

 **B**ICYCLE &
 **M**OTORCYCLE
2023 **D**YNAMICS



OCTOBER 18 - 20, 2023
DELFT, THE NETHERLANDS

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WELCOME PAGE

Welcome to the 5th Bicycle and Motorcycle Dynamics conference! The conference series began in 2010 here in Delft and we are pleased to have you all back 13 years later. Delft University of Technology has a long history of bicycle and motorcycle research. In the 1960s, the Man-Machine Systems group led by Henk G. Stassen pioneered research about the manual control of bicycles. A decade later, Hans B. Pacejka's Vehicle Engineering Group began developing advanced single track vehicle dynamics models that ultimately powered the robotically stabilized motorcycle ASMO in the late 1980s. In the 1990s, the group performed extensive motorcycle tire testing. In the 2000s, Arend Schwab started the Bicycle Dynamics Lab and strengthened bicycle dynamics research around the world with fundamental papers on bicycle dynamics. Today, the University has a broad range of bicycle related research that spans multiple faculties. This research is supported by The Netherlands, the best country in the world for bicycling. About 30% of trips are by bike thanks to the prioritization the Dutch government puts on cycling infrastructure and the citizens' desire for this simple means of travel. Electric bikes have now taken the country by storm and the merger of bicycle and motorcycle technologies are defining today's innovations. We believe we have assembled a program that highlights the latest topics in the field. We hope you agree. Thank you all for the contributions that make such an event possible.

Sincerely,

The BMD 2023 Organizing Committee:

Jason K. Moore, Andrew Dressel, Leila Alizadehsaravi, and Edwin de Vries



CONFERENCE COMMITTEES

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KEYNOTE SPEAKERS



AREND SCHWAB

Emeritus, Delft University of Technology

Bicycle Dynamics and Control: A 'Sleeping Beauty'



ICHIRO KAGEYAMA

Emeritus, Nihon University

The History of Two-wheeled Vehicle Dynamics in Japan and Subsequent Trends

SOCIAL EVENTS

TUESDAY October 17

Tuesday Drinks

17:30 - 20:30

Bierfabriek Delft

Burgwal 45-49, 2611 GC Delft

We will have an informal meetup for workshop attendees, early arrivers, and locals the evening before the start of the conference at the Bierfabriek Delft.

Drinks and food will be available for purchase in the reserved back area of the establishment and are not covered by your conference registration fee.

WEDNESDAY October 18

Bike Rodeo and Borrel

17:00 - 20:00

TU Delft X Cafe and Patio

On the evening of Wednesday we will host a welcome borrel (drinks and appetizers) alongside a "Bike Rodeo." At the bike rodeo you will be able to test drive an assortment of innovative bicycles, e-bikes, scooters, motorcycles, tricycles, etc.

The borrel and rodeo will be included as part of your conference registration fee.

THURSDAY October 19

Thursday Dinner

18:00 - 22:00

Cafe & Restaurant De Waag Delft

Markt 11, 2611 GP Delft

We will host a dinner for conference participants the evening of Thursday the 19th.

This dinner will be included with your conference registration fee if you registered by 5 October.

FRIDAY October 20

Delft Bicycle and Walk Tour

If you registered, please indicate your choice for walking or biking at the registration desk. Spots are first come, first served.

We are delighted to offer you the possibility to choose between a bicycle or a walking tour of Delft.

Bike Tour (15:00 - 16:45)

Start: X (Bldg 37)

Experienced guides will give you a look into the Dutch bicycle transportation design and its features (*50 slots available, bicycles provided*).

Walking Tour (15:30 - 17:00)

Start: Architecture Faculty (Bldg 8)

Local guides will take you through the city center and tell you about this beautiful Dutch town (*60 slots available*).

TUESDAY OCTOBER 17

Simulator Workshop

SCHEDULE AT A GLANCE

1230 - 1300	Registration (IDE, Building 32 - Hall T/Room A-1-020)
1300 - 1305	Welcome (IDE, Building 32 - Hall T/Room A-1-020)
1305 - 1415	Motorcycle Simulators: Realism and Validation
1415 - 1425	Break
1425 - 1535	Simulator Sickness and VR Realism
1535 - 1545	Break
1545 - 1655	Realism of Physical Interaction and Validation
1655 - 1700	Closing Words
1730 - 2030	Drinks at Bierfabriek Delft

TUESDAY OCTOBER 17

Simulator Workshop

DETAILED SCHEDULE

Opening

IDE, Building 32 Hall T/Room A-1-020 (Joost van der Grinten)

1300 **Welcome:** Linda van der Spaa, Tim Reuscher, Rinder Happee

Motorcycle Simulators: Realism and Validation

1305 **W01: The DESMORI Simulator – Review of its First Decade**
R. Pleß, S. Will, N. L. Merkel

1320 **W02: Exploring Different Ways of Simulating Steering for Motorcycles**
C. Bäverstrand

1335 **W03: An Adaptive Motorcycle driving Simulator to Enhance Motorcycle Ergonomics**
D. Wildner, F. Diermeyer

1350 **Discussion**

1415 **Break**

Simulator Sickness and VR Realism

1425 **W04: The UniBW M Bike-Riding Simulator for Traffic Safety Research**
A. Huemer, T. Stemmler, S. Hoffmann

1440 **W05: Design Recommendations for Motion-Based Bicycle Simulators**
Y. Wang, S. Dorfbauer, L. van der Spaa, F. Michahelles, P. Wintersberger

1455 **W06: Experiences with Training and Study Design Mechanisms Utilizing the DLR Bike Simulator**
K. Gröne, D. Martinez Garcia, M. Fischer

1510 **Discussion**

TUESDAY OCTOBER 17

Simulator Workshop

DETAILED SCHEDULE (cont.)

1535 **Break**

Realism of Physical Interaction and Validation

1545 **W07: Comparing a Virtual Reality Bicycle Simulator to Real-World Cycling Behavior**
*F. S. Bayer, A. Aizenman, A. Schroeger, H. Heidari-Gorji,
K. R. Gegenfurtner*

1600 **W08: Real-Feel Rollers: A Rollers-Based Bicycle Simulator Requiring Realistic Steering Input for Balance Control**
E. Maris

1615 **W09: Development of the Rider-Balanced Fytssimulator**
*L. van der Spaa, C. Kohler, B. Sporrel, A. Stuiver, D. de Waard,
H. Vallery, A. Schwab, R. Happee*

1630 **Discussion**

Closing

1655 **Closing Words:** Linda van der Spaa, Tim Reuscher, Rinder Happee

1730 **Drinks at Bierfabriek Delft (Burgwal 45-49)**

WEDNESDAY OCTOBER 18

Conference Day 1

SCHEDULE AT A GLANCE

0800 - 0900	Registration & Coffee (X Entrance & Foyer)
0900 - 0920	Welcome (X Theatre Hall)
0920 - 1020	Component Evaluation (X Theatre Hall)
1020 - 1040	Coffee Break (X Foyer)
1040 - 1200	Robot Bicycles and Motorcycles (X Theatre Hall)
1200 - 1300	Lunch (X Foyer)
1300 - 1420	Longitudinal Dynamics and Braking (X Theatre Hall)
1420 - 1450	Coffee Break (X Foyer)
1450 - 1610	Transportation (X Theatre Hall)
1610 - 1650	Unicycles and Wheelchairs (X Theatre Hall)
1700 - 1900	Borrel and Bike Rodeo (X Cafe & Patio)

DETAILED SCHEDULE

Opening

X Theatre Hall

0900 **Welcome:** Jason K. Moore and Frans van der Helm

Component Evaluation

X Theatre Hall, Chair: Edwin de Vries

0920 **O01: Identification and Modeling of a Mountain Bike Front Suspension Subsystem Equipped with a Telescopic Fork and Tire Damping**

N. Schoeneck, J. Sadauckas, M. Nagurka

0940 **O02: Improvement of Cycling Efficiency for Drivetrains with Elasticity**

W. den Boer

1000 **O03: Bicycle fork longitudinal vibrations induced by front braking**

M. Formentini, E. Giolo, E. Marconi, A. Rovarin

1020 **Coffee Break - X Foyer**

Robot Bicycles and Motorcycles

X Theatre Hall, Chair: Leila Alizadehsaravi

1040 **O04: Balancing Standstill Motorcycles by Steering Control with Feedback Delay**

H. Zsofia Horvath, D. Takacs

1100 **O05: On the Development of a Path Tracking Controller by combining Optimal Preview Control and Pursuit Control Methods**

D. Gabriel, D. Baumgärtner, D. Görges

1120 **O06: A self-stable remote control bicycle design and implementation as a teaching project**

Á. Varela, P. Rubial, E. Sobrino, U. LUGRÍS, E. Sanjurjo

1140 **O07: Using a steer-into-the-fall based control law to stabilize a pedelec**

Y. Hanakam, J. Wrede, M. Pfeiffer, S. Hillenbrand

WEDNESDAY OCTOBER 18

Conference Day 1

DETAILED SCHEDULE (cont.)

1200 Lunch - X Foyer

Longitudinal Dynamics and Braking

X Theatre Hall, Chair: Roberto Lot

1300 **O08: Instrumented Bicycle for Experimental Investigation of Braking Dynamics including Front Brake induced Rear Wheel Lift Up**

J. Skatulla, O. Maier, S. Schmidt

1320 **O09: Development of a Hardware-in-the-Loop Test Bench for Validation of an ABS System on an e-Bike**

N. Ramosaj, C. Fusco, E. Viennet

1340 **O10: Enhanced Braking of E-Scooters**

F. Klinger, J. Edelmann, M. Plöchl

1400 **O11: A Review on Test Method Development for Motorcycle Autonomous Emergency Braking Systems**

N. L. Merkel

1420 Coffee Break - X Foyer

Transportation

X Theatre Hall, Chair: Heather Kathis

1450 **O12: Essential Bicycle Dynamics for Microscopic Traffic Simulation: An Example Using the Social Force Model**

C. M. Schmidt, A. Dabiri, F. Schulte, R. Happee, J. K. Moore

1510 **O13: Investigation of the Applicability of a Motorcyclist Model for Trajectory Prediction in Real Traffic**

F. Scherer, M. Eschinger

1530 **O14: Trajectory Prediction for Powered Two Wheelers with Deep Learning**

K. Ludwig Stolle, A. Wahl, S. Schmidt

DETAILED SCHEDULE (cont.)

Transportation (cont.)

X Theatre Hall, Chair: Heather Kathis

- 1550** **O15: A mobile recording system featuring high-precision time synchronization**
T. Sone, T. Maeda, T. Kitani

Unicycles and Wheelchairs

X Theatre Hall, Chair: Stephen Cain

- 1610** **O16: Data Collection for Learning the Dynamics and Control of an Electric Unicycle**
L. Mihályi, X. A. Ji, G. Orosz, D. Takács

- 1630** **O17: Dynamics of a Manual Wheelchair and User During Propulsion**
*K. Pinnock Branford, M. G. Van Straaten, O. Jahanian,
M. M. B. Morrow, S. M. Cain*

- 1700** **Borrel and Bike Rodeo - X Cafe and Patio**

THURSDAY OCTOBER 19

Conference Day 2

SCHEDULE AT A GLANCE

0800 - 0900	Registration & Coffee (X Entrance & Foyer)
0900 - 0940	Keynote, Arend Schwab (X Theatre Hall)
0940 - 1040	Coffee and Poster Session 1 (X Dance Halls A & B)
1040 - 1200	Human Factors (X Theatre Hall)
1200 - 1300	Lunch (X Foyer)
1200 - 1300	Conference Committee Lunch Meeting (X Photo Studio Room)
1300 - 1440	Tires (X Theatre Hall)
1440 - 1600	Coffee and Poster Session 2 (X Dance Halls A & B)
1600 - 1700	Handling (X Theatre Hall)
1800 - 2200	Dinner (Cafe & Restaurant De Waag)

DETAILED SCHEDULE

Keynote

X Theatre Hall

0900 **K01: Bicycle Dynamics and Control: A 'Sleeping Beauty'**
Arend L. Schwab

Coffee and Poster Session 1

X Dance Halls A & B

0940 **P01: A bicycle can be balanced by stochastic optimal feedback control but only with accurate speed estimates**
E. Maris

P02: Position Measuring System for a Motorcycle Using Quad Omnidirectional Cameras
J. Hirasawa

P03: OMS: a software package for the minimum-time optimal-control simulation of motorcycles
E. Marconi, M. Formentini, E. Giolo

P04: Bicycle handling quality perception: mixed effect of stability and manoeuvrability
J. Ronné, L. Dubuis, T. Robert

P05: Motion Cueing utilizing gravity
C. Bäverstrand

P06: Modelling Braking and Steering Avoidance Maneuvers for Micromobility
T. Li, F. Bruzelius, M. Dozza

P07: Evaluating the handling of a tilting tricycle with variable stability
F. van Willigen, A. Dressel, J. K. Moore

THURSDAY OCTOBER 19

Conference Day 2

DETAILED SCHEDULE (cont.)

Coffee and Poster Session 1 (cont.)

X Dance Halls A & B

P09: Simulator validation – a new methodological approach applied to motorcycle riding simulators

S. Will, T. Hammer, R. Pleß, N. L. Merkel, A. Neukum

Human Factors

X Dance Halls A & B, Chair: Alejandra Polanco

1040 O18: Experimental assessment of the effect of cyclist's posture on comfort during time-trial events on road cycling

A. Polanco, D. Suarez, A. Doria, L. Munoz

1100 O19: Evaluation of Lane Change Maneuvers on a Dynamic Motorcycle Riding Simulator Utilizing a Rider Leaning Input

R. Pleß

1120 O20: Can a bicycle be balanced using an optimal feedback control mechanism that ignores the sensorimotor delay?

G. Sdoukopoulou, E. Maris

1140 O21: Planar Dynamics of a Motorcycle: Parameter Sensitivity of Ride Comfort to Engine Mounting System Nonlinearities

S. Kaul

1200 Lunch - X Foyer

Conference Committee Lunch Meeting - X Photo Studio Room

DETAILED SCHEDULE (cont.)

Tires

X Theatre Hall, Chair: Andrew Dressel

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| 1300 | O22: Theoretical and experimental findings for an tyre-road friction potential estimator for motorcycles
<i>C. Ott, F. Klinger, J. Edelmann, J. Plöchl</i> |
| 1320 | O23: Indoor measurement of the lateral characteristics of a cargo bicycle tyre
<i>G. Dell'Orto, F. M. Ballo, G. Mastinu,, R. Happee, J.K. Moore</i> |
| 1340 | O24: Thermal model for bicycle tire internal temperature evaluation in various contact conditions
<i>F. Farroni, G. Napolitano Dell'Annunziata, M. Ruffini, G. Dell'Orto, G. Mastinu</i> |
| 1400 | O25: Radial Stiffness and Damping of Mountain Bike Tires Subject to Impact Determined Using the Coefficient of Restitution
<i>J. Sadauckas, N. Schoeneck, M. Nagurka</i> |
| 1420 | O26: Measuring vertical tyre stiffness of bicycle tyres
<i>M. Rothhämel</i> |

Coffee and Poster Session 2

X Dance Halls A & B

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|------|---|
| 1440 | P10: A Vector-Loop Analysis Approach to Kinematics of Bicycle Steering Geometry
<i>A. Suresh, M. Barath, A. do Rego</i> |
| | P11: A Study of Suspension Geometry for Personal Mobility Vehicles (PMVs) with Inward Tilt Mechanism
<i>T. Haraguchi, T. Kaneko</i> |
| | P12: Analysis of stopping behaviour of cyclists at a traffic light controlled intersection using trajectory data
<i>C. Leschik, M. Zhang, K. Gimm</i> |

THURSDAY OCTOBER 19

Conference Day 2

DETAILED SCHEDULE (cont.)

Coffee and Poster Session 2 (cont.)

X Dance Halls A & B

P13: Analytical expression to calculate the suspension sag of vehicles

F. Vasquez

P14: Application of tire multiphysical modeling methodologies for the preliminary definition of a racing motorcycle setup

M. Ruffini, F. Alberti, D. D'Andrea, F. Farroni, G. Napolitano Dell'Annunziata, G. Risitano, D. Milone

P15: Experimental Identification of the Lateral Dynamics of a Steering-assisted Two-wheeled Vehicle

S. Lovato, M. Massaro, R. Lot

P16: Modeling and Implementation of a Reaction Wheel Stabilization System for Low Speed Balance of a Cargo Bicycle

J. K. Moore, J. Koshy Cherian, B. Andersson, O. Lee, A. Ranheim

Handling

X Theatre Hall, Chair: Thomas Robert

1600 O27: Experimental assessment of SST evaluation as handling quality indicator

J. Ronné, L. Dubuis, T. Robert

1620 O28: Adapting a variable stability mechanism for a tilting tricycle from the delta to the tadpole wheel configuration

A. Dressel, J.K. Moore

1640 O29: Objective evaluation of handling and stability of a bicycle

M. Keyser, E. Marconi, M. Formentini, E. Giolo

1800 Dinner - Cafe & Restaurant De Waag

FRIDAY OCTOBER 20

Conference Day 3

SCHEDULE AT A GLANCE

0800 - 0900	Registration & Coffee (X Entrance & Foyer)
0900 - 0940	Keynote, Ichiro Kageyama (X Theatre Hall)
0940 - 1040	Coffee and Poster Session 3 (X Dance Halls A & B)
1040 - 1200	Simulation (X Theatre Hall)
1200 - 1300	Lunch (X Foyer)
1300 - 1420	Vehicle Modeling (X Theatre Hall)
1420 - 1430	Voting for Awards (X Theatre Hall)
1430 - 1450	Closing (X Theatre Hall)
1500 - 1700	Bike and Walk Tours of Delft

FRIDAY OCTOBER 20

Conference Day 3

DETAILED SCHEDULE

Keynote

X Theatre Hall

0900 K02: The History of Two-wheeled Vehicle Dynamics in Japan and Subsequent Trends
Ichiro Kageyama

Coffee and Poster Session 3

X Dance Halls A & B

0940 P18: Influence of aerodynamic lift and centre of pressure position in motorcycle stability
B. E. González, F. A. Vasquez

P19: Balancing Control of a Unicycle Robot with Double Flywheels
M. Parnichkun, S. Chantarachit

P20: Influence of Rear Wheel Vertical Displacement and Target Sag on Suspension Performance of a Cruiser Motorcycle
K. Peck, J. Sadauckas

P21: 2-Skate Zero Wheel Fork-Angle Trail & Power Single-Track Vehicle tests by Many Riders for Rideability, Phase Lag and Steady-State Lean Angles
P. Ethier

P23: New design approach for leaf-springs in motorcycles
H. Fellner

P24: Racebike Dynamics: The Dynamic Racebike State Plot
C. Feichtinger

P25: From Theory to practice: monitoring mechanical power output during wheelchair field and court sports using inertial measurement units
M. van Dijk, M. Hoozemans, M. Berger, D. Veeger

DETAILED SCHEDULE (cont.)

Simulation

X Theatre Hall, Chair: Matteo Massaro

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| 1040 | O30: Modeling of a Bicycle Cargo Trailer with Magic Formula Tire Model for Vehicle Dynamics Simulation
<i>M. Miller, M. Pfeil, R. Kennel, R. Murri</i> |
| 1100 | O31: Lap Time Sensitivity Analyses in High-Powered Electric Motorcycles
<i>L. Flanagan, A. Popov</i> |
| 1120 | O32: Validation of a bicycle simulator based on objective criteria
<i>D. Martinez Garcia, K. Gröne, M. Fischer, M. Zhao, M. Bergen</i> |
| 1140 | O33: Towards Black-Box Dynamics Modelling within Learning-based Nonlinear Model Predictive Control for Virtual Motorcycles
<i>F. Bianchin, E. Picotti, M. Bruschetta</i> |
| 1200 | Lunch - X Foyer |

Vehicle Modeling

X Theatre Hall, Chair: Manfred Plöchl

- | | |
|------|--|
| 1300 | O34: Evaluating bicycle frame loads through semi-analytical multibody simulation methods
<i>J. Bolk, B. Corves</i> |
| 1320 | O35: Parameterized and validated equations of motion for a tadpole style cargo tricycle
<i>C. Groß, S. Müller</i> |
| 1340 | O36: BRiM: A Modular and Extensible Open-Source Framework for Creating Bicycle-Rider Models
<i>T. J. Stienstra, S. G. Brockie, J. K. Moore</i> |
| 1400 | O37: On the fundamental dynamics of rolling wheels: an Appellian approach
<i>M. B. Vizi, G. Orosz, D. Takács, G. Stépán</i> |

FRIDAY OCTOBER 20

Conference Day 3

DETAILED SCHEDULE (cont.)

Closing

X Theatre Hall

1420 **Voting for Awards:** Leila Alizadehsaravi

1430 **Closing:** Jason K. Moore

1500 **Bike and Walk Tours of Delft**

HELPFUL INFORMATION

BMD Conference website

<https://2023.bmdconf.org/>



The website contains more information such as keynote abstracts, maps to event venues, getting to Delft, etc.

Abstracts and conference papers

<https://dapp.orvium.io/communities/63c57270b637ecd577c3a733/view>



Wireless Network

*Industrial Design Engineering building
(Tuesday workshop)*

Please follow instructions on the screen behind the service/reception desk at the entrance.

X building

You will need to SMS a different code each day to receive a password to utilize wifi.

SMS the following code to 7873

Day	Code
18-Oct	tud12
19-Oct	81tud
20-Oct	tud14

Delft Free Wi-Fi

Visitors can make use of open Wi-Fi without the intervention of a TU Delft employee. This network, Delft Free Wifi, is accessible to everyone.

X TU Delft (building 37)

Mekelweg 8-10, 2628 CD Delft
+3 115 278 2442

This will be the main venue for the conference from 18 - 20 October.

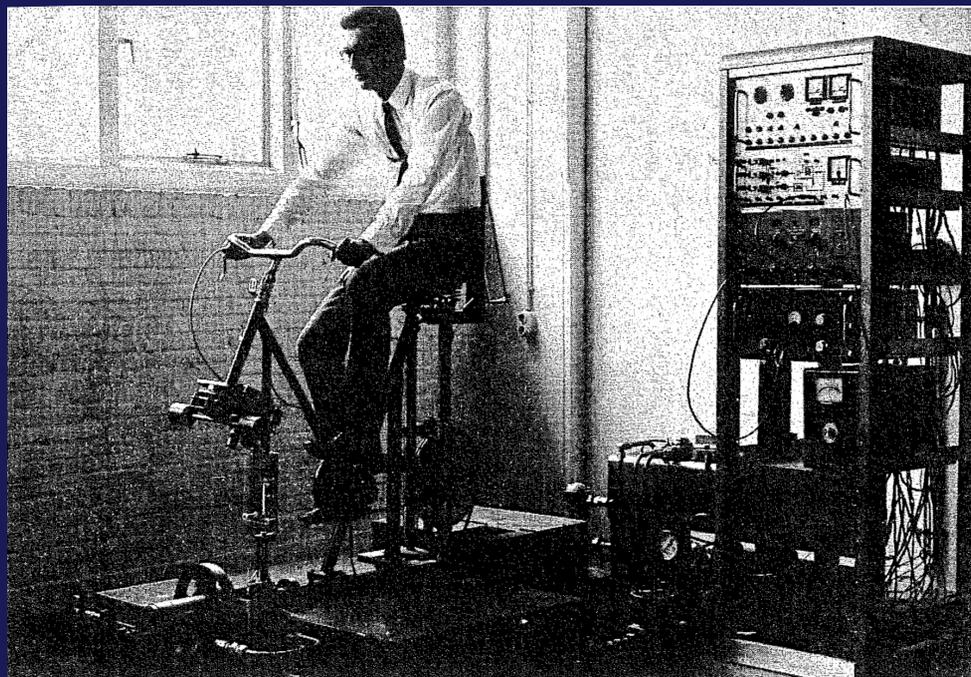
The workshop on 17 October will take place at:

Industrial Design Engineering, (building 32)

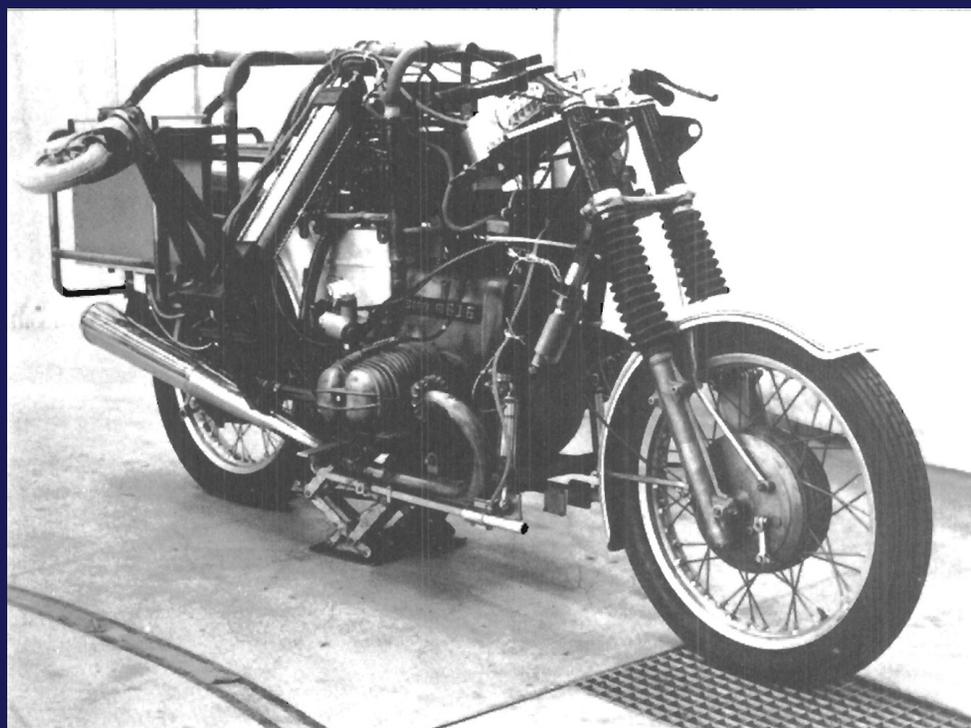
Landbergstraat 15, 2628 CE Delft

Please note, due to construction due to the tram, google maps is best for most up to date walking directions. For access by public transportation, please visit <https://9292.nl/en>. From the Delft train station, type "Delft" in the From field and "X TU Delft, Delft" in the To field.

Thank you for attending the 2023 Bicycle and Motorcycle Dynamics Conference!



Van Lunteren and Stassen's 1967 TU Delt Bicycle Simulator



Automatically stabilized motorcycle, ASMO, TU Delft, circa 1980

<https://2023.bmdconf.org/>

