KU LEUVEN

TECHNOLOGIECAMPUS GENT 2017

BIOMÉCANIQUE DE LA POSTURE ET DE L'ÉQUILIBRE

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Self-stability of City-(e-)bikes

1. INTRODUCTION

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INTRODUCTION

UNIVERSITY

KU LEUVEN

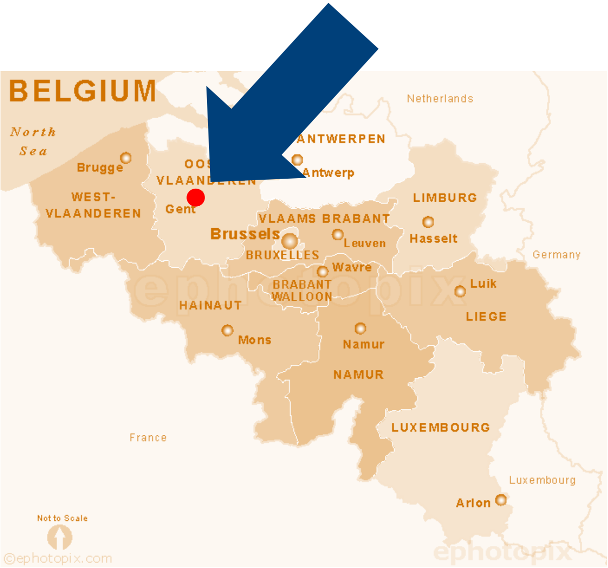
- Belgium, centrum of EC
- Most innovative university in Europe (Reuters ranking)
- 55.000 students – 134 nationalities
- 4600 PhD students
- Established in 1425 in Leuven
- Spread throughout Belgium

INTRODUCTION

CAMPUS

GHENT TECHNOLOGYCAMPUS

- Faculty of Engineering Technology
  - Mechanical Engineering
    - Technology for Logistics Group



RESEARCH

COMFORT AND SAFETY OF ELECTRICALLY POWER ASSISTED BICYCLES

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INTRODUCTION

TOPIC

- COMFORT AND SAFETY OF ELECTRICALLY POWER ASSISTED BICYCLES-

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- COMFORT AND SAFETY OF ELECTRICALLY POWER ASSISTED BICYCLES-

CHANGED MASS VALUES
- Stability
- Manoeuvrability
- Mental workload
- Safety

CHANGED PROPELLING POWER
- Physical workload
- Posture
- Comfort
- Efficiently

INTRODUCTION

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-COMFORT AND SAFETY OF ELECTRICALLY POWER ASSISTED BICYCLES-

CHANGED MASS VALUES

Stability

- Manoeuvrability
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CHANGED PROPELLING POWER

- Physical workload
- Posture
- Comfort
- Efficiently

RESEARCH QUESTION

DIFFERS THE STABILITY OF A CITY-E-BIKE FROM A CONVENTIONAL CITY-BIKE ?

WHICH CONFIGURATION IS THE MOST STABLE ?

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STABILITY-MODEL

DEFINITION *"Stability: a situation where no change will occur if there is no disturbance"*

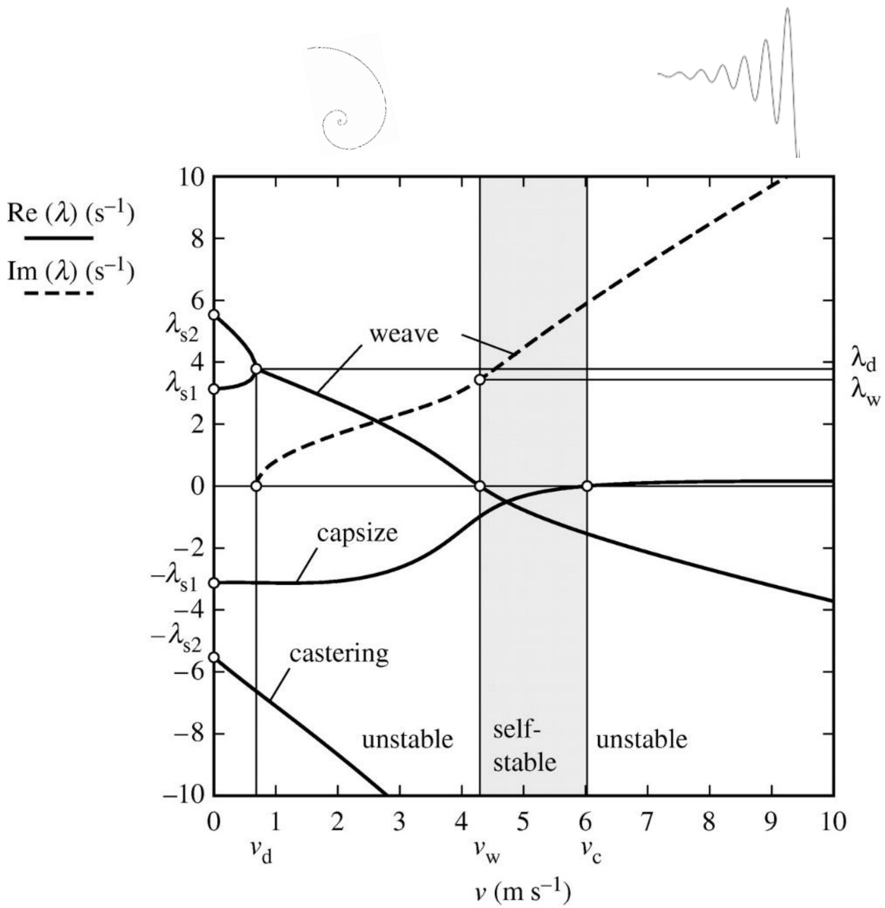
SELF-STABILITY

- Around 20 km/h
- Bicycle stabilizes itself
- Cyclist does not interfere

STABILITY-MODEL

VALIDATION

THEORETICAL SELF-STABILITY-MODEL BY CARVALLO AND WHIPPLE (1899)



$$\boldsymbol{M}\ddot{\boldsymbol{q}} + v\boldsymbol{C}_1\dot{\boldsymbol{q}} + [g\boldsymbol{K}_0 + v^2\boldsymbol{K}_2]\boldsymbol{q} = \boldsymbol{f},$$

g = *gravity constant*
v = *cycling speed*
q, f = *time-varying quantities*
***M*, C_1, K_0, K_2** = *matrices determined by bicycle design*

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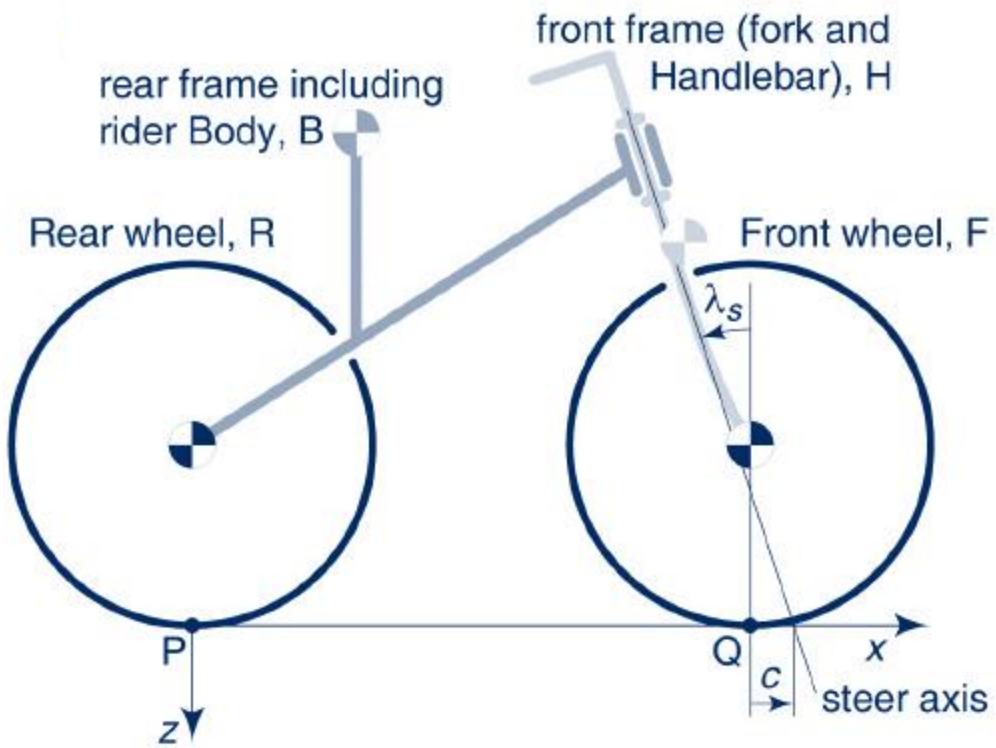
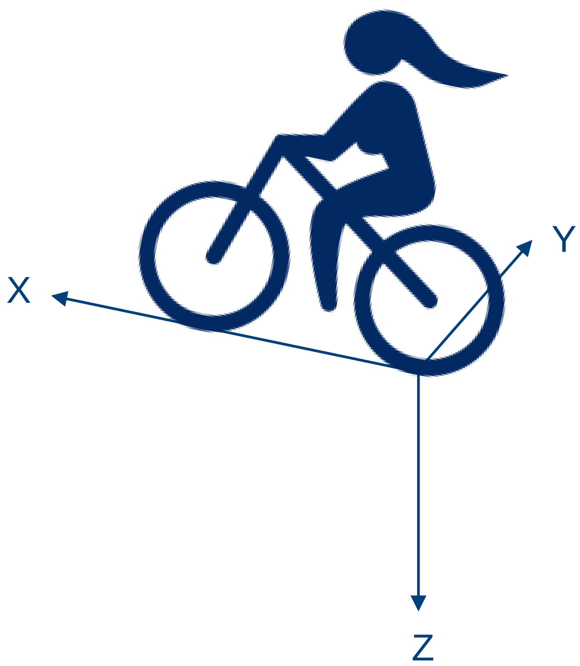
STABILITY-MODEL

STRUCTURE



STABILITY-MODEL

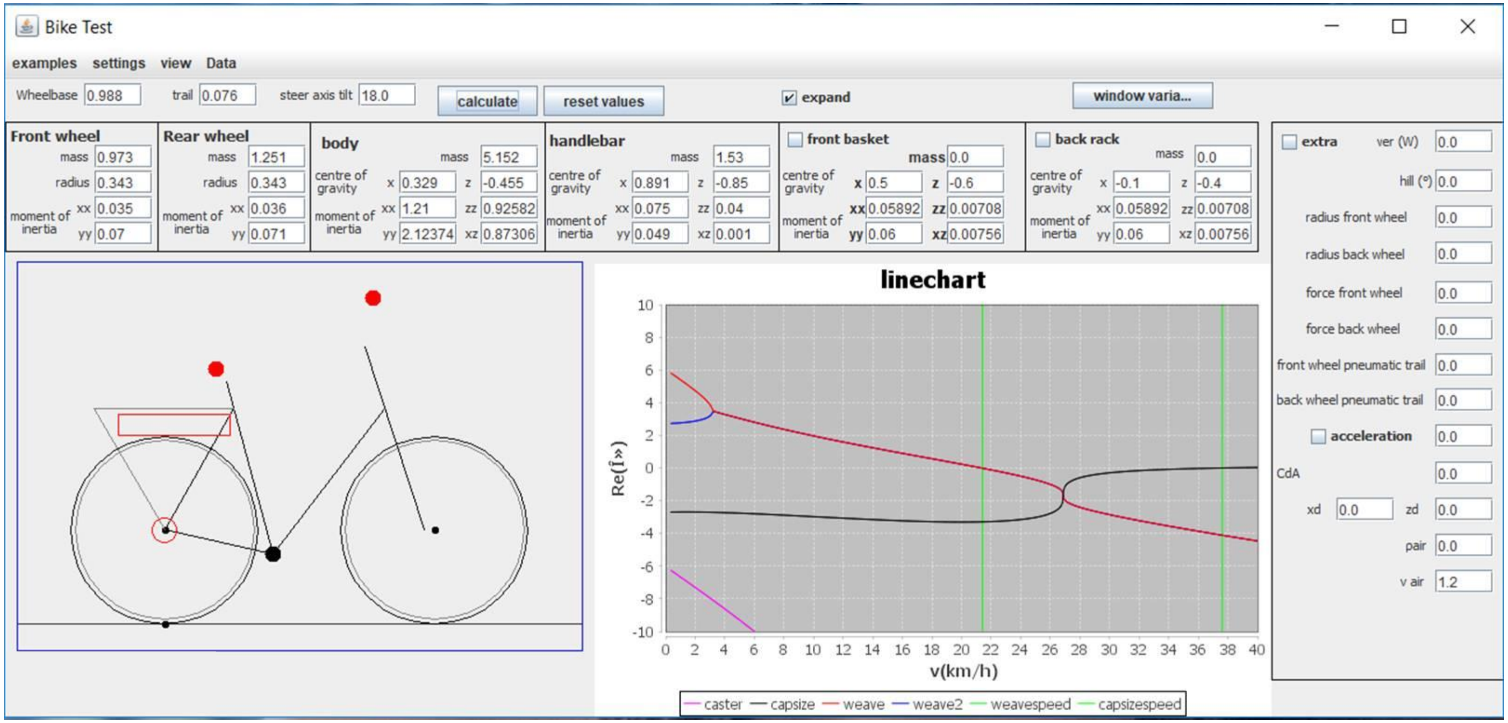
MASS VALUES



- DIMENSIONS [m]
- MASS [kg]
- CENTER OF MASS
  X, Y, Z [m]
- MASS MOMENT OF INERTIA
  XX, XZ,YY,ZZ [kg.m²]

STABILITY-PROGRAM

TOOLS



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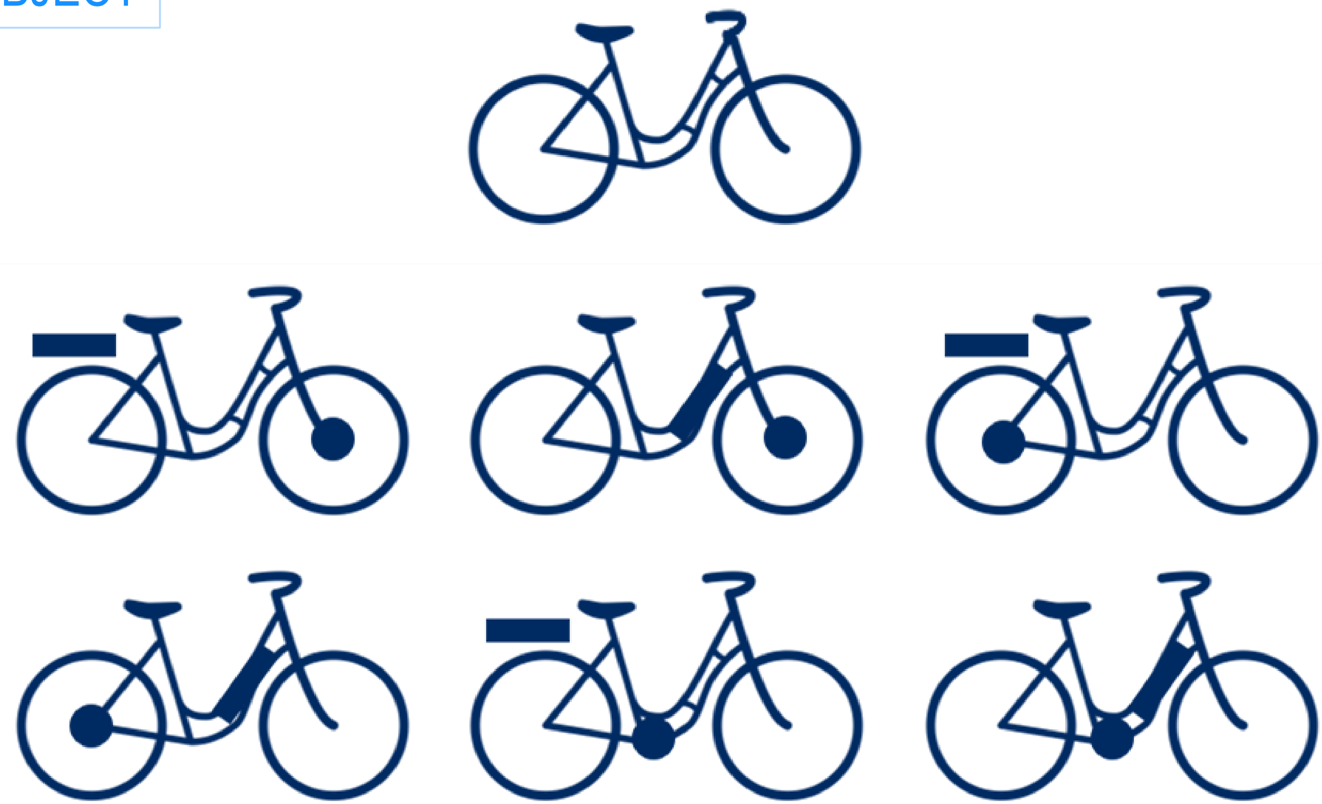
STABILITY-PROGRAM

SUBJECT



STABILITY-PROGRAM

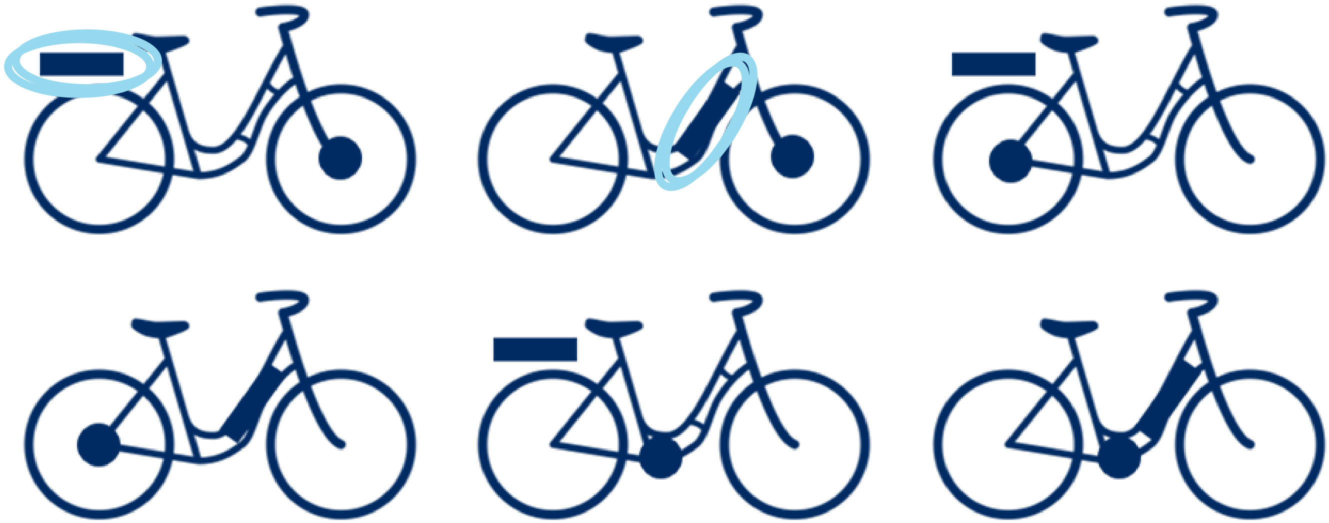
MOTOR-LOCATION

FRONT WHEEL: add mass values to front wheel
BOTTOM BRACKET: add mass values to rear frame
REAR WHEEL: add mass values to rear wheel

STABILITY-PROGRAM

BATTERY-LOCATION

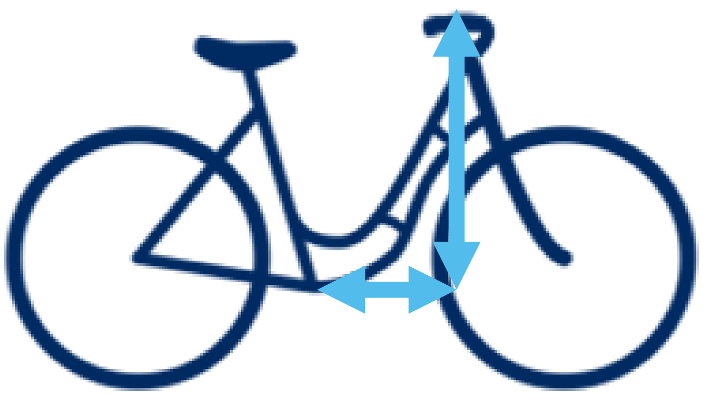
LUGGAGE RACK: add mass values to rear frame
LOWER MID-TUBE: add mass values to rear frame

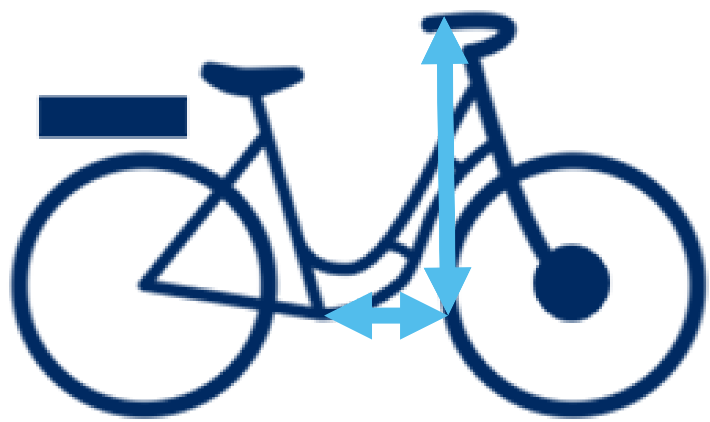


STABILITY-PROGRAM

CYCLER'S POSTURE

MORE PASSIVE POSTURE: add mass values to rear frame
MORE ACTIVE POSTURE: add mass values to rear frame





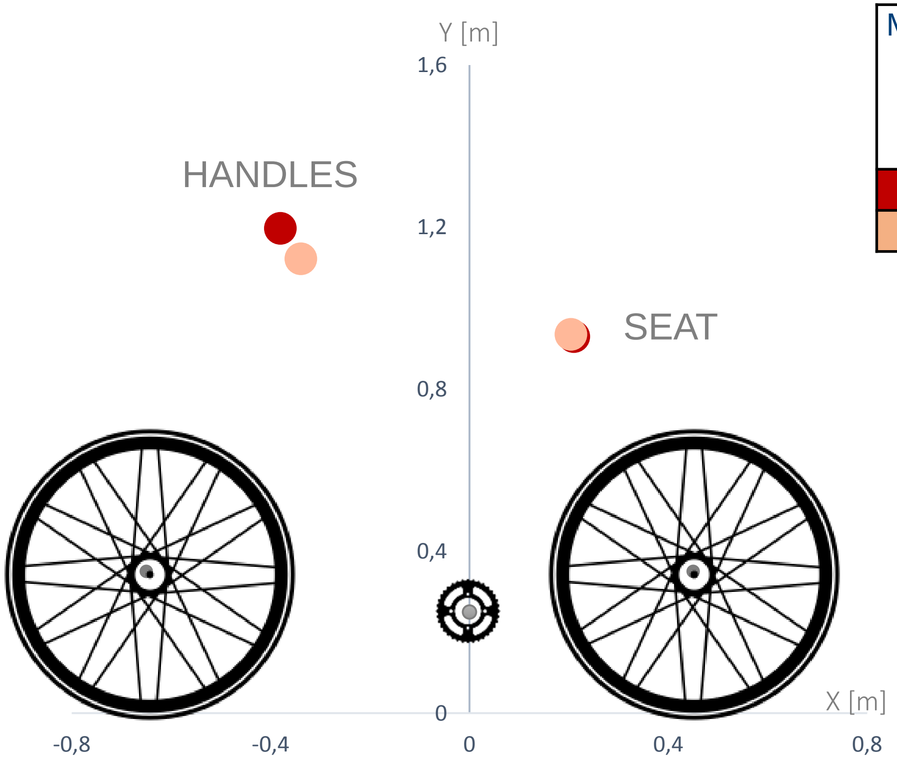
STABILITY-PROGRAM

CYCLER'S POSTURE

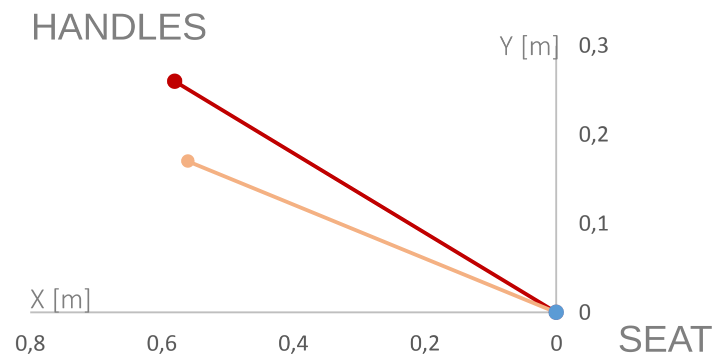
Measured 100 most popular city-(e-)bikes

STABILITY-PROGRAM

CYCLER'S POSTURE

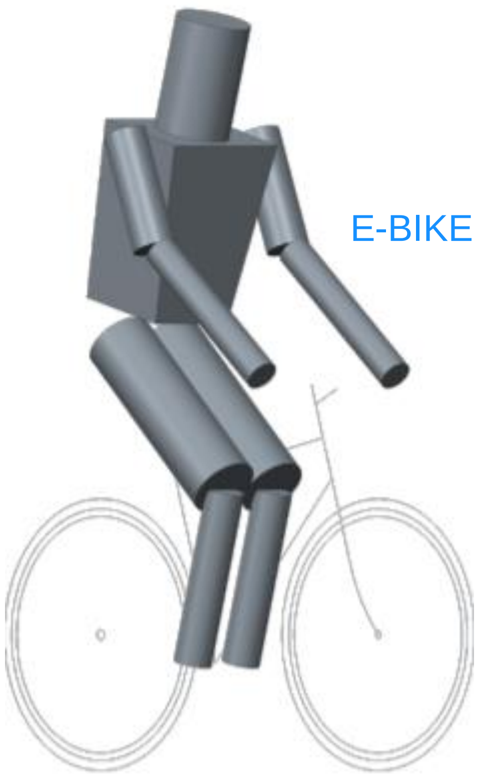


Mean distance [mm]		Seat to crank		Steer to crank		Mean Slope
		X-axis	Y-axis	X-axis	Y-axis	
(dark red)	Women's e-bike	212	682	374	935	0,44
(light orange)	Women's bicycle	214	689	350	858	0,31

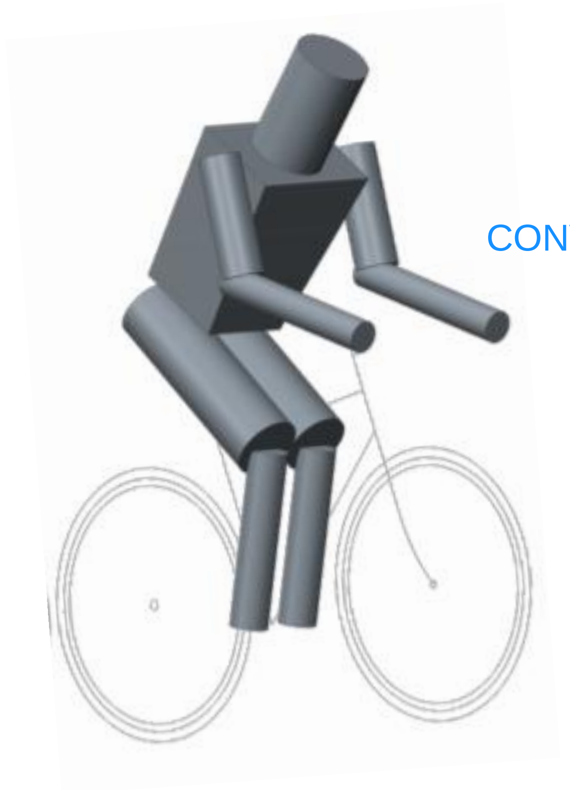


STABILITY-PROGRAM

CYCLER'S POSTURE



E-BIKE



CONVENTIONAL BIKE

Trevor Alan Wiliams
2015

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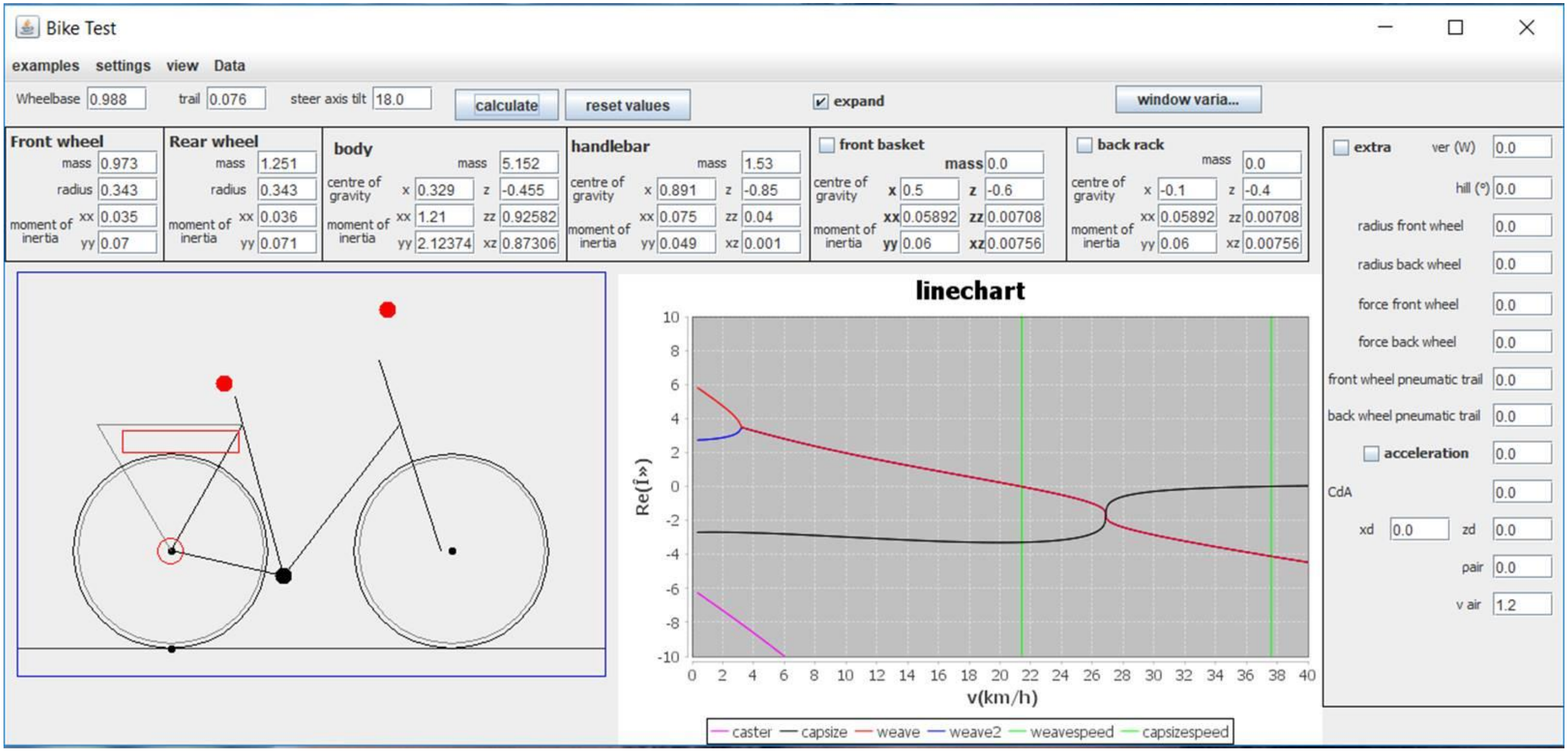
STABILITY-PROGRAM



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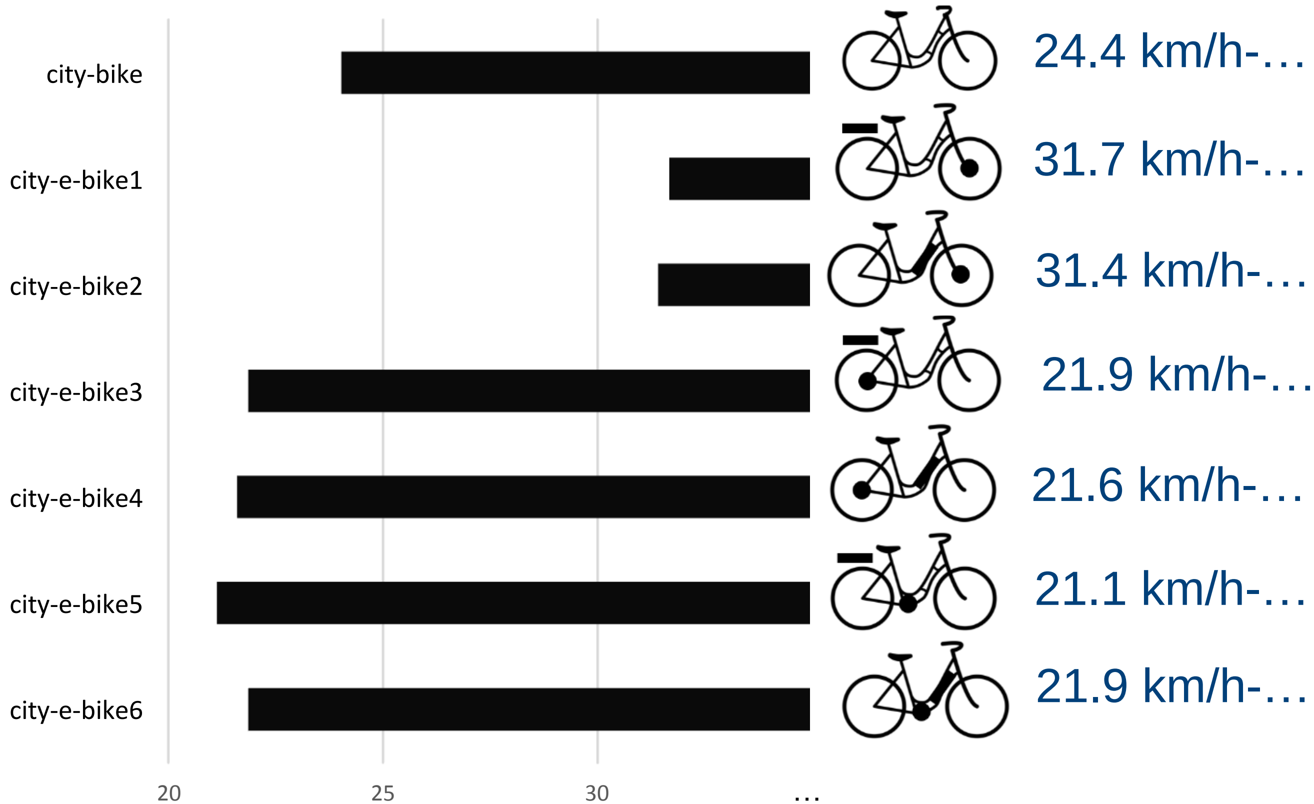
STABILITY-PROGRAM

COMPARISON

THEORETICAL SELF-STABLE RANGE



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POSSIBLE IMPROVEMENTS

MOTOR IN FRONT WHEEL
- Extract MMI of stator from front wheel
- Add MMI of stator to front frame

MOTOR IN REAR WHEEL
- Extract MMI of stator from rear wheel
- Add MMI of stator to rear frame

MOTOR IN BOTTOM BRACKET
- Take extra gyroscopically effect into account

NEGLIGIBLE FOR OUR COMPARISON

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FUTUR WORK

EXPERIMENTAL VALIDATION

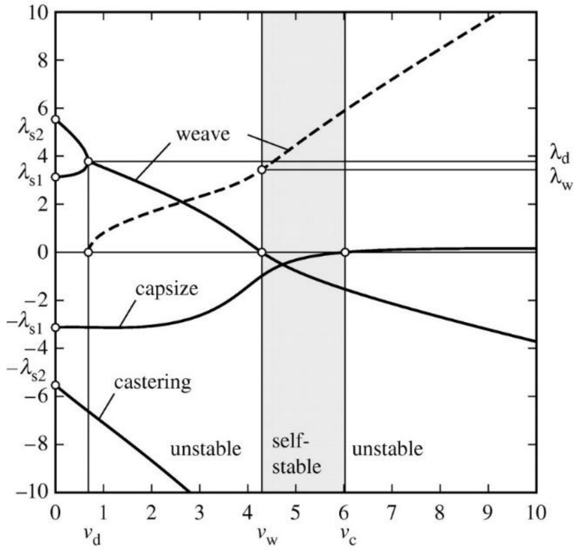
MEASURE:

- Forces and moments on steer, pedals and seat
- Steering angles
- Acceleration of steer and seat
- Speed
- Pedal and crank position

FUTUR WORK

EMPIRICAL IDEA

THEORETICAL MODEL



EXPERIMENTAL VALIDATION

END

Thank you for listening

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