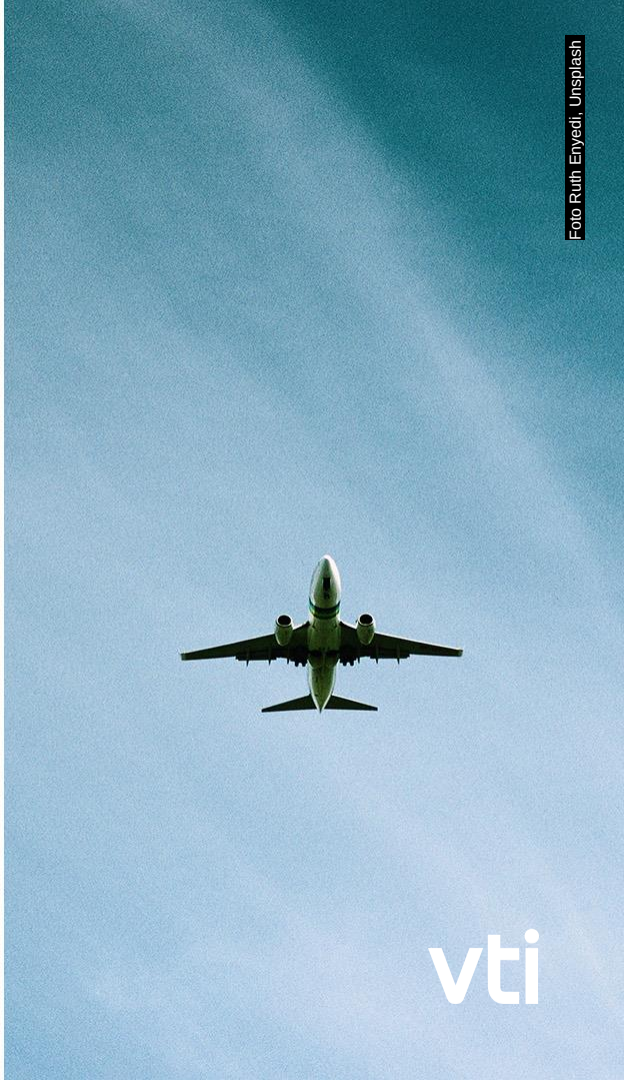
OUTLINE

- What is vehicle dynamics?
- Applications to bicycles
- With what can vehicle dynamics help with (traffic safety etc)
- A tool to approach bicycle dynamics research: the VTI bicycle simulator

VEHICLE DYNAMICS

- "***vehicle dynamics*** *is the study of how the vehicle will react to driver inputs on a given solid surface*"
- A combination of **deductive research** (classical mechanics, control engineering, tribology etc.) and **inductive research** (field measurements, statistics)
- Does *not* include the decision making of the driver



VEHICLE DYNAMICS ON BICYCLES

What is specific to a bicycle as a vehicle?

- Propelled by the rider
- 2 wheels aligned in the travel direction
    - Lean to account for the centripetal acceleration
    - Balance by the rider
- The rider to total weight ratio is of the order of 80-90% while for a car 2-4%

VEHICLE DYNAMICS ON BICYCLES

Example of research on bicycle dynamics

- Oscillations like wobble and weave
- Tyre dynamics
- Brake performance
- Mechanisms of balance

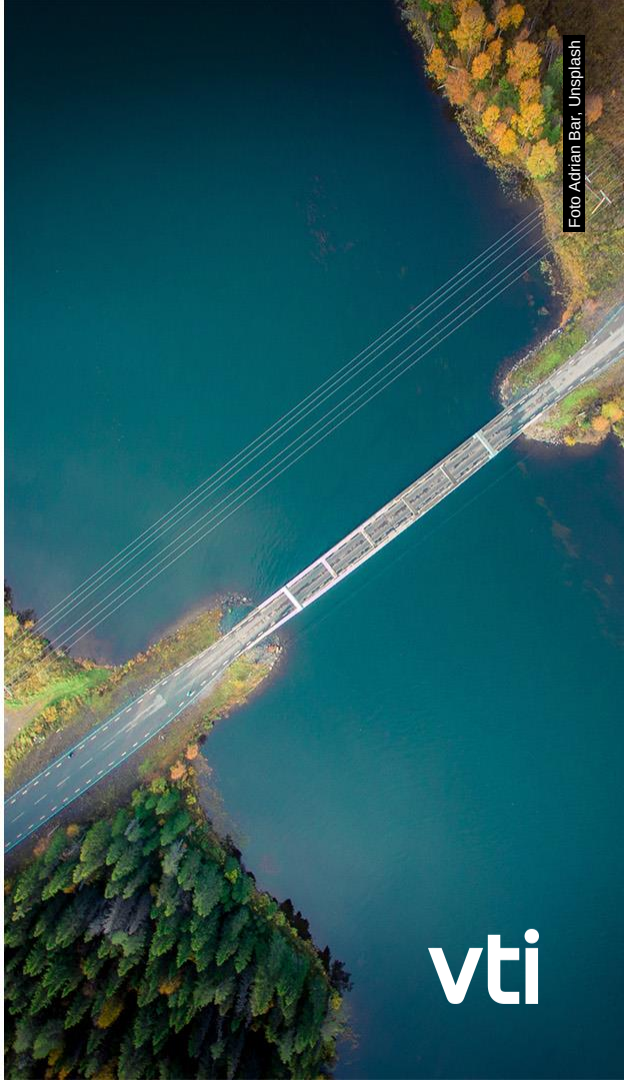
=> We need to include the rider into the analysis

IN TRAFFIC/TRANSPORT

Vehicle dynamics research on bicycles can be used to

- Design good bicycles (and define good)
- Set requirements on equipment (e.g. what kind of tires do I need, and what is the characteristics of importance)
- Set requirement on the road standard (e.g. how slippery is dangerous? Potholes, road geometry, etc etc)
- Basically anything related to the traffic situation with a dynamic course less than seconds (where the dynamics of the bicycle is essential)

=> The rider needs to be included here as well!



A TOOL: BICYCLE SIMULATOR

- A perfect tool to study the interaction dynamics between a (simulated) bicycle and a rider
- Main idea: Utilize the existing infrastructure provided by the SimIV driving simulator at VTI
- Develop as an additional “cabin”, next to the existing car and truck cabins
- Focus on the dynamics, i.e. the motion
- Make extensive use of the motion platform to simulate the response of the bicycle

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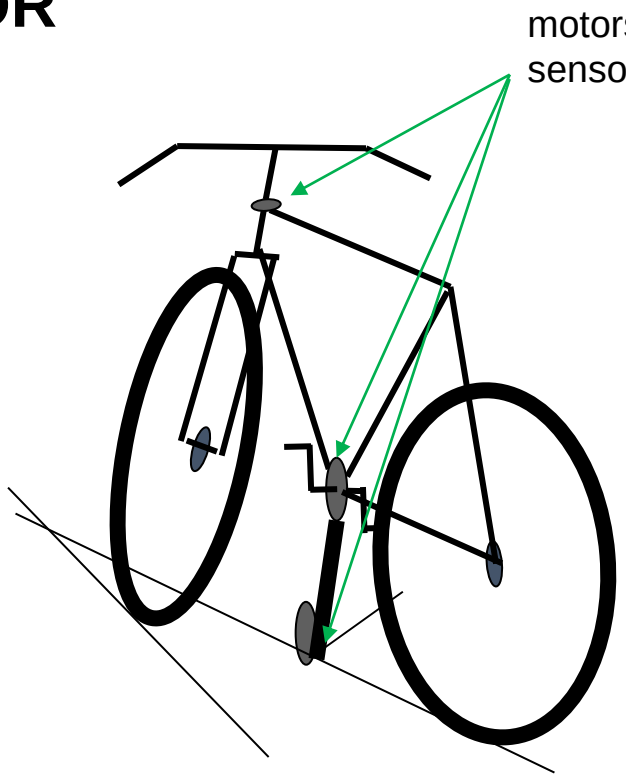
A TOOL: BICYCLE SIMULATOR

Simulate the interface to the rider:

- Handlebar torque and angle
- Pedal resistance and speed
- Roll angle and torque



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A TOOL: BICYCLE SIMULATOR

A first attempt

- Simulate balancing with straight riding
- Let the rider balance the bicycle against the simulator in a roll angle
- Move the platform sideways as the rider counter steer the fall to straight up

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A TOOL: BICYCLE SIMULATOR

We did it!

- My college managed to balance, I didn’t ☹
- Turned out that the latencies we have in our visual system was too high to be compensated for
- The latencies from steered angle to platform displacement makes the balancing task challenging

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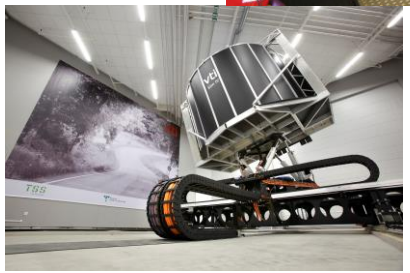
A TOOL: BICYCLE SIMULATOR

Current status and next steps

- The roll degree of freedom is now locked
- The simulator is used in studies where bicycle dynamics is of less importance
- Study motion cuing (with fixed roll degree), i.e. understand the perception of motion
- Chase the latencies (graphics & motion) to release the roll degree again



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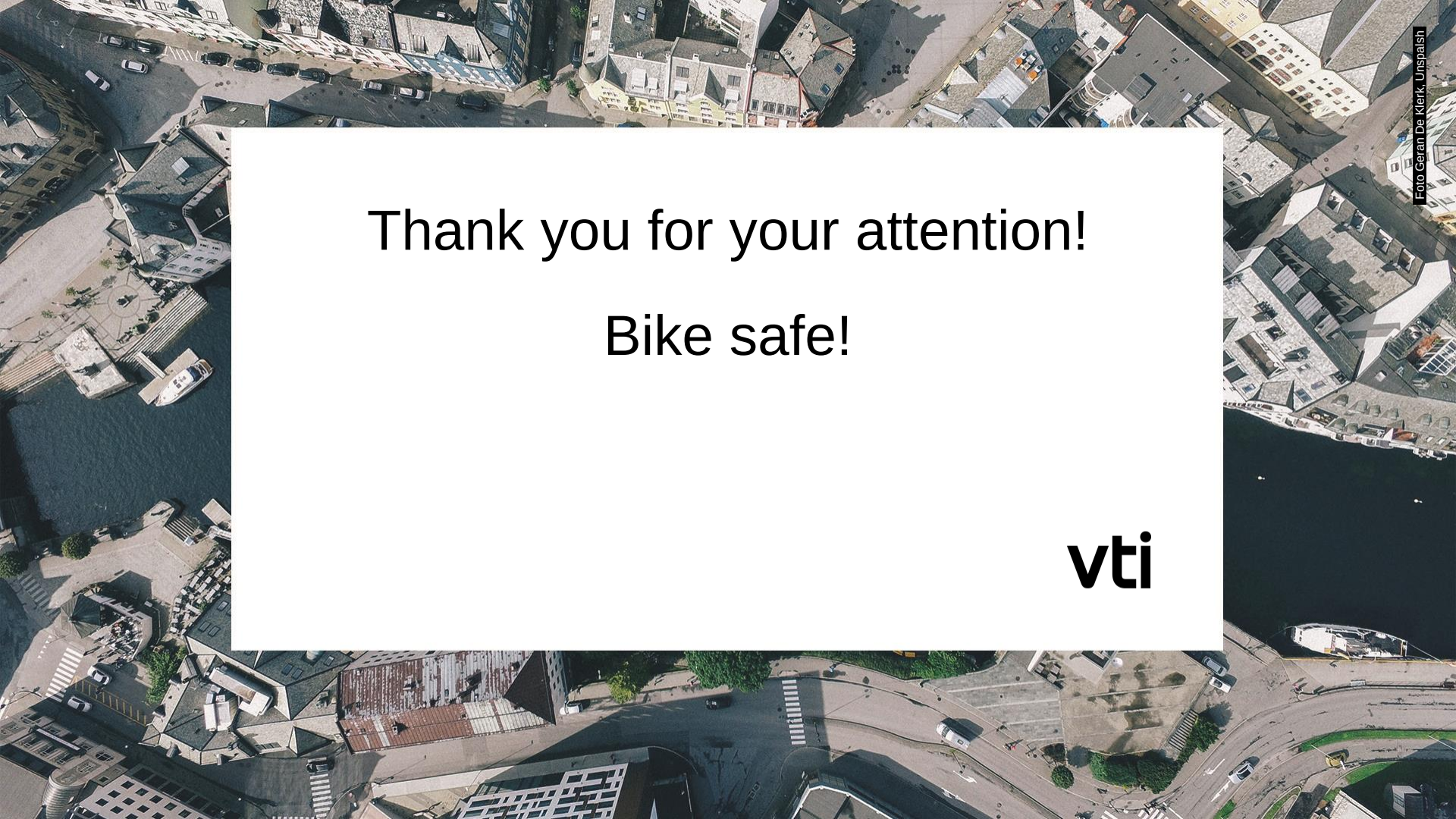

Thank you for your attention!

Bike safe!

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