8th International Velomobile Seminar

Dornbirn 30.10. – 1.11.2015

„Schneewittchen"- band 31.10.2015

cycling-day 1.11.2015

Invitation

We are delighted to present the 8th International Velomobile Seminar, to be held in Dornbirn – Austria, Kulturhaus 30th October. – 1st November 2015.
22 years ago the seminary was founded by Carl Georg Rasmussen in Lyngby, Denmark in 1993 and we are particularly pleased to present him as opening lecturer. He will do a short historical review on the passed 100 years of velomobiles.
Friday morning continues with the "northern lights". Kuba Szankowski from Denmark stays with the Leitra theme and shows his redesign of the classic velomobile. After the coffee break, Per Hassel Sørensen from Norway refers to the advantages of the hydropneumatic suspension on (4-wheeled) velomobiles. The current HPV world champion Charles Henry from Switzerland will talk about the development of the single-track velomobile Peregrin and Joachim Fuchs from Germany completes the theme of single-track velomobiles with his experiences in everyday life.
In the afternoon the German Frank Regge, well-known in the scene presents the theme "Let there be light" with practical examples, especially for VM and recumbents. Falk Klinge "Prof. Wind-Tunnel" will speak about aerodynamics. His lecture is divided into two parts, part 1 on bike / recumbents on Friday and a part 2 on Velomobiles on Saturday. A hotly debated topic in the automotive sector is the „autonomic vehicle" picked up by Per Hassel Sørensen with his 2nd lecture based on velomobiles.
Brakes are a particular problem in the mountains. The afternoon will bring reports with practical tests of water-cooled drum brakes and an update on disc brakes. Presented by the "southern lights" with Thomas Zurbrügg from Switzerland, Patrick Flé and Tim Botzelmann from Lake Constance. Finally there will be Theo van Andel from Holland with an informal presentation: "Why does not everyone ride a velomobile?"

Timetable Friday

may be subject to changes

Presidency Werner Klomp, AT

- 8:00 AM registration
- 8:40 AM opening
- 9:00 100 years velomobile - Carl Georg Rasmussen, DK
- 9:50 Leitra velomobile 2.0 - Kuba Szankowski, DK

10:30 coffee break
- 10:50 Hydropneumatic suspension - Per Hassel Sørensen, N
- 11:20 Single track velomobile development - Charles Henry, CH
- 12:00 Single track velomobile commuting - Joachim Fuchs, D

12:40 PM lunch break
- 14:00 Lighting - Frank Regge, D
- 15:00 Aerodynamics Part 1 - Falk Klinge D

16:00 coffee break
- 16:40 Autonomous Driving - Per Hassel Sørensen, N
- 17:20 Disc brakes - Thomas Zurbrügg, CH
- 17:50 Brake cooling - Patrick Flé, AT and Tim Botzelmann, D
- 18:20 A velomobile for everyone? - Theo van Andel, NL

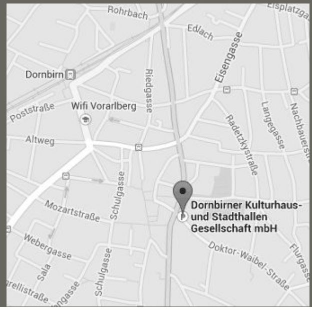
07:30 PM social evening (registration required)

The seminar language is prim. English on Friday. The questions and answers will be moderated in English, German and Dutch.

Venue: Kulturhaus in Dornbirn

Rathausplatz 1, 6850 Dornbirn
+43-5572 27770

Further Information
www.velomobilize.at
+43-681 84860006



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Saturday starts early again with two longer technical presentations.

Martin Wöllner from Germany tries to bring clarity to the complex processes of the chassis. Falk Klinge will supplement his lecture with the aerodynamics part 2 about Velomobiles and answer the question - are there new aspects? Charles Henry from Switzerland talks about rolling resistance and its measurements (in German). Followed by Helge Herrmann from Germany with a report on tyres.
After of the lunch break, the seminar divides in a closed part that will takes place in the restaurant and an open public part, in the small hall and in the foyer of the Kulturhaus. Jessica Miller and Ymte Sijbrandij conduct through the afternoon for the manufacturer and dealer meeting - market and marketing - what do we want and what can we do?
After the opening of the public afternoon, Manfred Raich can be heard in the small hall. He is professional commuter on his velomobile. For years he has traveled almost every working day from his home in Dornbirn to Lichtenstein and back. He reports on experiences he has collected over the years. Wulf Kraneis from Germany then will illuminate the private transport in an energy-optimized view with practical example. Thereafter, the current world record holders Nicola Walde, Roland Schell, Thomas Schechinger, Hubert Englmann and Igor Paliouk answer the most frequently asked question of the audience: How fast is a velomobile?
After the coffee break, the audience and producers come together again and the seminary continues with biomechanics in the small hall. Tristan Willbrandt from Germany gives a lecture on "rapid cycling". As a counterpoint Heinrich Schlack from Germany is thinking about the use of braking energy and presents his timing-belt recuperation brake. Helge Herrmann did a trip to Iceland with his velomobile. In his film he describes the endurance test with the velomobile.
Roland Schell and Tim Botzelmann will present the closing speech in images with journeys over mountain passes to countries beyond the Alps.

Party with "Schneewittchen" from Hannover - admission 08:00 PM.
Tickets are available at the door. Entrance for participants is free.

Timetable Saturday

may be subject to changes

Presidency Werner Klomp, AT

- 7:45 AM admission
- 8:10 Suspension, chassis - Martin Wöllner, D
- 9:20 Aerodynamics Part2 - Falk Klinge, D

10:30 coffee break

- 11:20 Rolling resistance measurements - Charles Henry, CH
- 12:00 Tires - Helge Herrmann, D

12:40 PM lunch break

Open to the public from 02:00 PM

- 14:00 Opening of the public afternoon
- 14:10 Commuting by velomobile - Manfred Raich, AT
- 14:30 Motorized velomobile - Wulf Kraneis, D
- 15:30 Trans-Austria and DEKRA world records - Team VMZ, int.

16:00 Coffee Break (Meet the Experts, exhibition in the foyer)

- 16:30 Biomechanics - Tristan Willbrandt, D
- 17:20 regenerative brake - Heinrich Schlack, D
- 17:50 Iceland film - Helge Herrmann, D
- 18:10 Heading off beyond the alps - Tim Botzelmann, D and Roland Schell, D
- 18:50 Closing remarks

Approximately 07:00 PM End of the event

The seminar language is mainly English in the morning and German in the afternoon.

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www.velomobilize.at

2015

powered by Velomobilize KG

Speaker
Kulturhaus Dornbirn 30.10.- 1.11.2015

DI Carl Georg Rasmussen
Danish velomobile pioneer. Designer of Leitra velomobile (**Le**ight **i**ndividual **tra**nsport) and founder of the velomobile seminar.

Kuba Szankowski, BSc
Mechanical engineering B. Eng. DTU Diplom, Ballerup
Investigated Subjects: electrical assistance, use of Coroplast as fairing.
Final project: Leitra velomobile analysis and redesign, grade 10.

Per Hassel Sørensen, MSc
While studying at University of Stavanger for an MSc in sustainable energy, he wrote a master thesis on how to make a Velomobile more suitable for daily use. He has recently started the company Elpedal AS for commercializing new velomobile solutions under the registered trade-mark Podbike®

Charles Henry
Dipl. Phil. Designer of Velomobiles. Focus on aerodynamic drag and rolling resistance measurement. Board of Futurebike.ch. Active HPV athlete and 2015 World Champion.

DI Joachim Fuchs
Design and building of Aeolos twowheeler velomobile – 1993-1995
Practical Vehicle Test – a standardized test for everyday HPV – 1996-1998
Organizing 5th Velomobile Seminar Germersheim 2004
Car dinghy award – 2008. 20 years of Aeolos everyday riding - 2015

Frank Regge
Salesman. Technical service department for Busch & Müller and Rohloff.
Passionate recumbent rider and active sportsman (PBP, LEL, Cape Epic)

Prof. Dr. Ing Falk Klinge
Professor of mechanical engineering at OSTFALIA University of applied science, Wolfenbüttel. He received his degrees in mechanical engineering from Technical University of Clausthal, Germany in 1999 and his doctorate (PhD) in 2003 from University of Hannover, Germany while working at DLR (German Aerospace Center) in Göttingen. He developed different optical measurement techniques and applied them to many industrial-scale wind tunnel facilities at different sites in Europe.

Speaker
Kulturhaus Dornbirn 30.10.- 1.11.2015

Thomas Zurbrügg
Disc brake instead of drum brakes. Adaptations of the Quest struts.
Conversion from regular wheel to "dished - wheel".

DI Tim Botzelmann
Liegeradclub Vorarlberg. Micromechanical machine builder, developer at ifm ecomatic. Official observer of UMCA at DEKRA 2014 and Trans-Austria 2015. Passionate recumbent and velomobile rider.

DI Theo van Andel
Studied High power electrical science at HTS (university) Alkmaar 1988-1993. Graduation project & Job at Flevobike from 1993-1998 Building Alleweders. Joined Velomobiel.nl in 2001 until now. Designed and built over 30 different (2 wheel) recumbents since 1989. Racing at HPV races since 1989. He presents his new development – a 4 - wheel velomobile.

DI Martin Wöllner
Automotive Engineering studies at the University of Applied Sciences in Zwickau, Germany. Since 2007 design engineer at HP Velotechnik. Taking part in every development made in the company such as Scorpion fs, the Gekko trike range and Scorpion plus models. 2009 design of „woe-low“ velomobile for private use und 2010 the velomobile „exxos“.

DI Helge Hermann
Mechanical engineer from Hannover. Co-owner of the Räderwerk and producer of the Milan - velomobile. Known as long-distance record hunter and as a representative of sustainable mobility.

FachW. Manfred Raich
Liegeradclub Vorarlberg. Electrical mechanical engineer and programmer. Co-founder of the VMZ KG. Commuter and world record holder 100 and 200 miles HPV,2014.

Ymte Sijbrandij
Co-owner of company InterCity bikes and producer of the DF. Co-founder of Velomobil.nl and former accountant and tax consultant with Flevobike. Years of successful HPV - athlete and long-distance rider. Lives and loves velomobiles and the family.

Speaker

Kulturhaus Dornbirn 30.10.- 1.11.2015

DI Wulf Kraneis
Mechanical engineer. Optimize GmbH. HPV world record with 676km in 12 hours, 2014 with a modified Milan. Developing and testing electrically assisted velomobiles for daily use since 2010. The goal is to use not more than 0.5 -1-0 kWhel per passenger kilometers in daily traffic.

Nici Walde
12 hours world record holder at DEKRA 2015 debut with a modified DF - velomobile. Triathlete and professional musician.

Roland Schell
Liegeradclub Vorarlberg. 4x relay world record at DEKRA 2014 with Milan SL, Trans-Austria world record holder 2015 (Milan SL). Composer and conductor. Logistician at Fa . Seeberger Specialties, Ulm.

Thomas Schechinger
Liegeradclub Vorarlberg. 4x relay world record at DEKRA 2014 with Milan SL Professional musician and former competitive swimmer.

DI Hubert Englmann
Liegeradclub Vorarlberg. 4x relay world record at DEKRA 2014 with Milan SL, Mechanical engineer and co-founder of the VMZ KG. Passionate cycling and velomobile rider.

DGKP Igor Paliouk
Liegeradclub Vorarlberg. 4x relay world record at DEKRA 2014 with Milan SL. Musician and nurse in Monaco

Tristan Willbrandt M.A.
Sports scientists . Biostatistics programmmer. Active HPV athlete and former competitive athlete in sailboarding.

Ing. Heinrich Schlack
Communications engineer and software development in the industry. "Recuperation as a useful tool to safe drum brake shoes." review after 1000 km with a maximum of 1kW electrical braking power.

Organization

Kulturhaus Dornbirn 30.10.- 1.11.2015

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Ing. Werner Klomp
Designer and developer in the food industry, frequent velomobile rider - velomobile - DF. Active HPV athlete and 4th place in the World Championships 2015. Chairman of the velomobile seminar .

Erich Burschowsky
Chairman of the Liegeradclub Vorarlberg. Active recumbent rider and political activis . Organization of the 8th velomobile seminar 2015

Dr. Jessica Miller, MBA
Liegeradclub Vorarlberg. Co-owner of VMZ KG. VMZ - world record team. Organisation of the 8th velomobile seminar 2015.

Patrick Flé
Liegeradclub Vorarlberg. Moderator in the German Velomobile Forum. Formerly with Velomobiles. Co-owner of VMZ KG and organization of the 8th velomobile seminar 2015.

Sunday: Guided trips
There are 3 routes of varying length and severity to choose, for which you can sign up during the two conference days.
The meeting point is at 9:00 clock or later in front of the Kulturhaus.

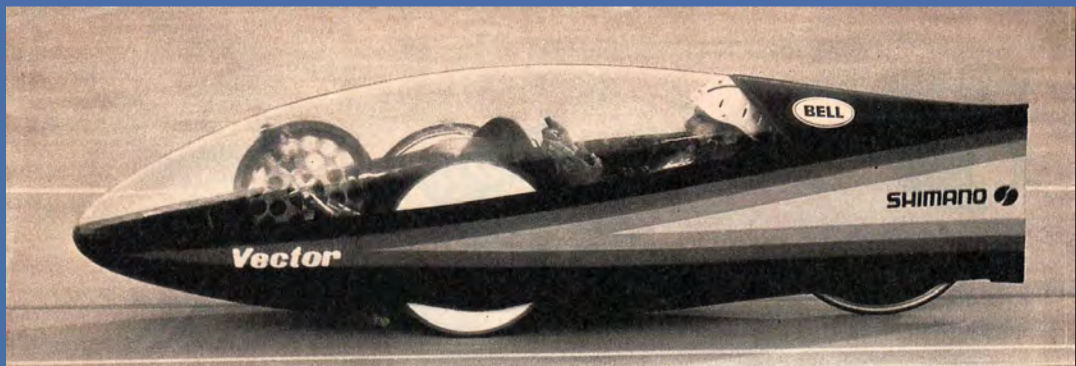
There is no special insurance coverage. Participation is voluntary, free of charge and at their own risk.

8th European Velomobile Design Seminar

Dornbirn - October 2015

Historical Introduction

Presented by C.G. Rasmussen



An Overview of a Hundred Years Velomobiles

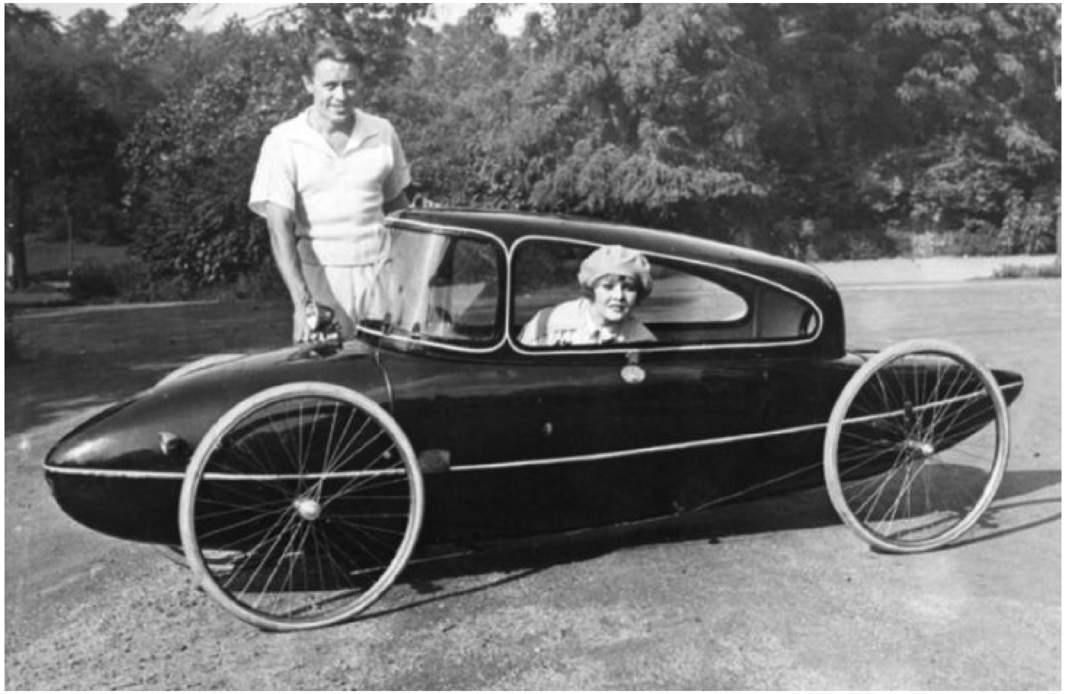
1925-1950 The Pioneering and War Period

1950-1975 The Motorization Period

1975-2000 The Oil Crisis and the Velomobile Renaissance

2000-2015 The Diversified and Expanding Market

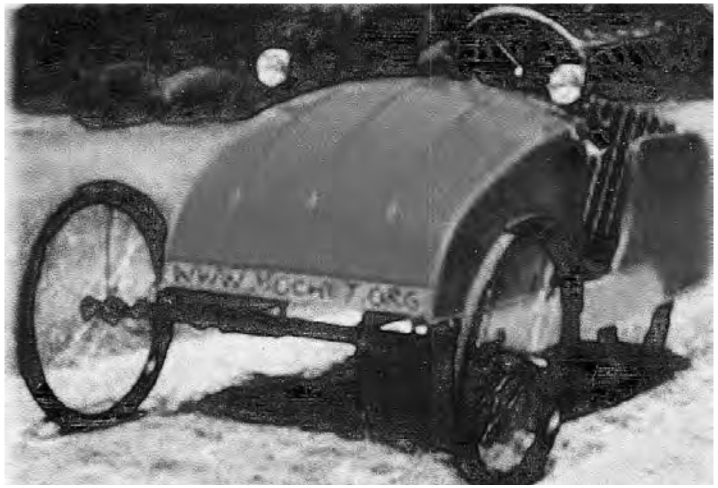
1925-1950 The Pioneering and War Period



Velomobiles as a popular hobby mainly for racing.

< This velomobile designed approx. 1925 by Dr. Manfred Curry has the shape of a torpedo and was quite fast (up to 35 miles per hour).

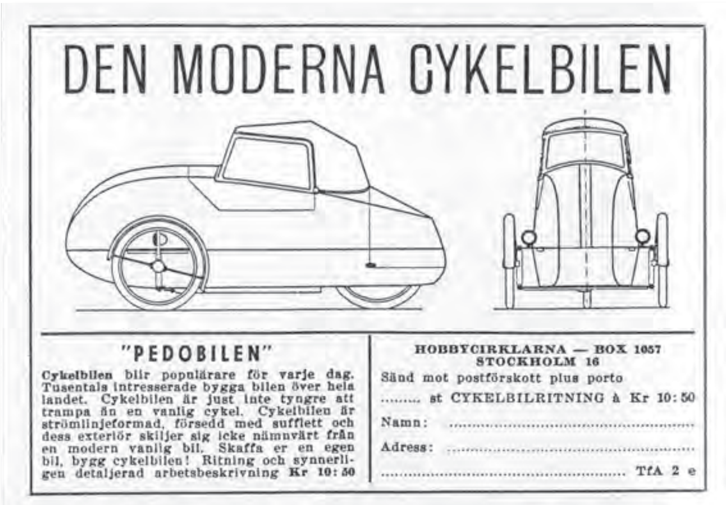
Charles Mochet produced several hundred of this four-wheeler in France in the 1930s. It was popular for racing and for practical transportation.



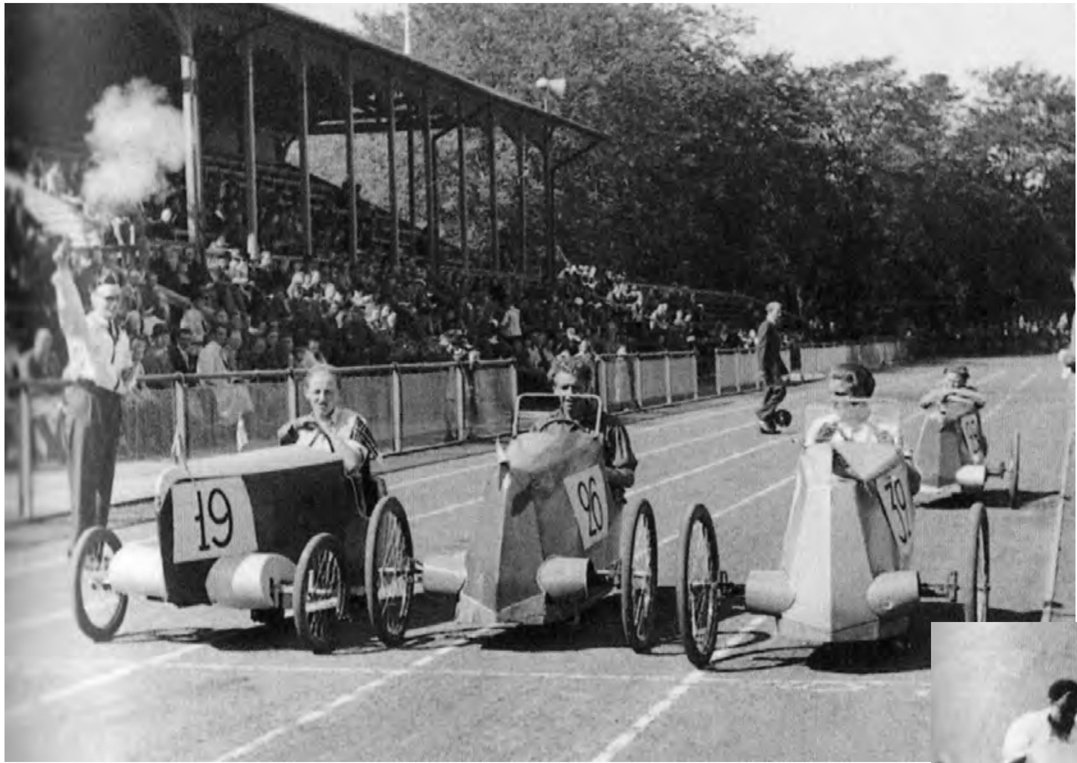
A modern replica of Mochet-alike Swedish Fantom.

Swedish velomobiles

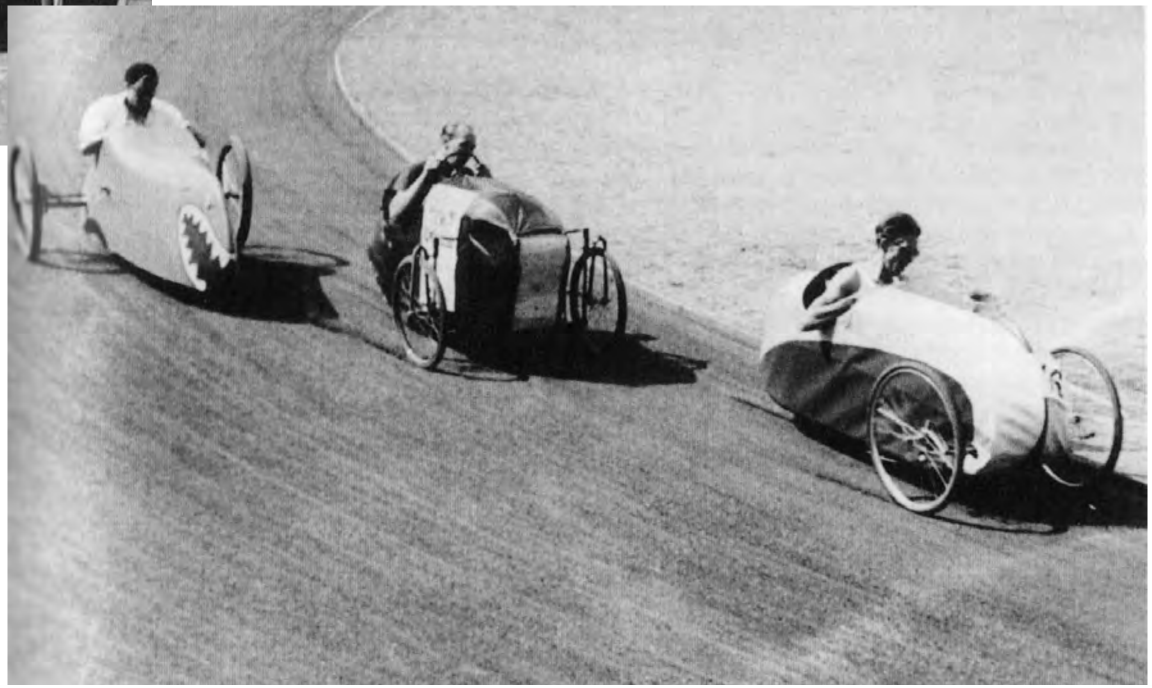
In the period 1930-50 velomobiles became popular in Sweden thanks to the magazine ***Teknik för Alle***. It published a number of designs and you could buy blueprints and descriptions how to built your own velomobile. Many thousands of descriptions were sold, but not very many velomobiles were actually built.



Swedish velomobiles

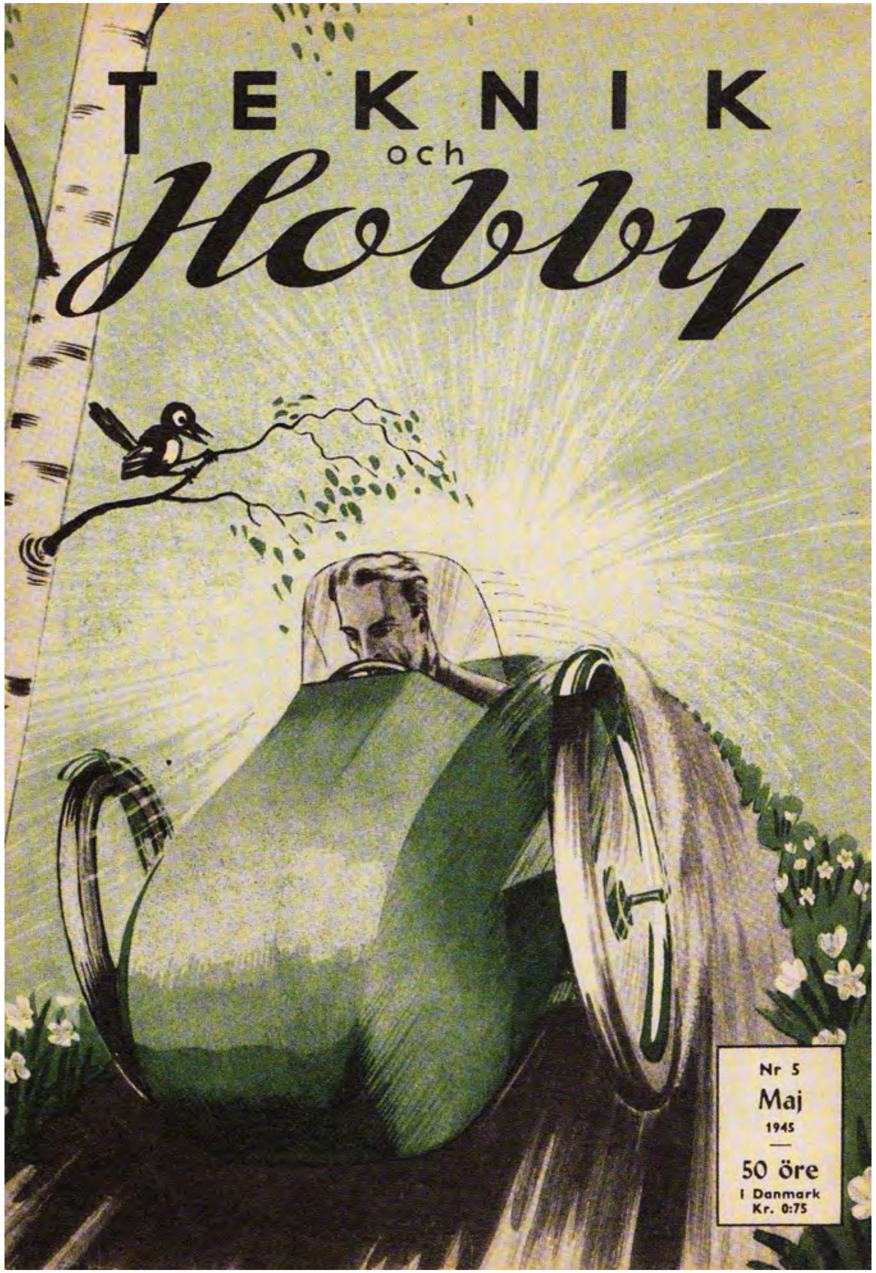


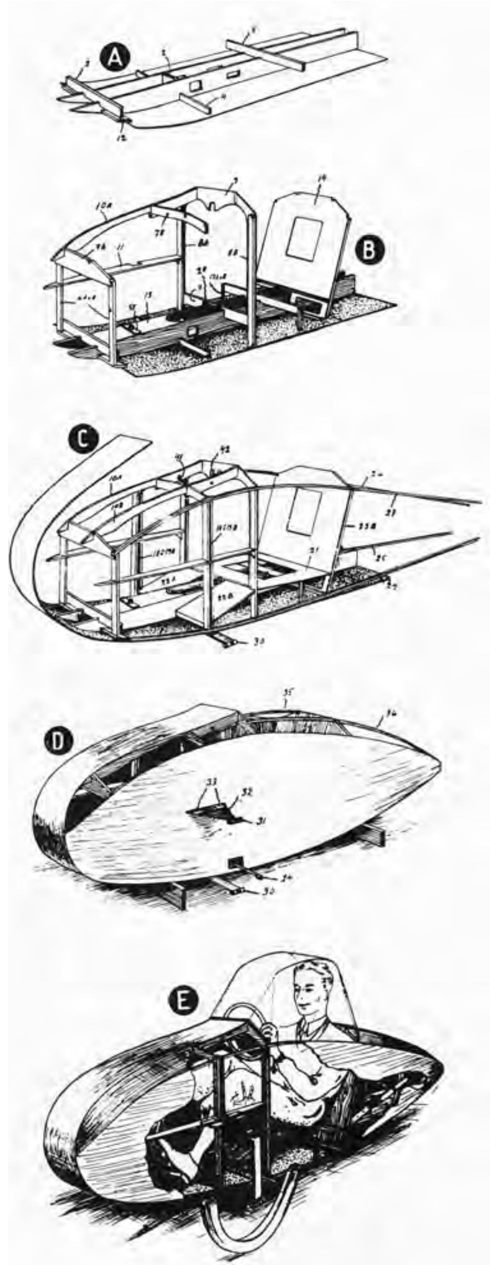
Some Swedish designs were commercialized and sold in small series. But do-it-yourself velomobiles became a popular hobby and they were mostly used for public racing.



Swedish velomobiles

When I was as a teenager, I was inspired by the Swedish magazine ***Teknik och Hobby*** and built this Ulf Cronborg design from wood.
This aerodynamical three-wheeler had suspended front wheels and the weight was around 40 kg.





From velomobile to the Messerschmitt Kabinenroller

After World War II gasoline was still expensive and hard to get for private people.
In München, Germany, the engineer Fritz Fend designed this velomobile for general use.
It was developed through several stages and later equipped with a small combustion motor.
The design was later taken over by the Messerschmitt Company, where it was further developed into the famous Messerschmitt Kabinenroller.

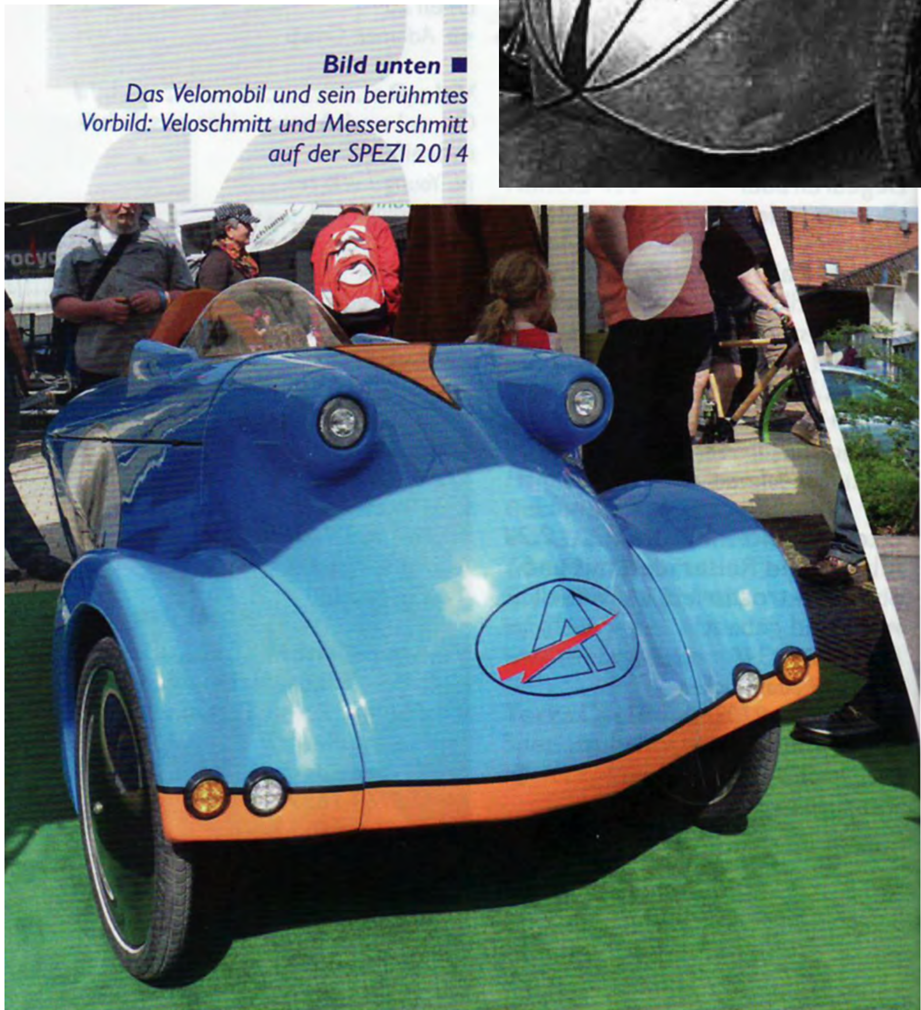


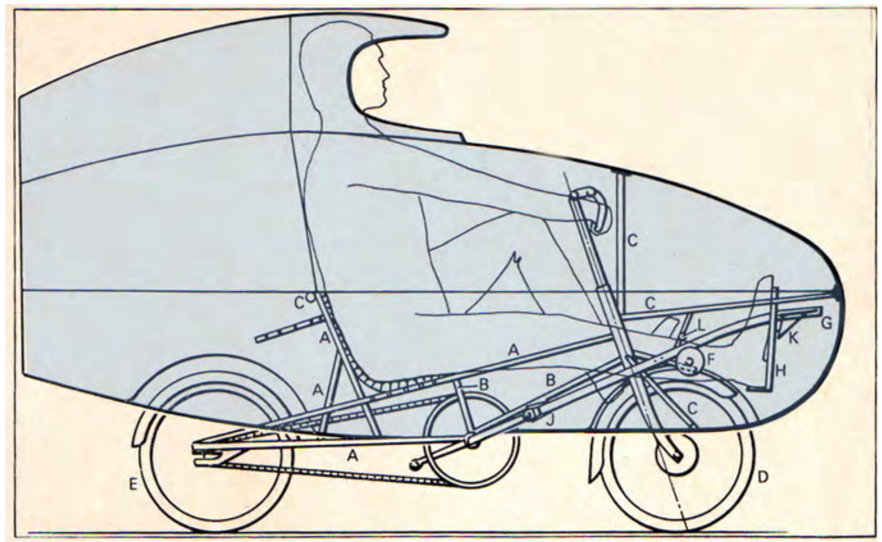
Photo and text from SPEZI catalogue 2015 – but the velomobile came first.

1950-1975 The motorization period

The interest for velomobile sport faded away soon after the Second World War.
A strong trend towards motorization dominated in this period, supported by low oil prices.
Bicycle infrastructures in the towns were closed down in order to make more space for car traffic.
The conditions for cyclists became more difficult and dangerous.
Cars, motorcycles, mopeds, scooters and cabin-scooters forced out the cycle culture. Very few innovations in bicycle design were seen. Here are two examples, both designed by aircraft engineers.

^ In the USA a ”Pedicar” with wire transmission came on the market in 1971.
Unfortunately it was too heavy (>50 kg) to become a success.

In England this two-wheeled recumbent bicycle with glass fiber fairing, called ”Bicar”, received First Prize in a competition in 1969. >



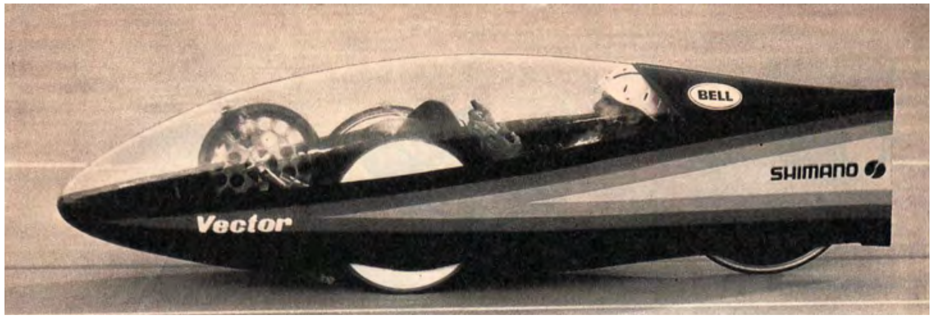
1975-2000 The Velomobile Renaissance

Suddently two oil crises in the 1970's changed the conditions. Ideas of ”limits to growth",
the need for environment protection, and change towards sustainable societies and life-style gave inspiration to a revival of cycling.

Races organized by the IHPVA (Intern. Human Powered Vehicle Ass., founded 1975) demonstrated, how fast bicycles with aerodynamical fairings could be. Stories of speedy bikes appeared in many newpapers and magazines (e.g. Scientific American). Speed records of the American Vector (1980) were hunted by many speed monsters.

Battle Mountain in Nevada, USA, became the preferred site for annual competitions in 200 m sprint with 8 km run-up. Already in 1999 the World Record reached 133 km/h. These very specialized speed machines can only operate on closed racing tracks.

The original Vector, designed by A. Voigt,
and a German successor. >



From speed machines to practical velomobiles

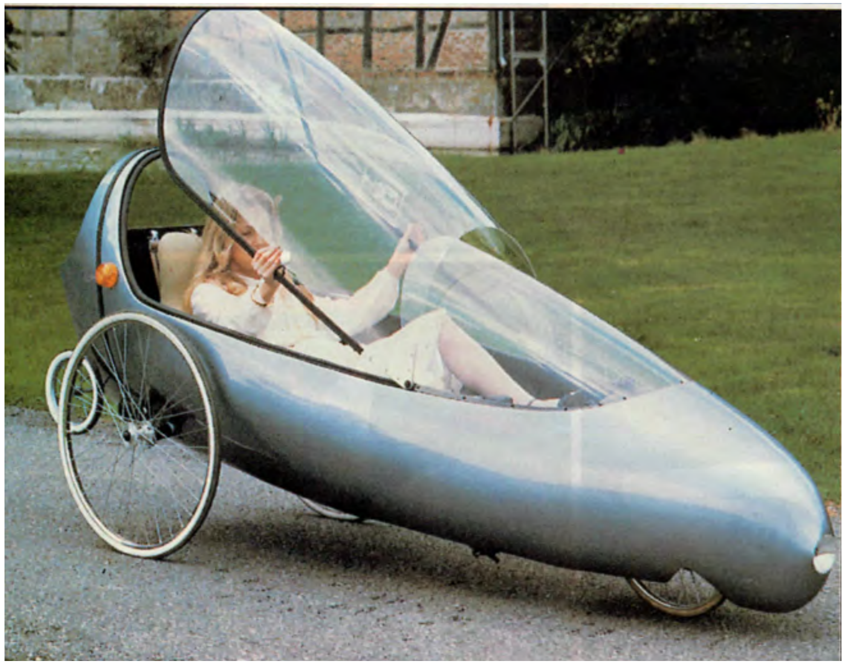
When maximum speed no longer is the ultimate goal, other specifications get priority in the design process. For a practical velomobile, this could be:

- Comfort
- Maneuverability
- Safety
- Luggage capacity
- Durability and maintenance
- Styling
- Price

It is said, that *form* follows *function*. It leads to a high diversity of designs, since functions depend on many different needs and wishes. There is nothing like an ideal velomobile, which satifies everyones needs. So for many people it is fun to design and build a velomobile of their own.

< An early velomobile design from Lithuania, 1982. The V-8 is a 35 kg monocoque with front wheel drive and rear wheel steering.

Also commercial cycle producers like Kalkoff (Germany), Gazelle (Netherlands) and Velerique (Belgium) tested the market in 1982 with concept models. They were stylish, but not really practical. Only the Velerique came into series production for a couple of years around 1985.



A practical velomobile must be able to operate safely in normal traffic, on streets, roads and bicycle lanes, by night and day, all year, in all kinds of weather.
Maneuverability, stability and the ability to see and to be seen are very important qualities.
The vehicle must provide quick and easy access to get in and out, a comfortable seating position and good ventilation.

Low weight and good aerodynamics are also essential, in order to minimize the power needed from the rider. These are the criteria, which inspired me to start development of a practical velomobile in 1979/80, after almost 30 years without one.
I called it the *Leitra* (*Le*t *I*ndividuel *Tra*nsport). It was not intended as a vehicle for racing.

^ Two early Leitras. First velomobile to complete Oslo-Trondheim-Oslo (1983).

^ Later production version, first velomobile to complete Paris-Brest-Paris (1987).
Foto: Jürgen Eick.

There are basicly two concepts of velomobiles: The monocoque, with integrated chassis and cabin, and the convertible, which is a recumbent cycle with an exchangeable cabin/fairing.
I chose the convertible principle for the Leitra, mainly for flexibility in various applications. You can easily modify fairings for different purposes: e.g. transport of children, animals, tools, and music instruments. You can ride it as an open recumbent bike/trike in fair weather, and it can be disassembled for long distance transport in trains and airliners.

The Festival of Human Power, Thamesmead (UK 1984)

As an example, I went to the HPV Festival in London by private airplane. Rode to Copenhagen Airport, Roskilde, disassembled the Leitra in 10 minutes and took it on board a Piper Cherokee.
I landed in the small GA-airfield ”Biggin Hill” south of London and rode to the Festival.

The legendary Windcheetah

One of the first practical velomobiles, the Windcheetah, a convertible trike designed by Mike Borrows, participated in the First HPV-Festival in Thamesmead, furnished with a sport fairing. It came into series production in UK, and it is still on the market, especially for speed lovers.

It was strong in the street races, where two Vectors crashed because of their low maneuvrebility.

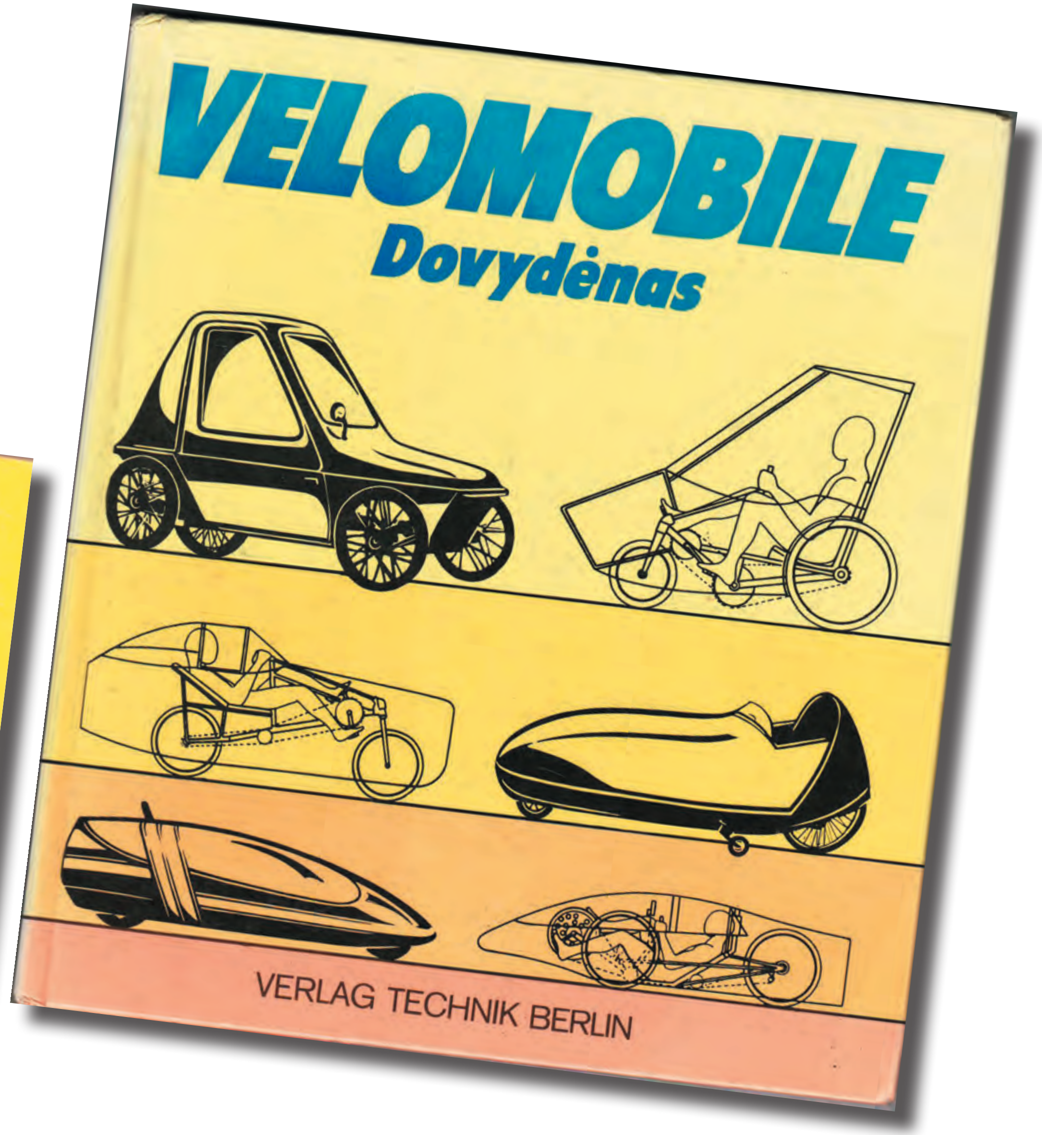
< I took this picture of one of the first Windcheetahs (Thamesmead, July 1984).

Here an example of later versions. Some fairings were for racing, others for practical use. >

The first books on velomobiles

The first books on velomobiles were written in Russian by A. C. Popolov, (1981) and Lithuanian prof. Vytas Dovydenas (1986). The latter was translated to German and published in Berlin (1990).

It has very nice graphics of realized velomobiles as well as very futuristic designs.



In the mid-80's the European HPV movement organized a number of national HPV Clubs.
In Switzerland they called it Future Bike CH, and they promoted Swiss designs like Twike and Birkenstock through competitions. In 1986, Future Bike CH presented a used Leitra velomobile at an international Bike Show in Geneva. Later (1991) the first velomobile building course was organized in Bern by Andreas Fuchs. Five Leitras were assembled and tested in three days by the new owners.

Ladies priorities: Luggage capacity and black velvet

The Leitra has room for luggage under the seat and in the rear fairing. This early classic, owned by a Danish lady, has a portable basket for shopping articles. On demand it was extended for even more capacity.

Also the internal finish is important for a lady. Here black velvet all over, with small pockets for phone, letters, extra lamp etc.

After some years riding by pedals only, the lady (then 70 years) invested in a 250 Watt electric assist motor for higher comfort.

A lady in South England wanted a velomobile for her recreation tours with her dog. The Leitra was furnished with a dog cabin behind the rider. I rode it from Copenhagen to her home in Christchurch via Esberg-Harwich-London-Southhampton.

Young parents wanted to bring their children to kindergarden or school or to take them along on visits.

< This dentist in Aachen, Germany could transport three children all year around in all kinds of weather.

Older children, like this Swedish boy, was touring with his father in a special trailer. They communicated through a plastic tube with two funnels.

Individual outfits

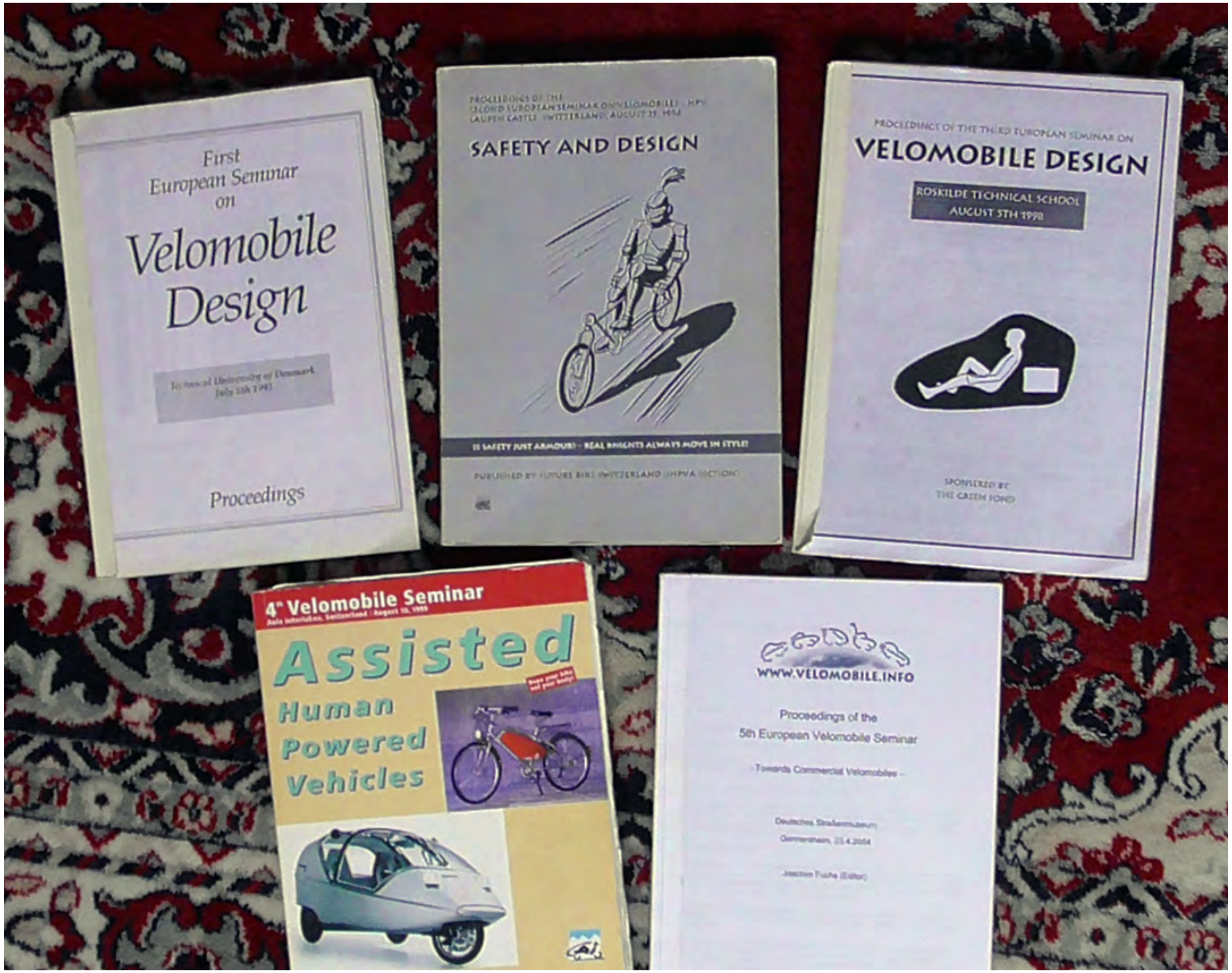
A former car owner missed the impression from a car. This Leitra was furnished with blinker, two extra backmirrors and two heavy car front lights. It increased the weight of the fairing by 100% and required extra heavy battery. >

More suitable additional equipment, like a solar panel on top of the fairing, has been installed by several Leitra-owners.

Also styling is used to give a velomobile an individual touch. Photo below from Interlaken 1999.

Design Seminars

The First European Seminar on Velomobile Design was held on July 8th, 1993 at the Technical University of Denmark. It was followed up by six more seminars in Switzerland, Germany, Denmark and the Netherlands. The 8th seminar is planned for Dornbirn, Austria, on 30 October 2015. Proceedings from the first 5 seminars were published on paper. The rest are in digital form. Thanks to the initiative of Simon Bailey, all earlier proceedings will soon be available in digital form.



Long distance group touring

Theory and design are important exercises in the development of velomobiles, but practical experience on the road will tell, if the design is successful.

In 1996, a group of Leitras from Germany and Denmark was touring in England, some went up to Edinburgh and Glasgow.

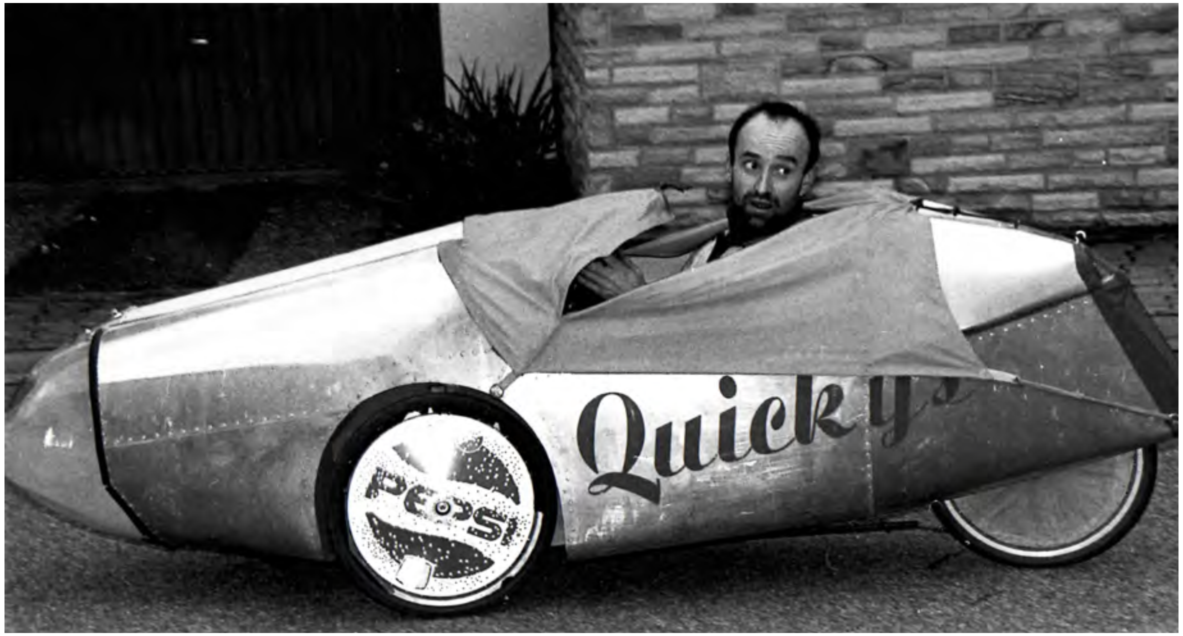
Here the group made a stop in Cambridge. Jurgen Eick (in the middle with his wife Ulla) is reponsible for the foto.

Interesting designs in the UK

Members of the British HPV-Club created interesting velomobiles, both for racing and for practical use. I already mentioned the Windcheetah, but also a company like King Cycle became recognized for it's elegant design. In order to make the vehicle as small as possible, it had a special drive system, which could be integrated in the nose cone.

Flourishing velomobile development in the Netherlands

In the spring of 1993, the Dutch HPV-Club, in cooperation with a Dutch bike magazine FIETS and University of Eindhoven, organized a competition ”365 days bicycle”.
It was also the market introduction of the ”Alleweder”, produced by the company Flevo Bike.
It is one of the few velomobiles built from Aluminium.
It became popular as a do-it-yourself product, and it has been further developed in composite material.
It became inspiration for other companies in their design.



New models from Germany

Two monocoques models, the Cabike and the Go-One came on the market in the late 90th, both inspired by the Dutch Alleweder.

The Cabike, designed by Reinholt Schwemmer and German Eslava, was first produced in Giessen, later in Poland and the USA.

The Go-One, created by the designer Michael Goretzky, was produced by the German company Beyss Kunststof and came on the market in 1997.

Two Cabikes joined the tour to Switzerland in 1999 for the 4th Velomobile Design Seminar in Interlaken. Riding in the Alps and over distances of several thousand km became routine for practical velomobiles. Also Joachim Fuchs joined the group in his own design, the two-wheeler Aeolos.

The velomobiling doctors

In Germany, several medical doctors combine their own physical training with visits to clients.

There is more than enough space for a doctor’s bag in the Leitra luggage box, and the distance between clients is often just 5-15 km in urban areas.

Exercise is an important factor for general health and for the fight of obesity.

”When we arrive in a velomobile, it is easier to talk about excercise, and our own example helps to convince people.”

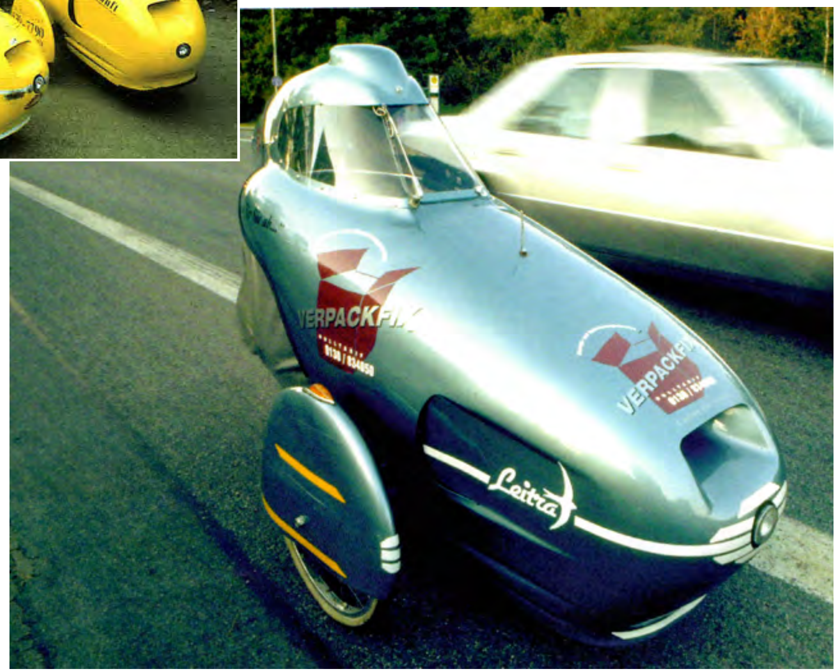
The styling of a doctor-velomobile is an individial matter. Dr. Wolfgang Schneider-Rathert of Braunschweig (left) prescribed “pills” in many sizes.

Artists promoting sustainable mobility

Some artists, concerned about the environment and climate change, have changed their life style radically. Goodiepal, musician and painter, thought he had used up his CO_2 quota on his many flights in Europe and the USA. He bought a Leitra velomobile and toured through Scandinavia from the Faroe Islands, Iceland, Norway, Sweden and Finland to the Baltic countries, playing his music and creating decorative paintings.

Goodiepal's first Leitra can now be seen in the National Museum of Art in Copenhagen.

Tobias Enke, from Germany, lived for a whole year (1996) in his Leitra, traveling from town to town with his sculpture art and silverworks. A stop in the pedestrian zone attracted immediate attention, and people became impressed by his art and his vehicle. Later, his was able to get income from sponsorships. A velomobile fairing is an excellent carrier of adverticements.



Practical on 2 wheels

While most high speed record machines are on 2 wheels, the preferred concept for practical velomobiles has for many years been 3 wheels.

Some early designs of practical 2-wheelers, like the Velerique from the 80's, were not stable enough to be used safely in normal traffic.

However, there are a few successful examples of practical velomobiles on 2 wheels in the 90's.

^ Joachim Fuchs also believed in the 2-wheeler concept for a practical velomobile. He designed the Aeolos and has been using it for pendling and touring through many years.

^ Stefan Gloger made careful studies of the stability in gusty wind with his Desira, as well as the safety in crash situations. He was able to ride the Desira in normal city traffic, thereby demonstrating it’s potential as a practical vehicle.

2000-2015 The diversified and expanding market

About the turn of the millennium the development of commercial velomobiles gained momentum, first of all thanks to groups of very dedicated and determined bicycle designers in the Netherlands and Germany. Speed became the ultimate design goal and competition parameter, resulting in very low, aerodynamic monocoque models with minimum cross section.
Consequently, lower priority was given to manoeuvrebility, visibility, luggage capacity and easy access to get in and out. Still a number of compromises are necessary to keep some caracteristics of a practical velomobile in the new generation of vehicles for commuting and long distance travelling.

Mango
Velomobiel.nl

Quest
Velomobiel.nl

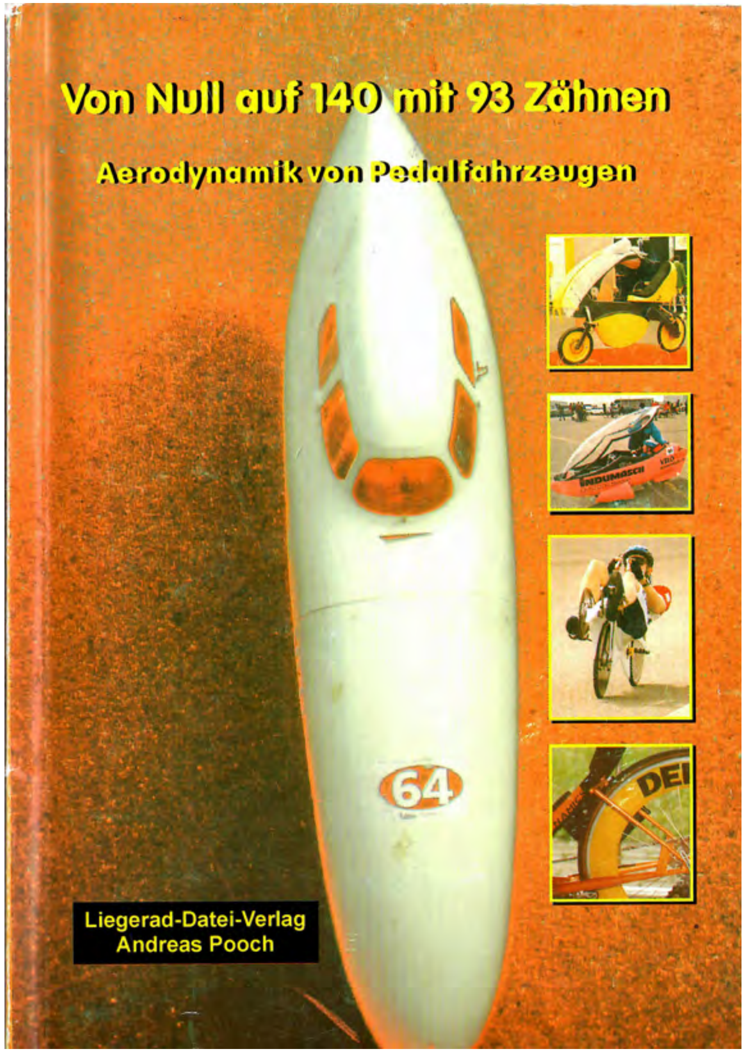
Strada
Velomobiel.nl

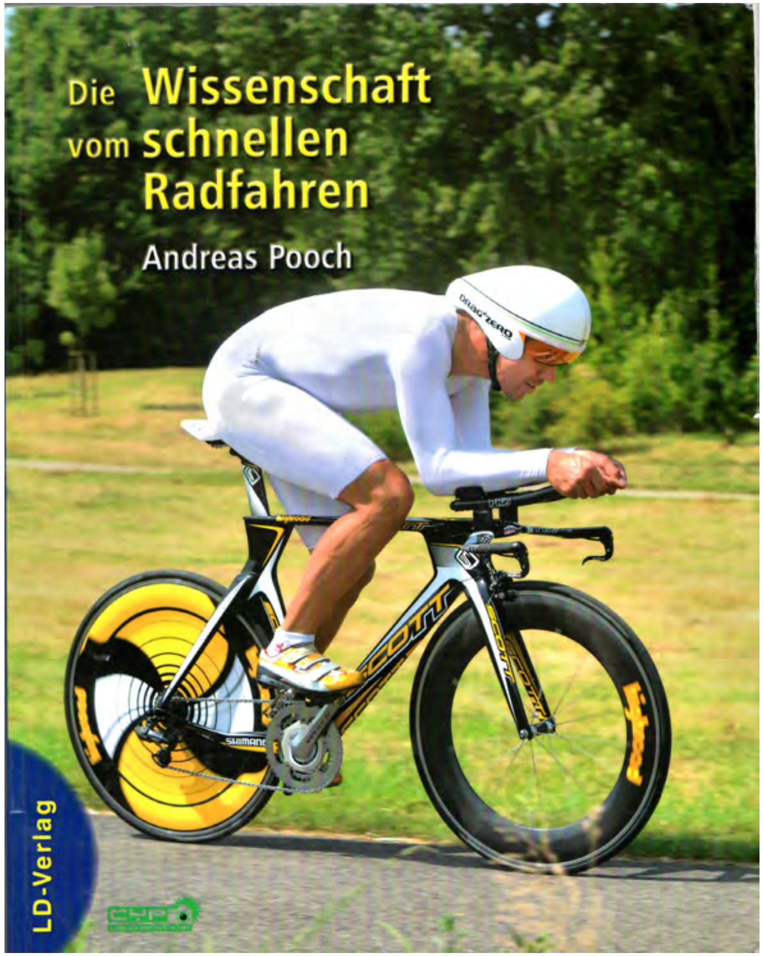
Orca from Flevobike

Inspiring literature

Andreas Pooch published his first book on velomobile aerodynamics in 2001. It gave inspiration to many designers of high speed as well as practical velomobiles.

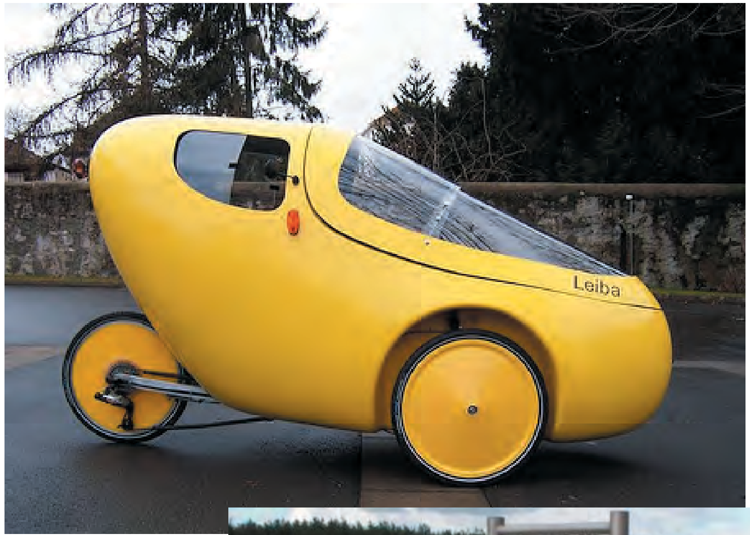
His later updates present important contributions to the scientific basis of design. He describes technologies useful for professionals as well as Do-It-Yourself enthusiasts.





More German professionals

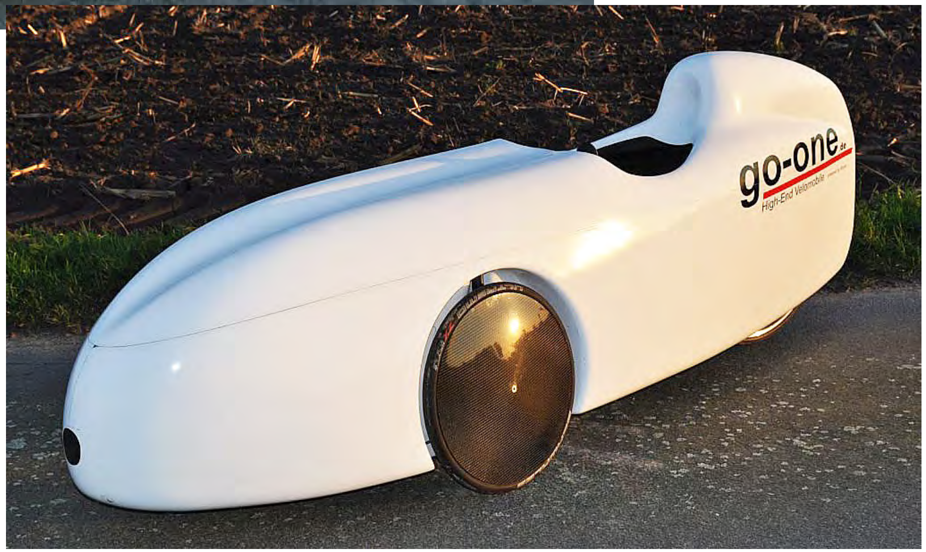
In the first 10 years of 21st millennium, two new German companies joined the velomobile market, both located in the Hannover area.
The Leiba belongs to the category of practical velomobile, with room for luggage and easy access, while the Milan, from Räderwerk, is an extremely low high speed racer, based on Eggert Bülk's many years of development with low racers.



Leiba

Leiba X-Stream XXL

Milan



The Cab-Bike became popular in the USA. Below is Mary Arneson and Dale Hammerschmidt in Minneapolis, Minnesota in 2003.

New generations Go-One and Cab-Bike

The original ”Bubble” Go One has been followd by new models, with higher speed as primary design goal.
The Cab-Bike was adopted by the American company Blue Velo. It was presented to the US market in a cabrio version.

Back to motorization – now electrical

After almost 25 years of practical velomobiles, powered by 100% human power, the first commercial hybrid vehicles appeared on the market. The Dutch Aerorider, designed by Bart de Vert, has a 500 Watt electric motor to assist pedal power. It has a total weight of 80 kg (including an 18 kg battery).
Since then (about 2005) new European rules for electric bicycles have set a limit of 250 Watts for the category of motor assisted bikes (pedelecs).

The last 10 years has seen many new electric motor systems for bikes and velomobiles. You can now get them as crank, middrive or hub motors, and the battery technology has improved a lot. The organization Extra Energy (www.extraenergy.org) has played an important part in the promotion and testing of e-bikes and pedelecs.

Pedelecs and E-bikes

Newer models of early practical velomobiles are now available as pedelecs or E-velomobiles.

^ Leitra pedelec available with hub-motor, crank or middledrive — not as e-bike.

Alleweder as e-bike or pedelec.

DIY design

The last 5 years has been a period with high activity by homebuilders and DIY (Do-It-Yourself) designers. The velomobile is now a very popular design object in schools, clubs, or for individual inventers and designers. Many different materials have been taken into use in order to make a practical velomobile more affordable, lighter, easier to maintaine and suitable for a specific purpose. Individual styling creates identity, and that is part of the fun by the design process. The Internet is crowded by DIY-projects and open source design, CAD-designs and even programs for 3-D scanning.

Super light designs:

Danish nylon fabric.

MEUFL, design with PE-foam by Harald Winkler.

The French Mosquito.

Dutch Plywood.

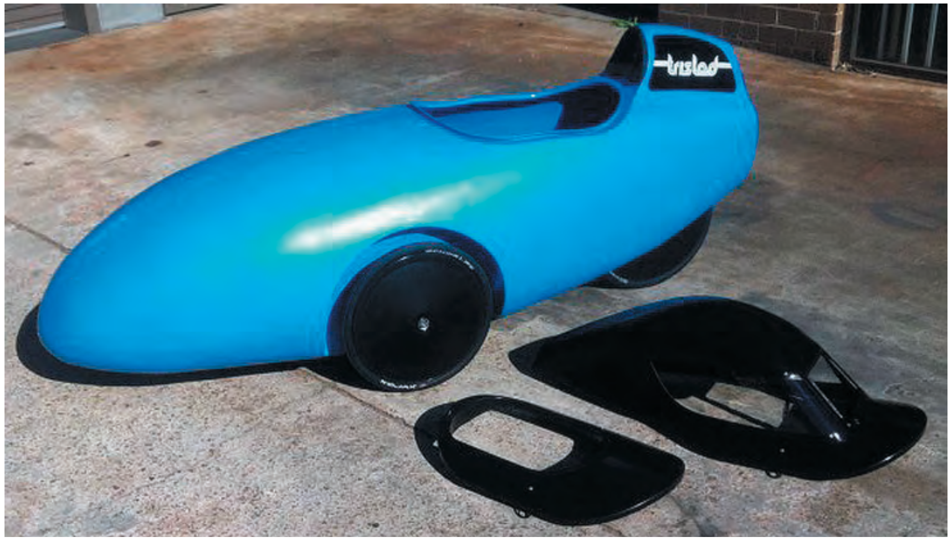
Emerging market for semi-production and components

For those who want to build their own velomobile, there are plenty of opportunities to get semi-produced components from professional velomobile producers.

Fairings, which is an essential part (but expensive in time and equipment to build), are available in different models. They can be combined with trikes from different producers - or with a homebuilt recumbent.

Arcus fairing, Finland

Wildcat, Denmark



Rotovelo, Australia

Boralis, Canada

Young entrepreneurs

The World needs more sustainable means of individual transportation, and the velomobile is an obvious candidate. Therefore, schools and technical universities show an increasing interest in subjects and projects related to light vehicles. Practical training in velomobile design and manufacturing takes place in cooperation with industry.
As an example, the Leitra company has hosted many international engineering students on internships and trainee projects, some with the support of a 6 month grant from EU.

New company, www.velovergne.fr, started with license production.

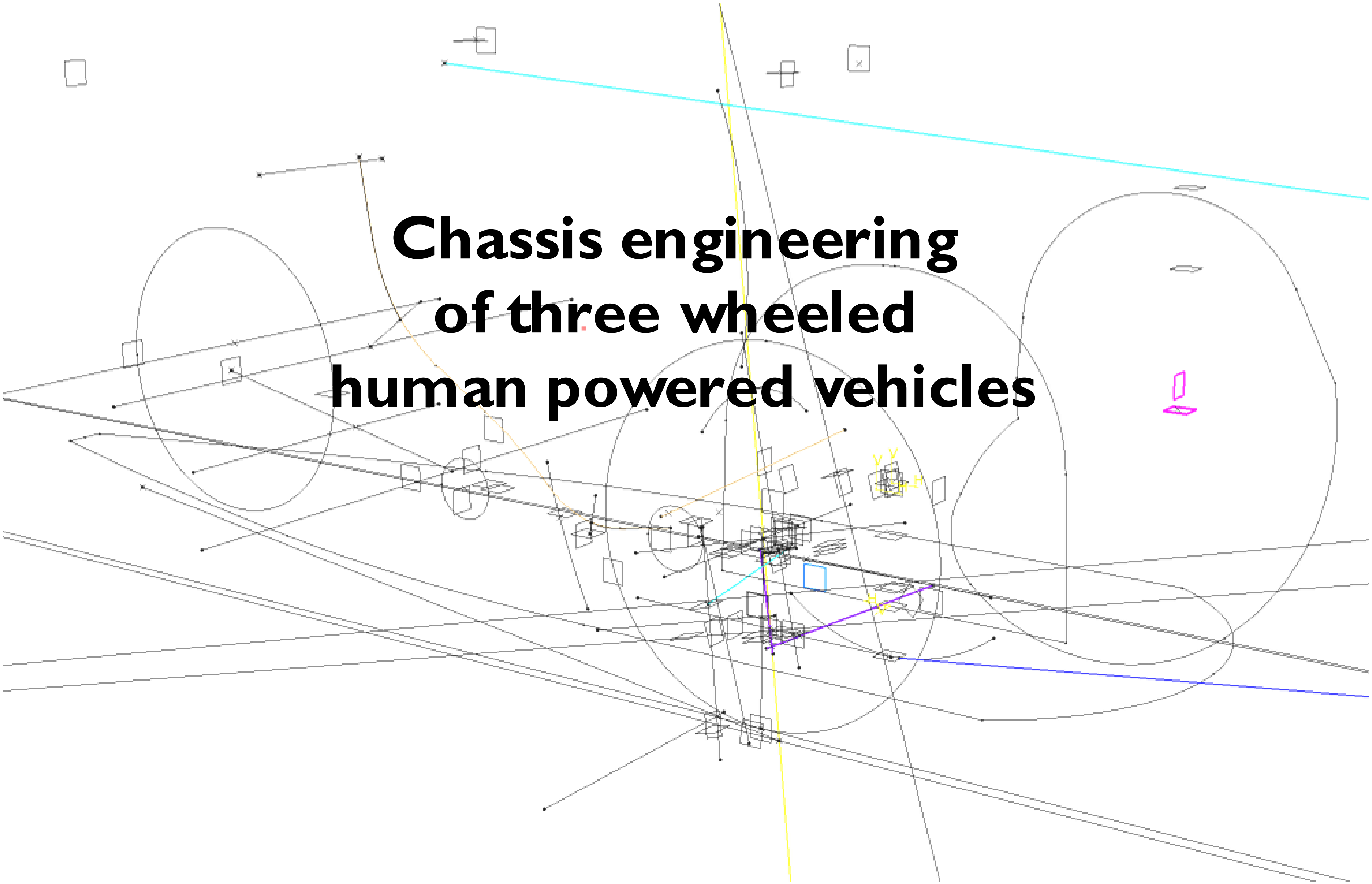
Some students have established their own companies as velomobile producers and dealers. One of them, Sylvain Lemoine, of Velovergne in France, received, together with Leitra DK ApS (host company), a 3rd place prize in a competition organized by the EU program ERASMUS for Young Entrepreneurs. The total number of velomobile producers and dealers is growing year by year – so there is hope for the future.

Modern life style – a paradox

What do you see here? One of the many fitness centers, which sprout up everywhere like mushrooms in the autumn. Exercise has become big business.
People take their car to the fitness center, pay a tidy fee for sitting an hour spinning on a stationary exercise cycle, then they drive home again by car. I pass several such centres on my way to work. 50 cars are parked in front of the show windows – seldom you see a bicycle.

I am happy with my mobile fitness training machine, a velomobile, free of charge.

Chassis engineering of three wheeled human powered vehicles



Who I am

Martin Wöllner

- born 1980
- recumbent enthusiast since 1994
- Diploma Engineer for Automotive Engineering
- University of Applied Sciences (FH) Zwickau, Germany

- body engineer at Neoplan Coach company

- design engineer at HP Velotechnik
  recumbent bicycle company since 2007

- first velomobile "woe-low" in 2009
- second velomobile "eXXos" in 2011

Content

What We Are Talking About
- chassis basic terms
- basics about kinematic parameters
- the goals of chassis engineering

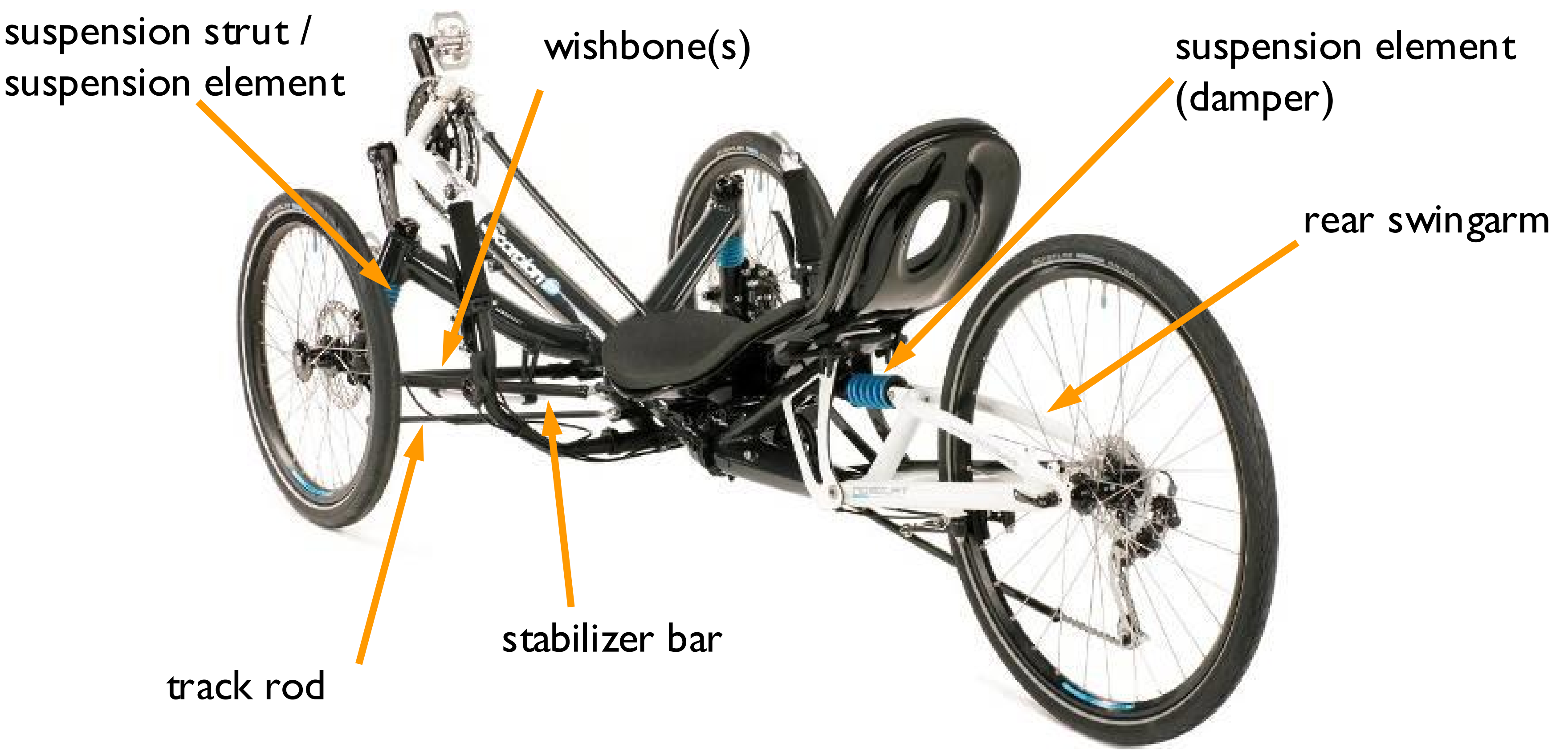
The Front Axle
- front axle designs
- front axle kinematic parameter changes
- forces on front wheels
- front axle suspension
- steering

The Rear Axle
- rear swingarm
- influence of chain tension / chainline

Basic terms

Chassis basics

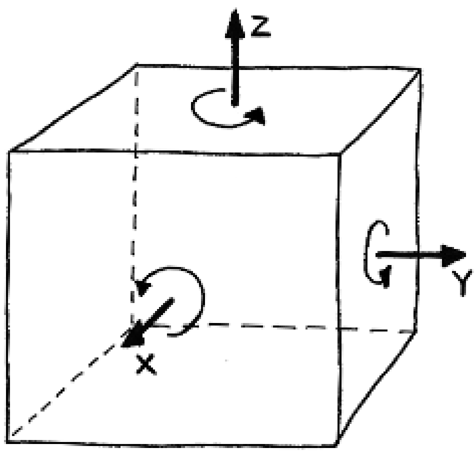
Chassis or running gear is all parts that functionally connect a vehicle's wheels to the frame or selfsupporting body.

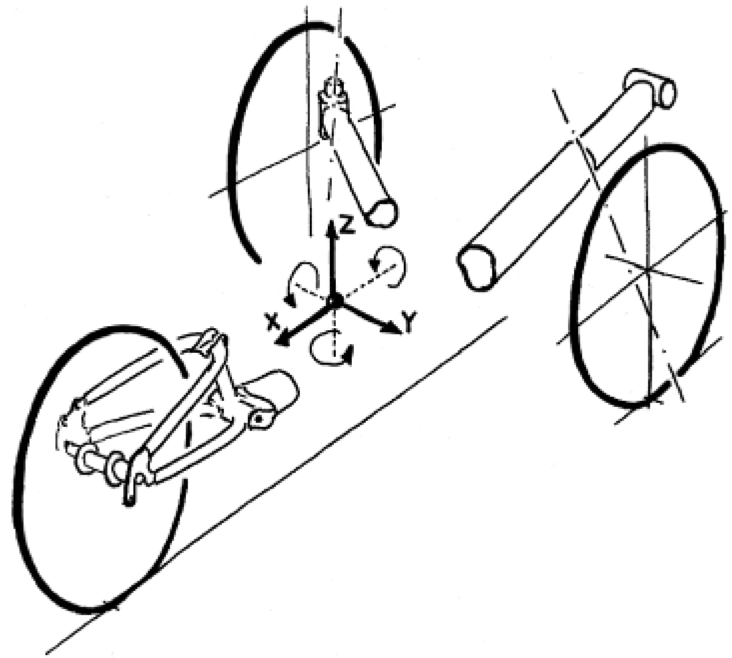


Kinematic parameters

Vehicle movements

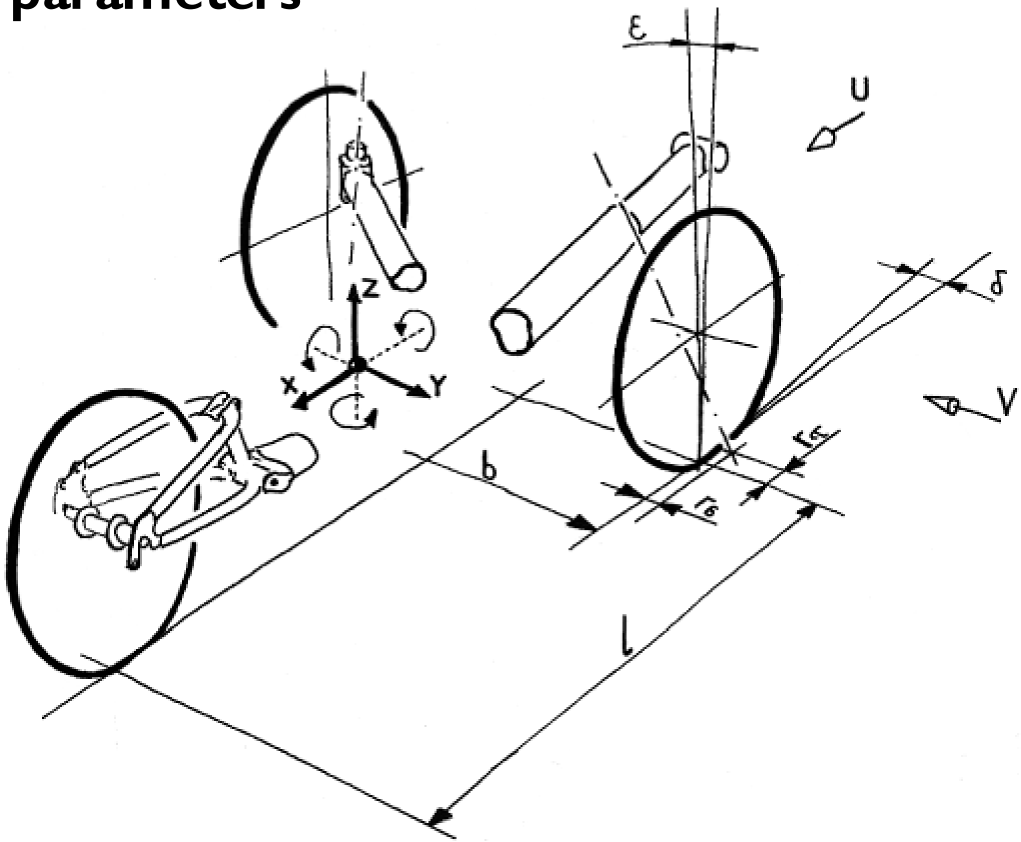
6 degrees of freedom





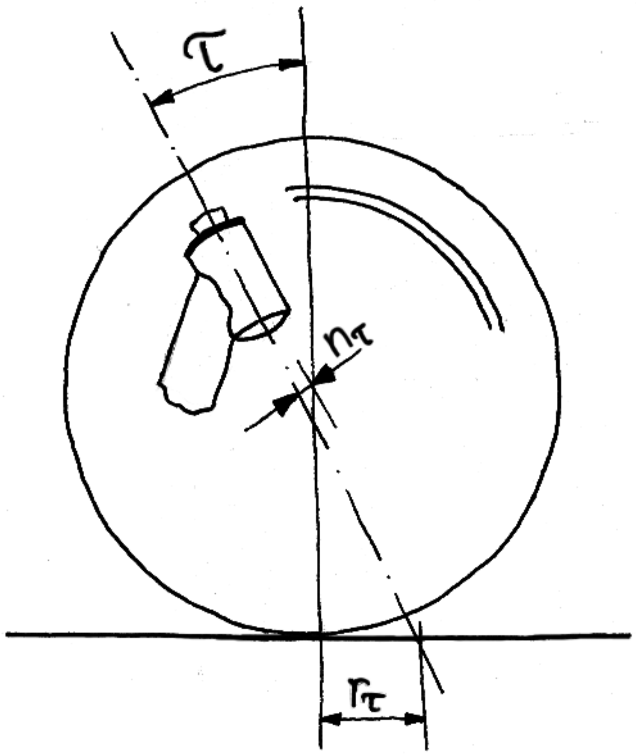
axis	**linear movement**	**rotational movement**
x-axis	-drive	-roll
y-axis	-slide	-pitch
z-axis	-suspend	-yaw

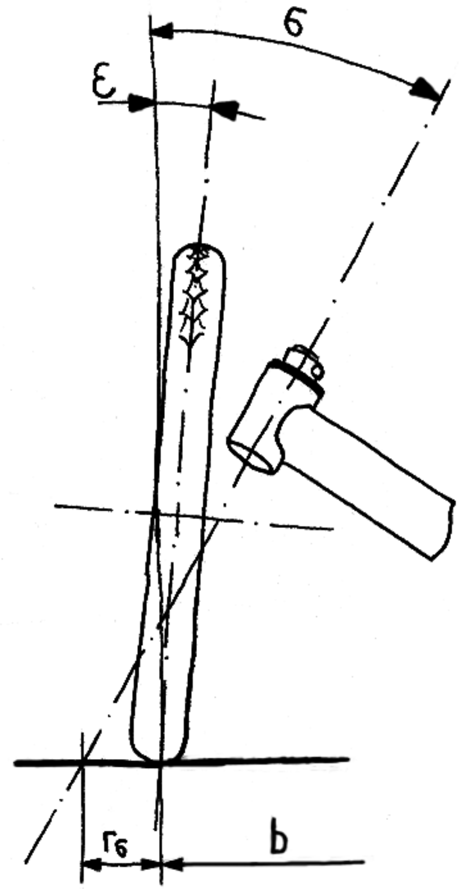
Basic kinematic parameters



Values of kinematic parameters and their alteration while riding are determined by chassis design.

Basic kinematic parameters





caster angle τ
trail r_τ
trail offset n_τ
(toe angle δ)

spread angle σ
camber angle ε
scrub radius r_σ
track width b

brake force lever r_b
longitudinal force lever r_a
vertical force lever q
...

Goals of chassis engineering

Design goals

(high) Rider comfort

- suitable suspension travel
- good response characteristic
- proper direction of deflection
- roll reduction
- control at higher speeds
- low tire noise transfer

(optimum) Vehicle handling

• predictability
• intuitivity
• safety

- defined wheel positions
- specific wheel movements
- controlled body movements
- independent motion of all wheels
- advantageous force distribution into the body (stiffness)

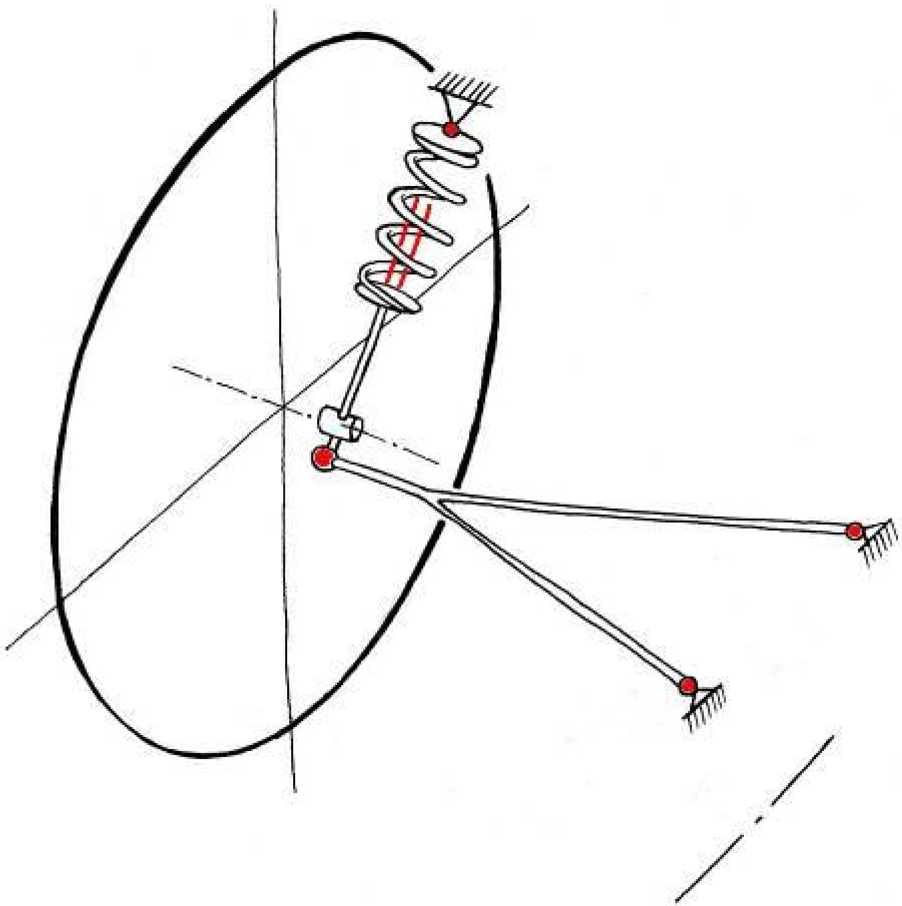
additionally
small installation space, low mass, easy to access, easy to adjust, high life span, low cost, styling issues ...

Front axle designs

Front axle designs

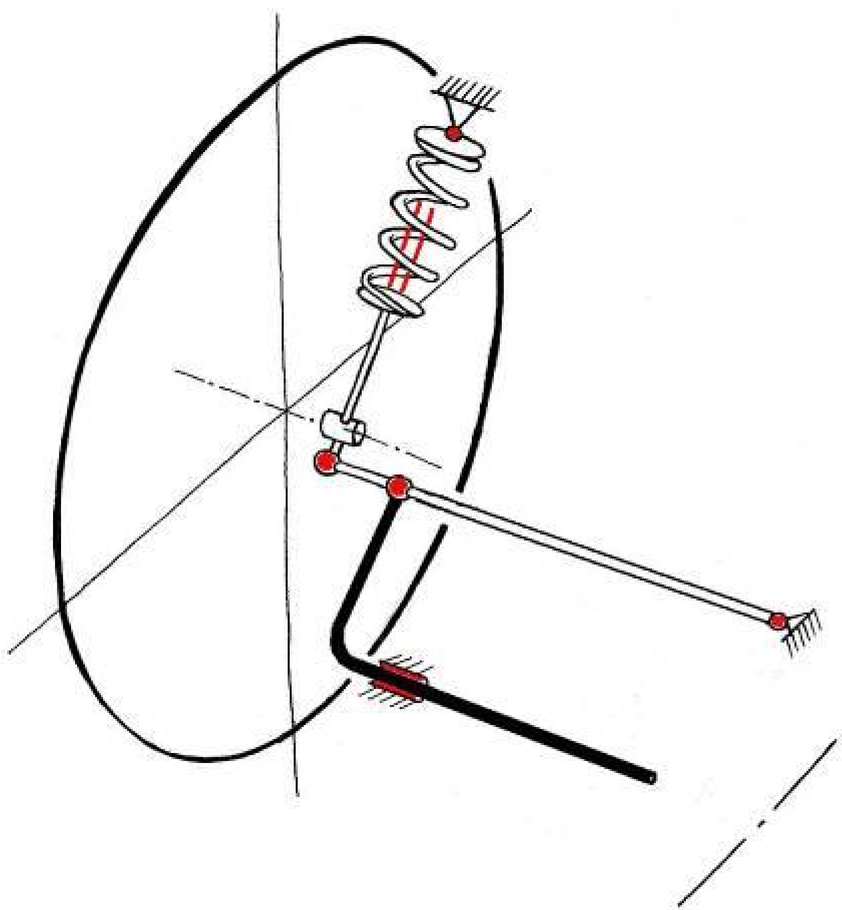
Wheel guiding suspension strut with single wishbone

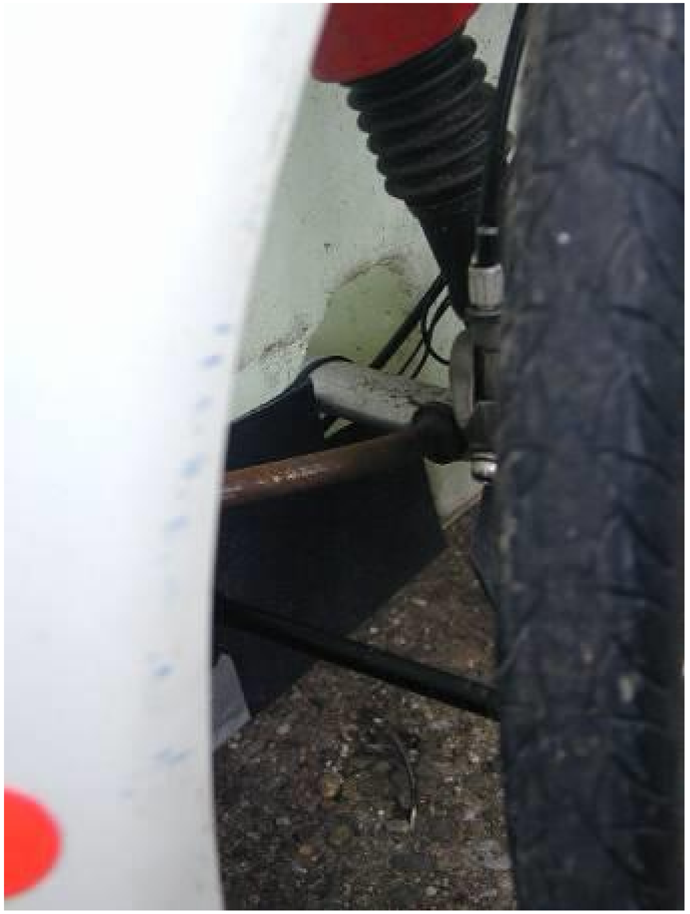
"McPherson axle"



Front axle designs

Wheel guiding suspension strut with single wishbone beam and stabilizer
McPherson axle





Front axle designs

Double wishbone

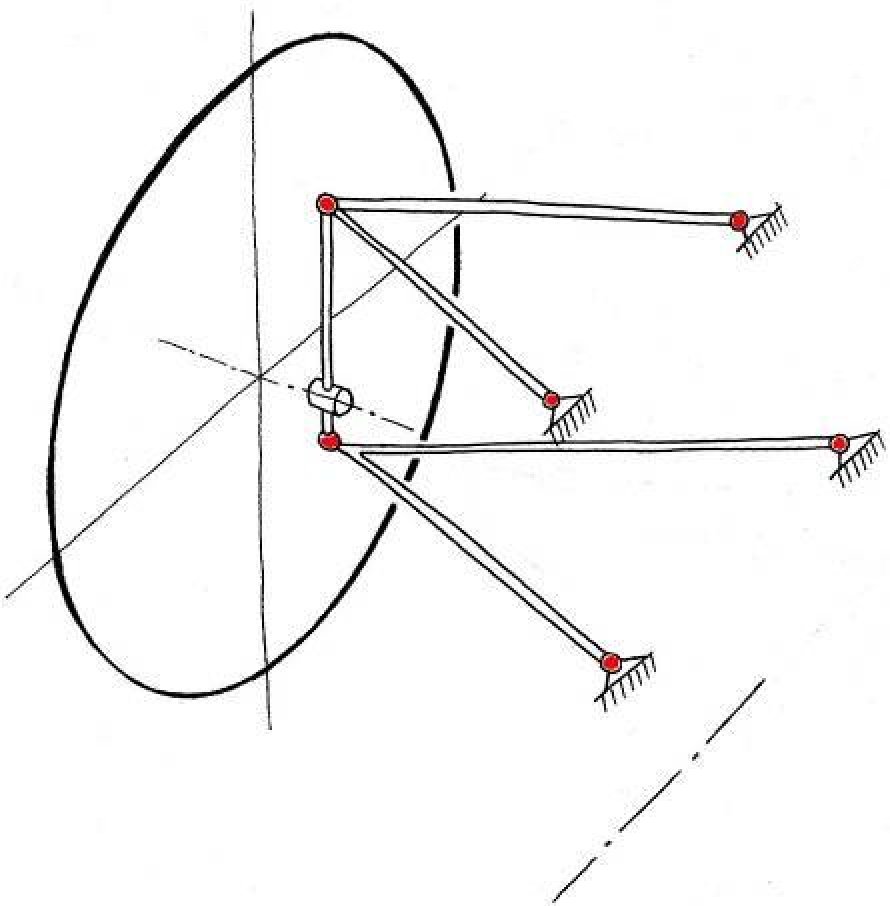


photo by Arno Schröder

photo by Bike Revolution

Front axle designs

Swing axle

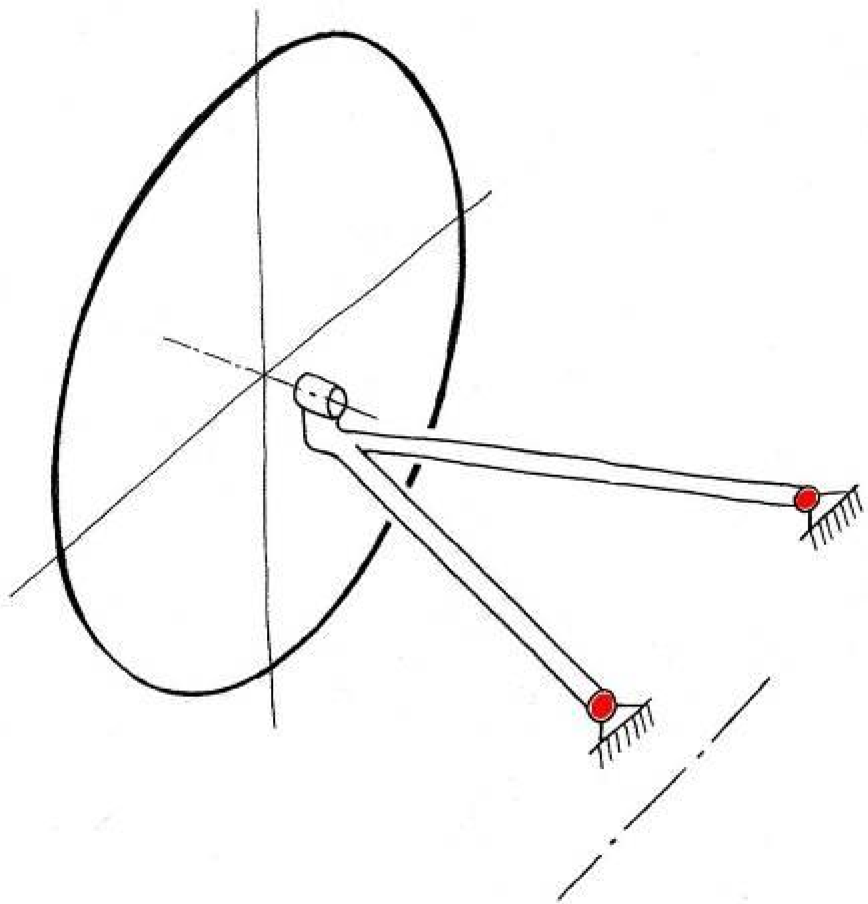


photo byligfiets.net

Front axle designs

Wheel guiding suspension strut

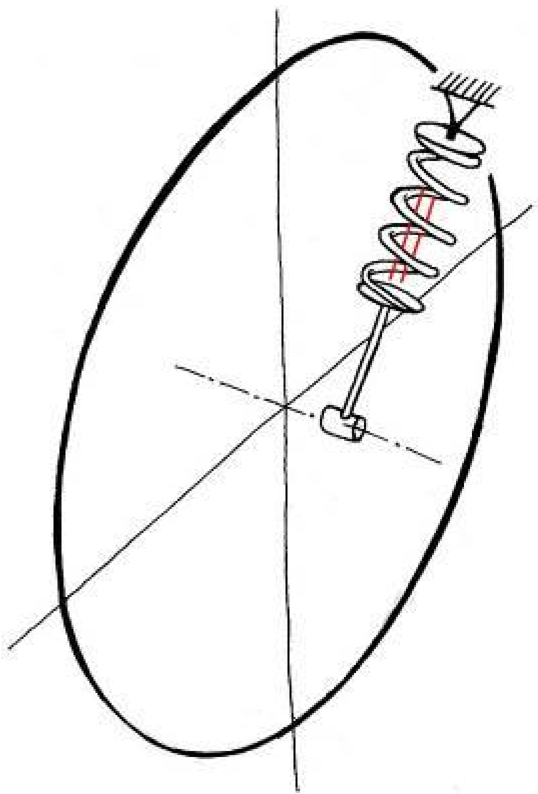


photo by ewok/velomobilforum.de

Front axle designs

(Semi) Trailing arm / leading arm

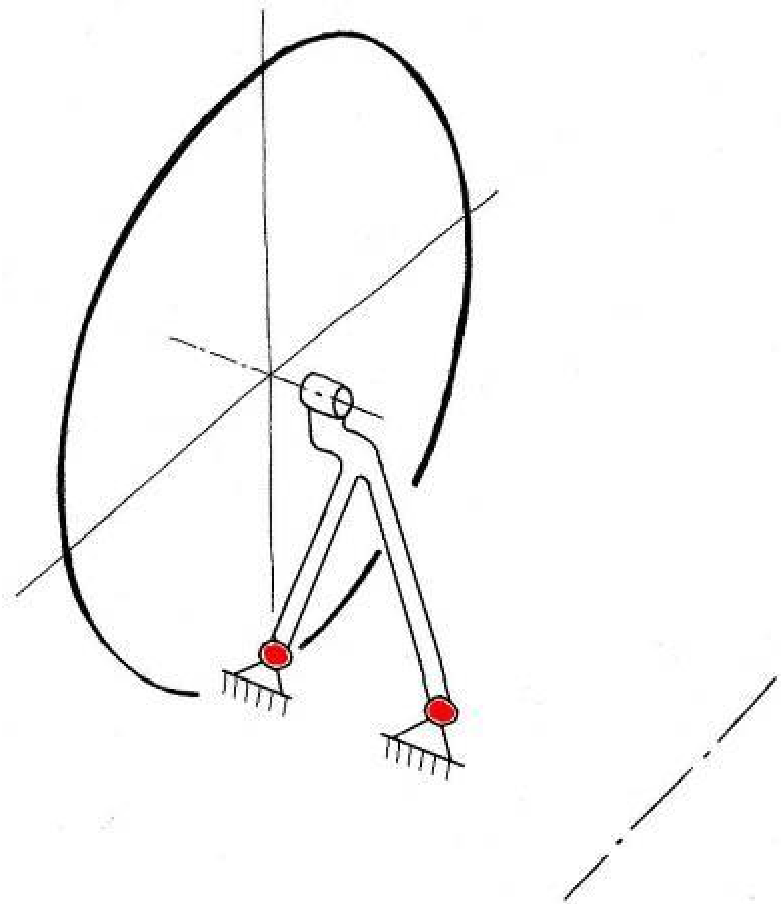
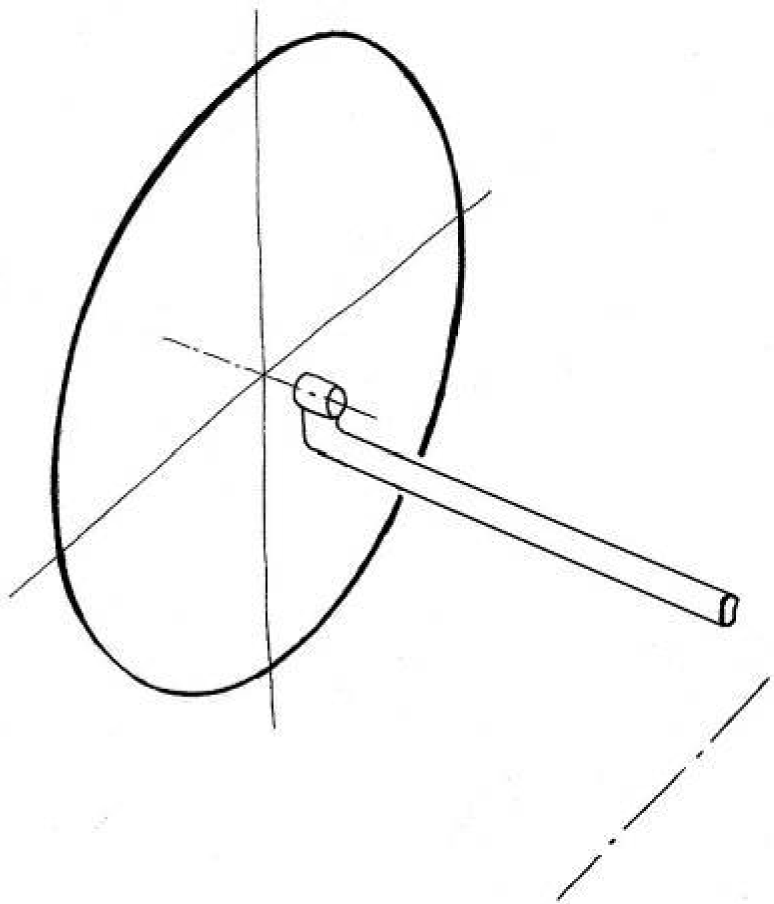
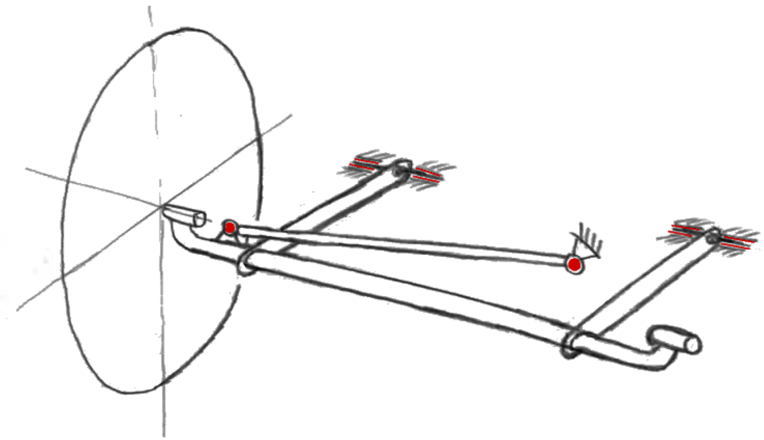


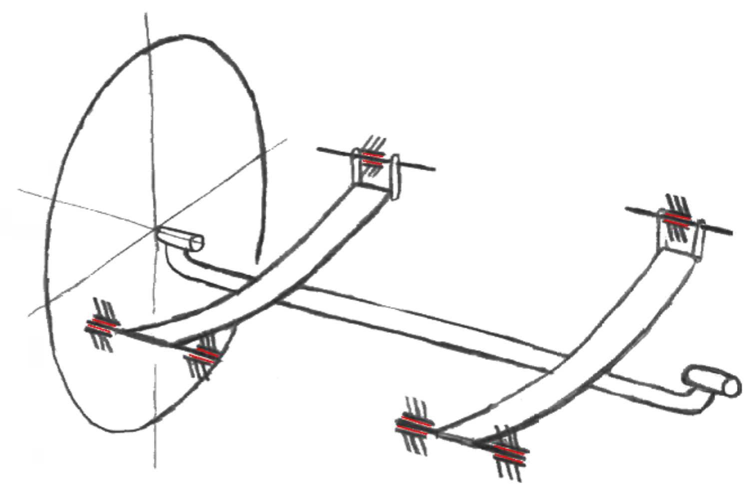
photo by Peregrine Bicycle Works, Inc.

Front axle designs

Rigid / beam axle



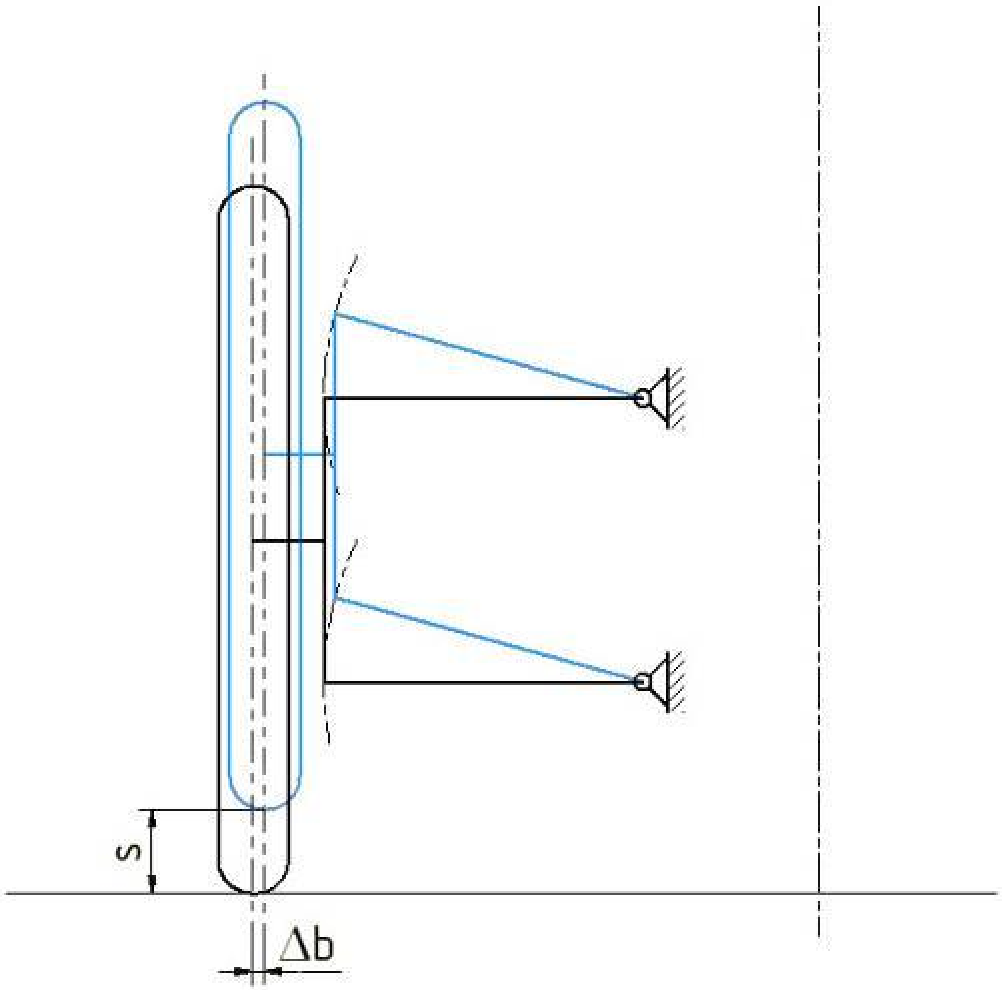




Kinematic parameter changes

Kinematic parameter changes

Track width



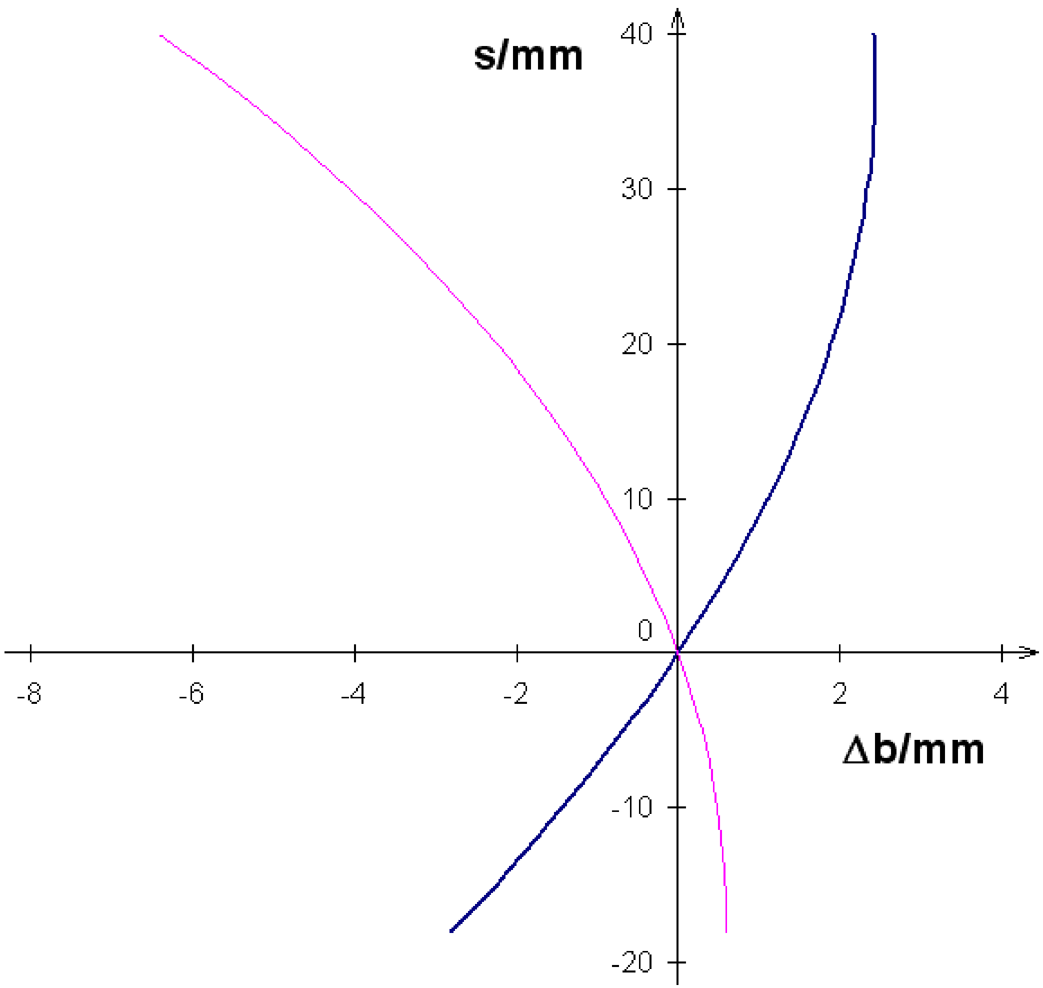
track width changes while suspension deflects

- bad longitudinal stability
- tire wear

➔ change should be as small as possible

Kinematic parameter changes

Track width



track width changes while suspension deflects

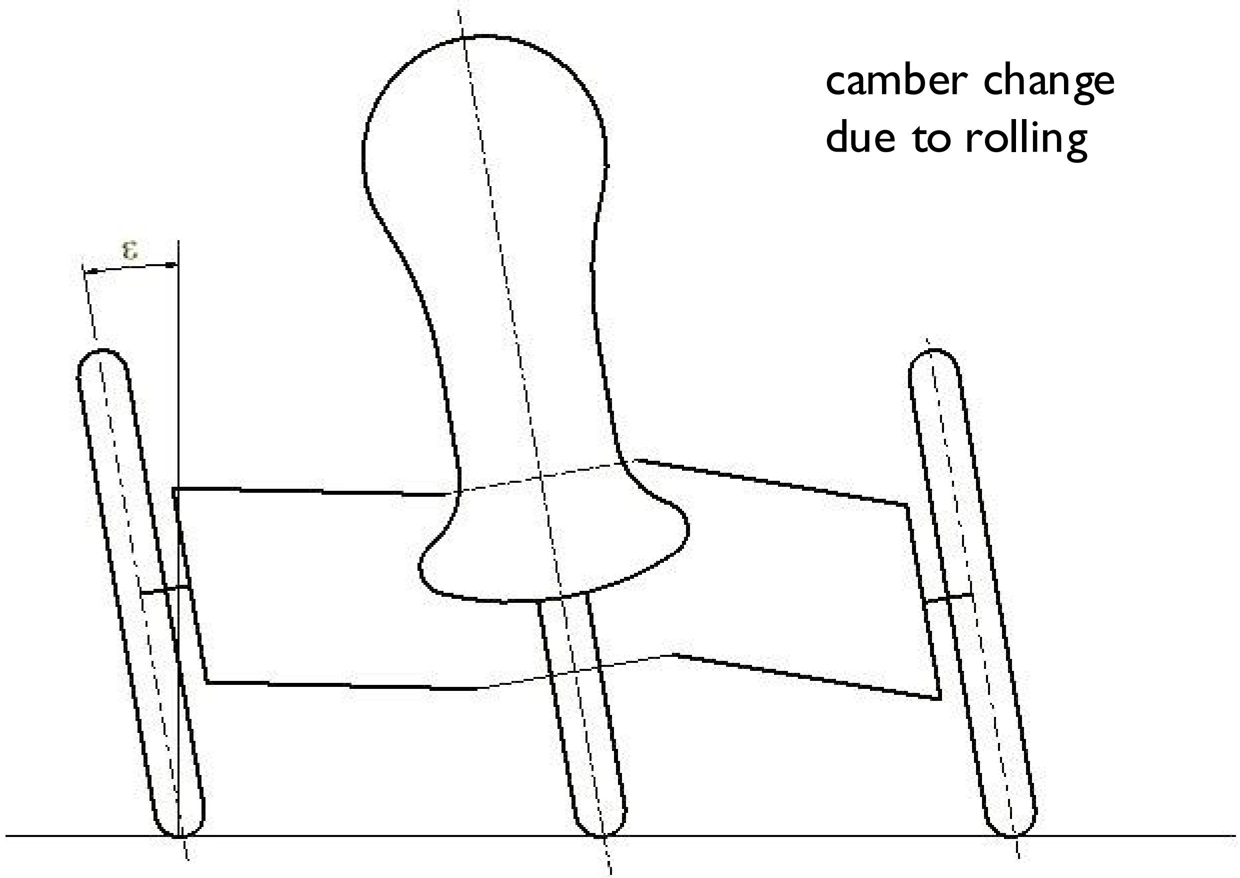
- bad longitudinal stability
- tire wear

➔ change should be as small as possible

Kinematic parameter changes

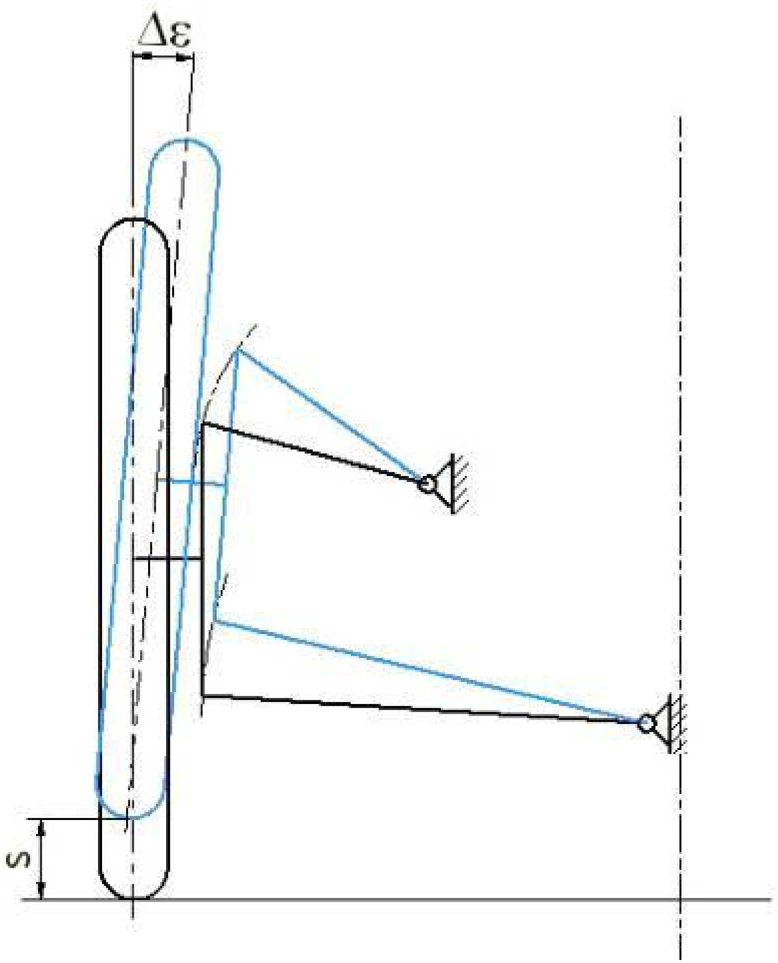
Camber angle

camber change
due to rolling



Kinematic parameter changes

Camber angle



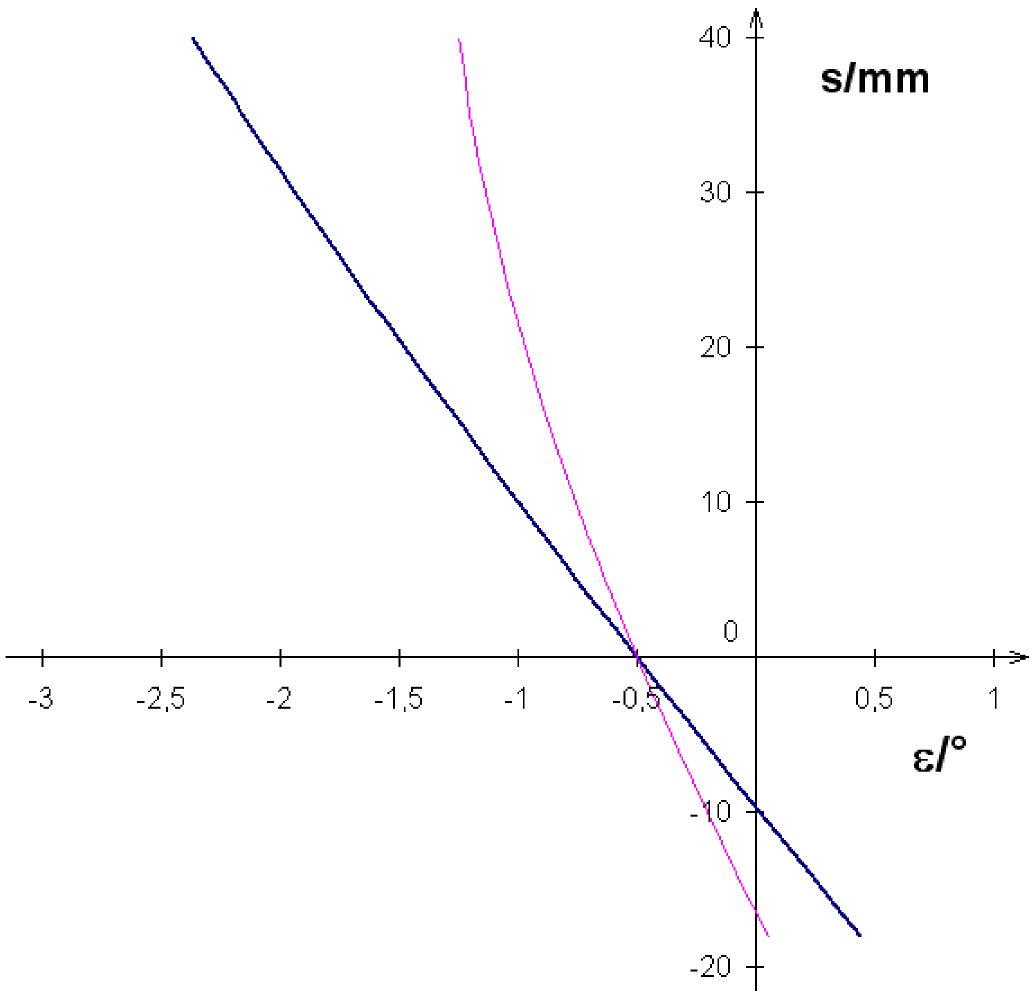
camber angle gets negative while suspension deflects

- compensates camber change due to rolling
- higher side forces can be established (more "grip")

➔ negative camber on outside wheel is a design goal

Kinematic parameter changes

Camber angle



camber angle gets negative while suspension deflects

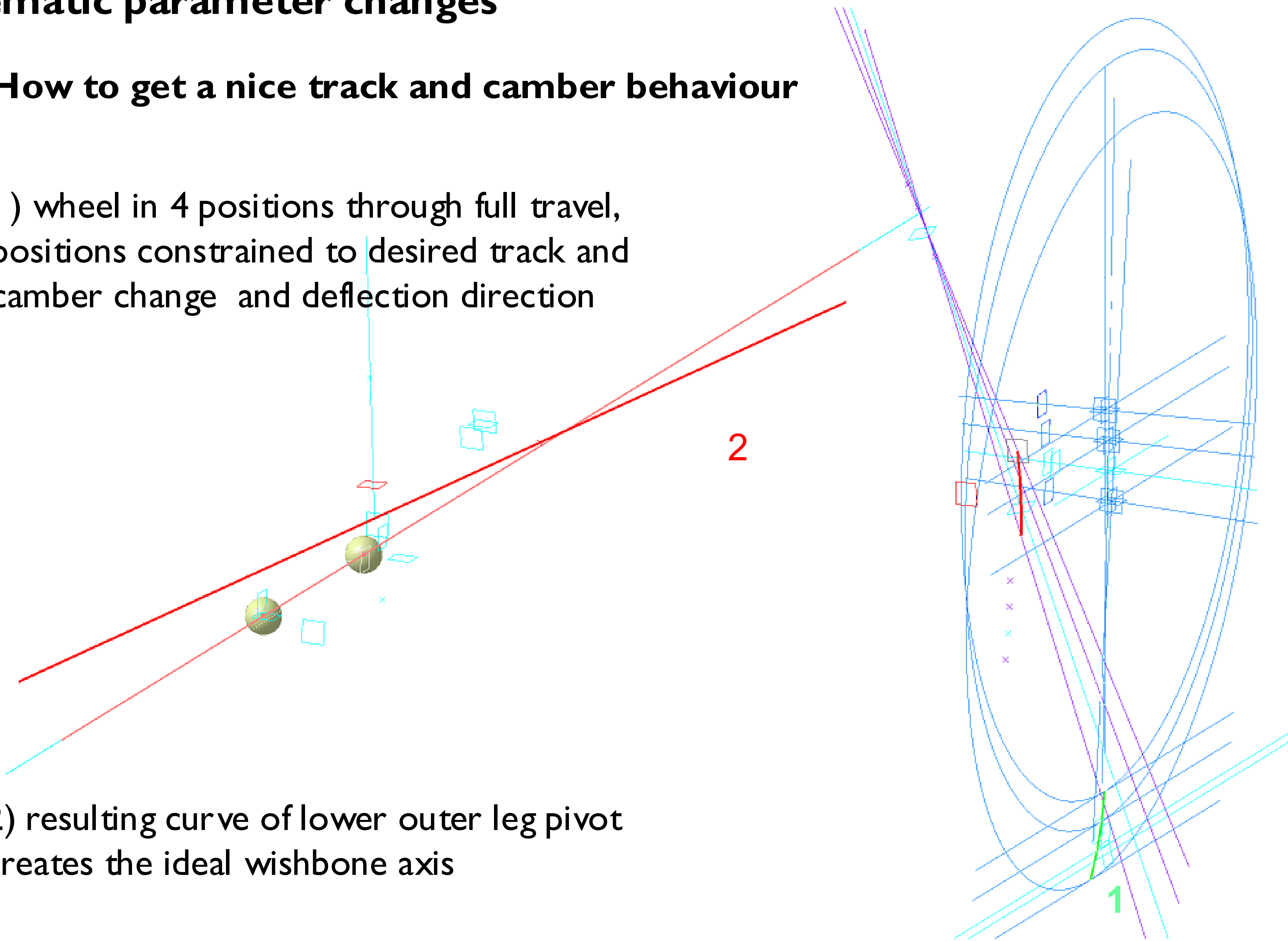
- compensates camber change due to rolling
- higher side forces can be established (more "grip")

➔ negative camber on outside wheel is a design goal

Kinematic parameter changes

How to get a nice track and camber behaviour

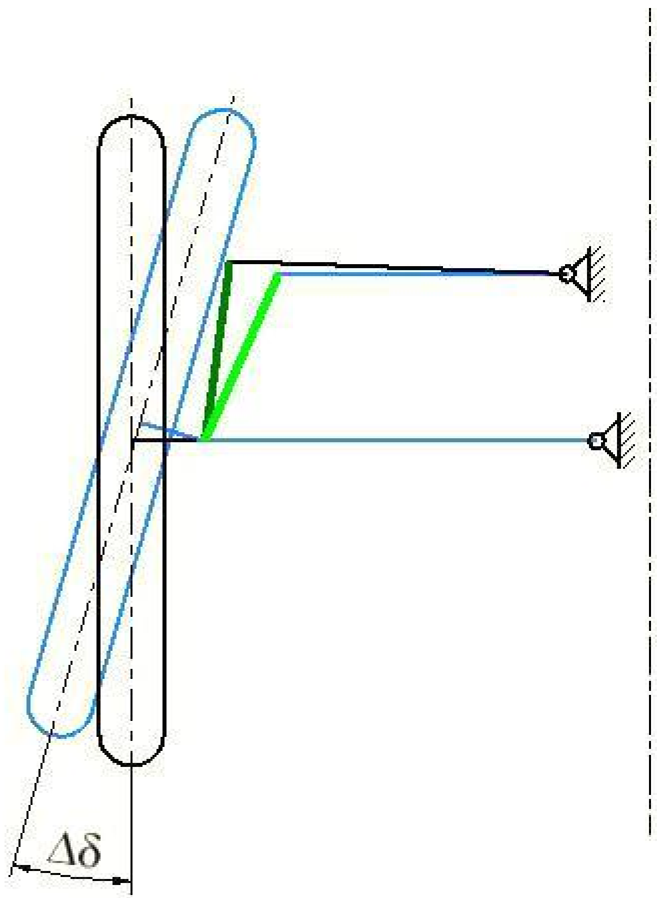
1) wheel in 4 positions through full travel, positions constrained to desired track and camber change and deflection direction



2) resulting curve of lower outer leg pivot creates the ideal wishbone axis

Kinematic parameter changes

Toe



toe may change while suspension deflects

change to positive toe
("V" opened to front)

- outside wheel goes toe-out while cornering: understeer behaviour - safe handling

change to negative toe
("V" opened to the back)

- front axle goes toe-in when braking: more longitudinal stability

toe change generally

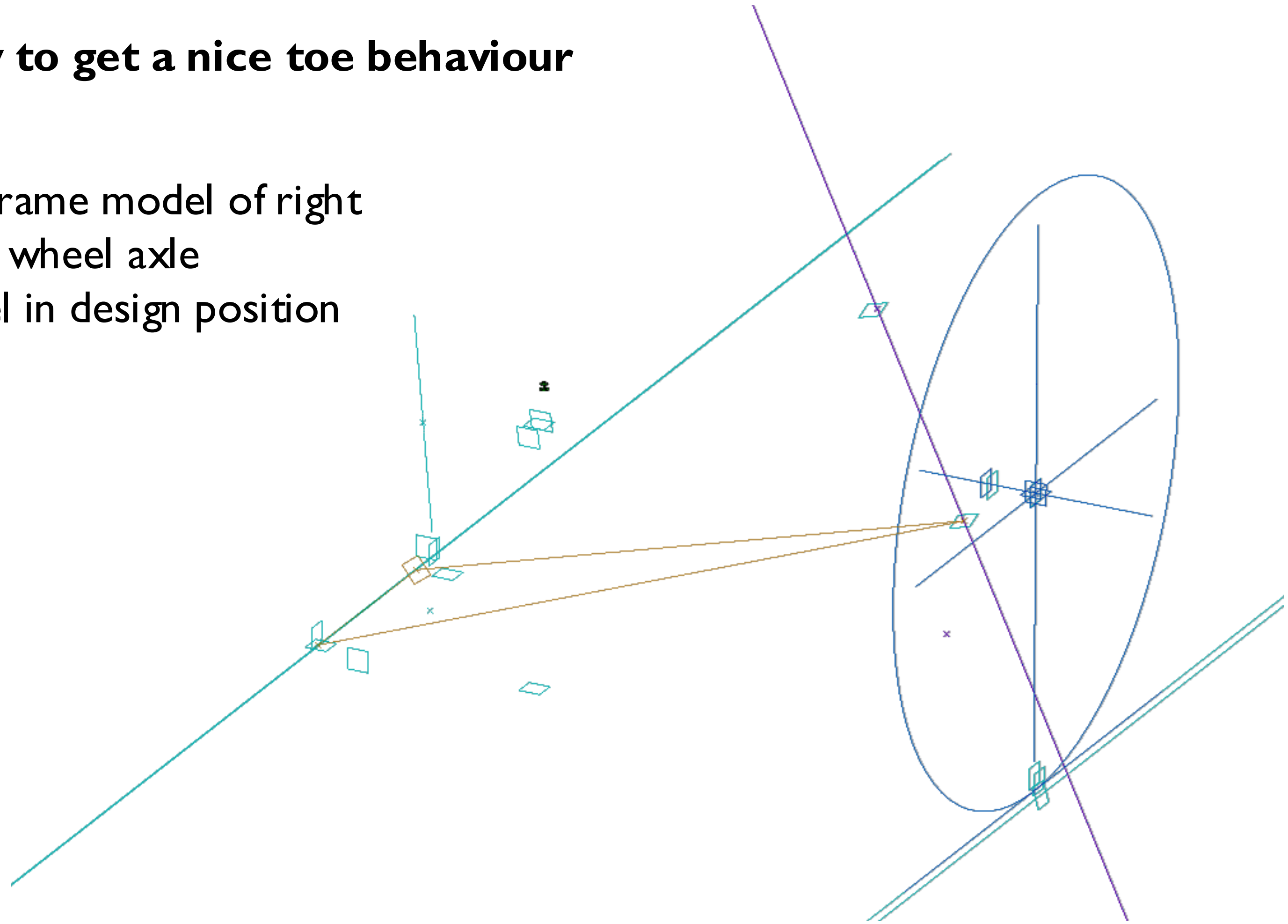
- tire wear
- unsteady behaviour

➔ toe change should be minimized

Kinematic parameter changes

How to get a nice toe behaviour

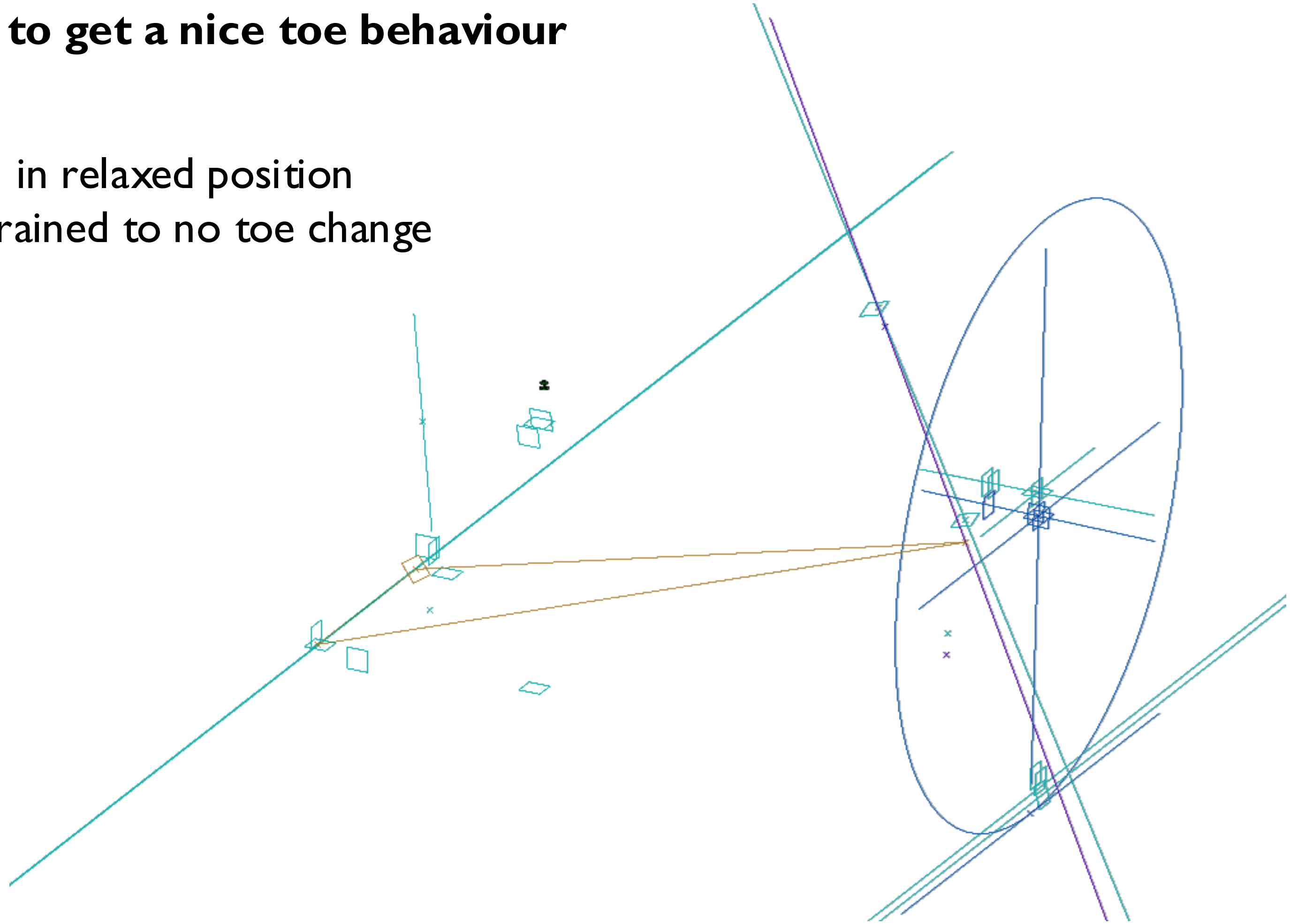
wireframe model of right
front wheel axle
wheel in design position



Kinematic parameter changes

How to get a nice toe behaviour

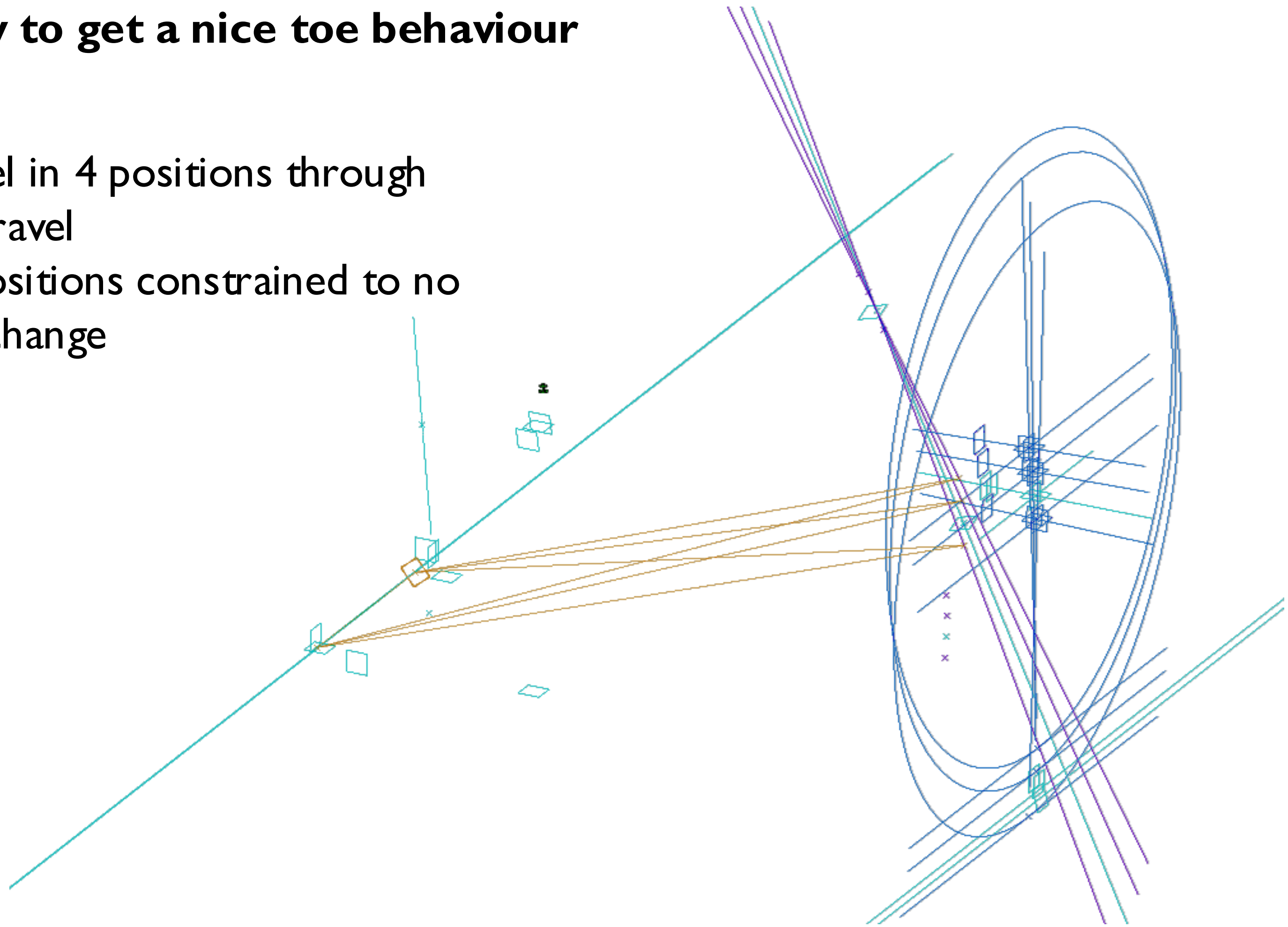
wheel in relaxed position
constrained to no toe change



Kinematic parameter changes

How to get a nice toe behaviour

wheel in 4 positions through
full travel
all positions constrained to no
toe change

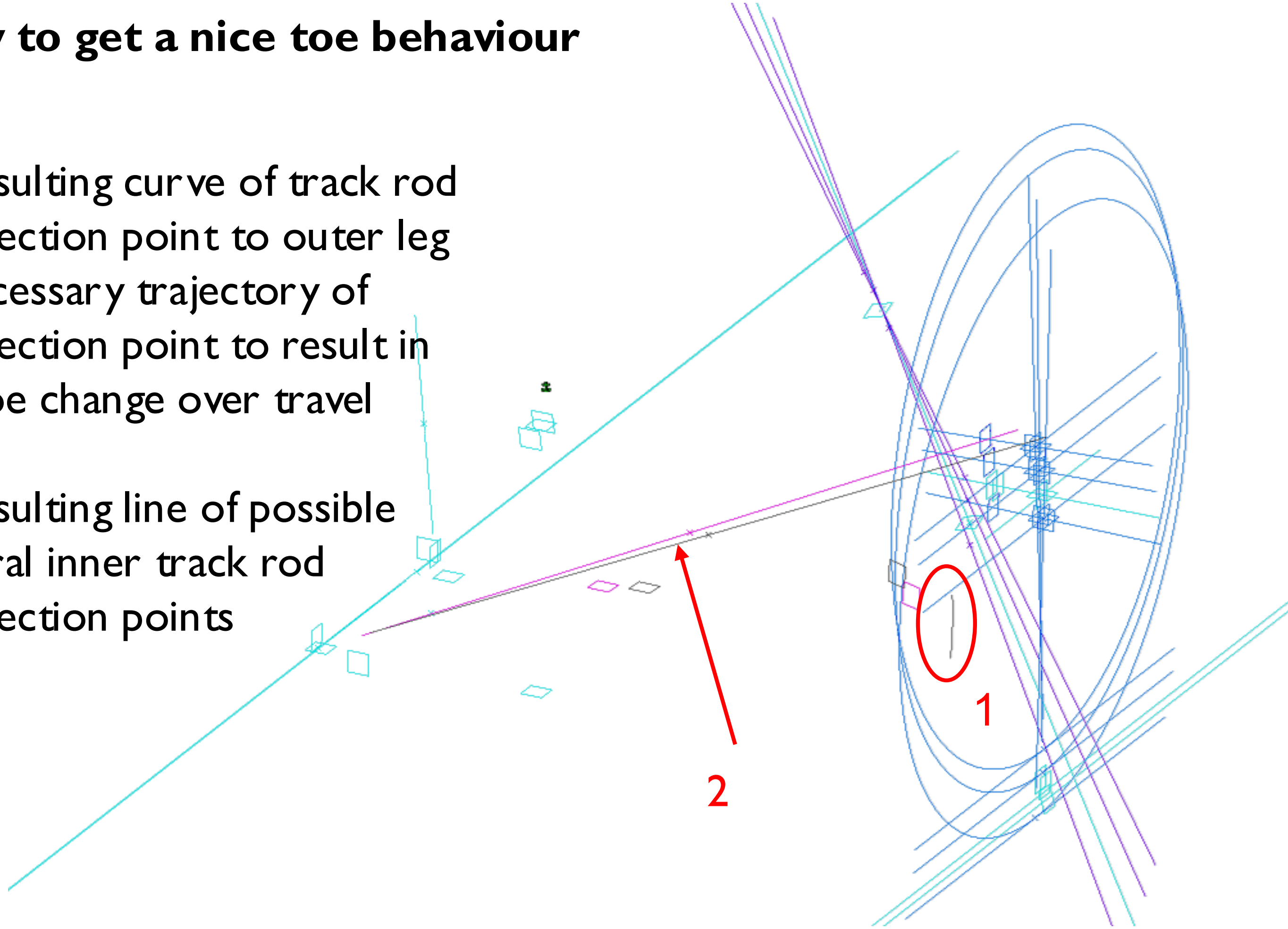


Kinematic parameter changes

How to get a nice toe behaviour

1) resulting curve of track rod connection point to outer leg = necessary trajectory of connection point to result in no toe change over travel

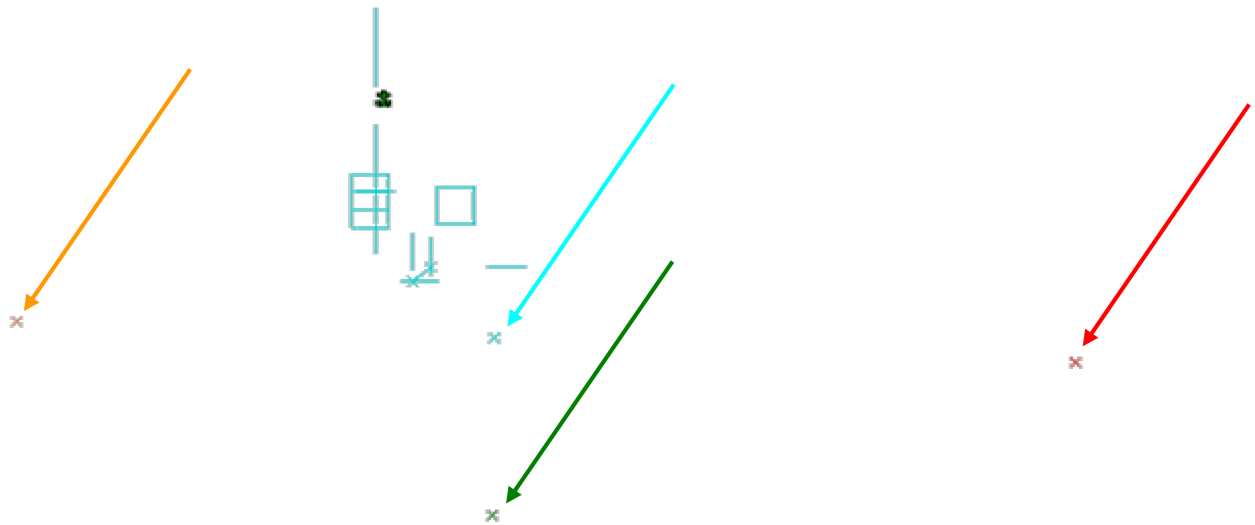
2) resulting line of possible neutral inner track rod connection points

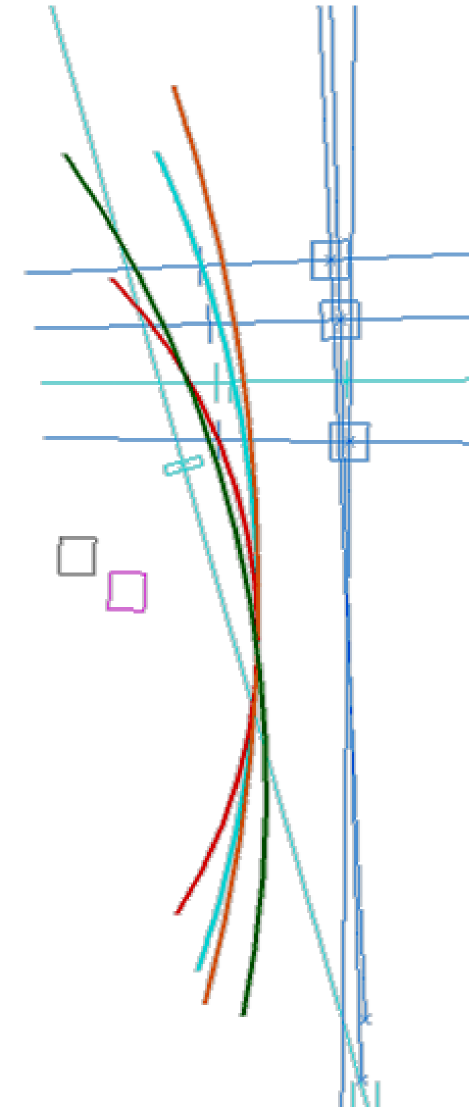


Kinematic parameter changes

How to get a nice toe behaviour

resulting curves of deviating
inner track rod connection points





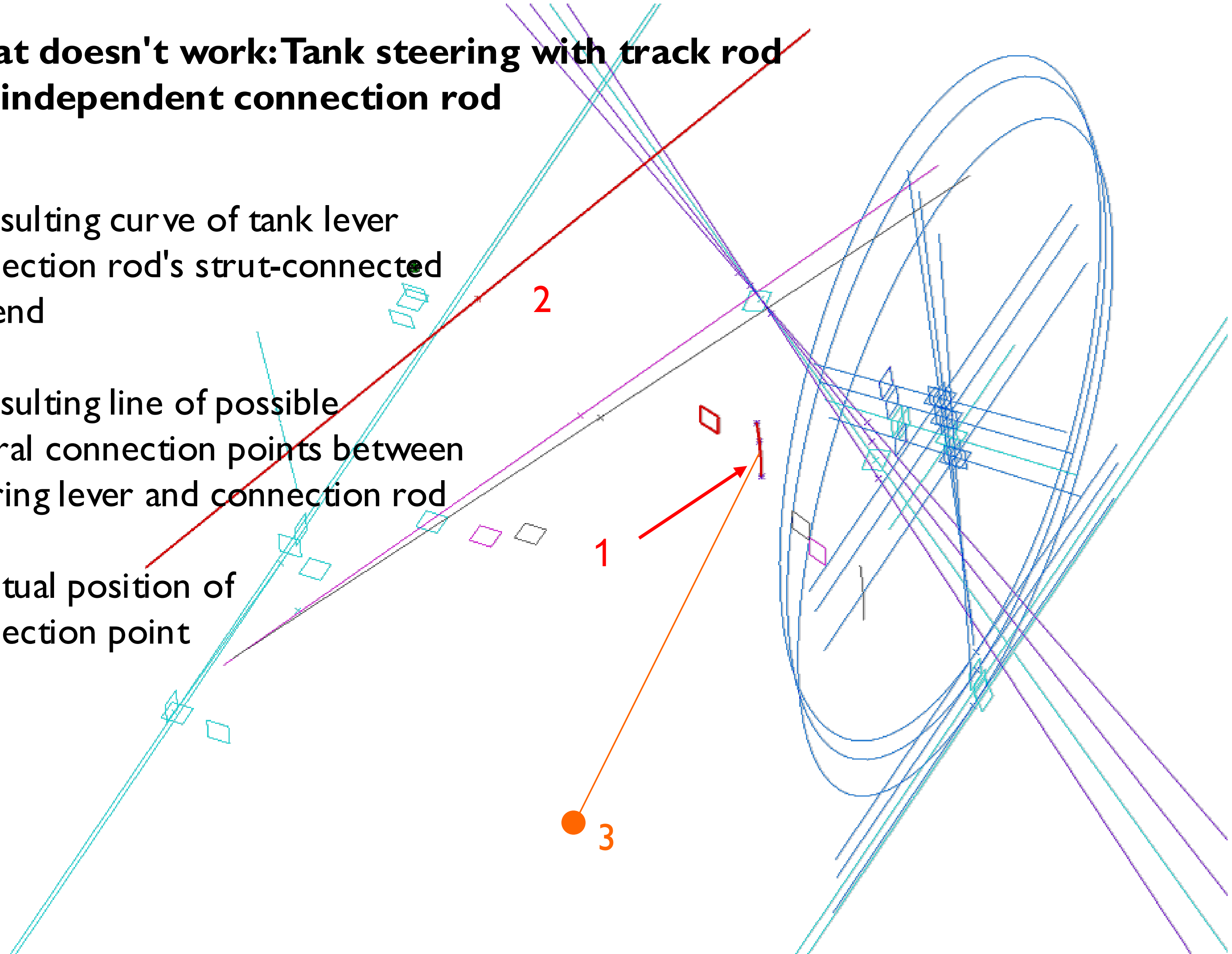
Kinematic parameter changes

What doesn't work: Tank steering with track rod and independent connection rod

1) resulting curve of tank lever connection rod's strut-connected ball end

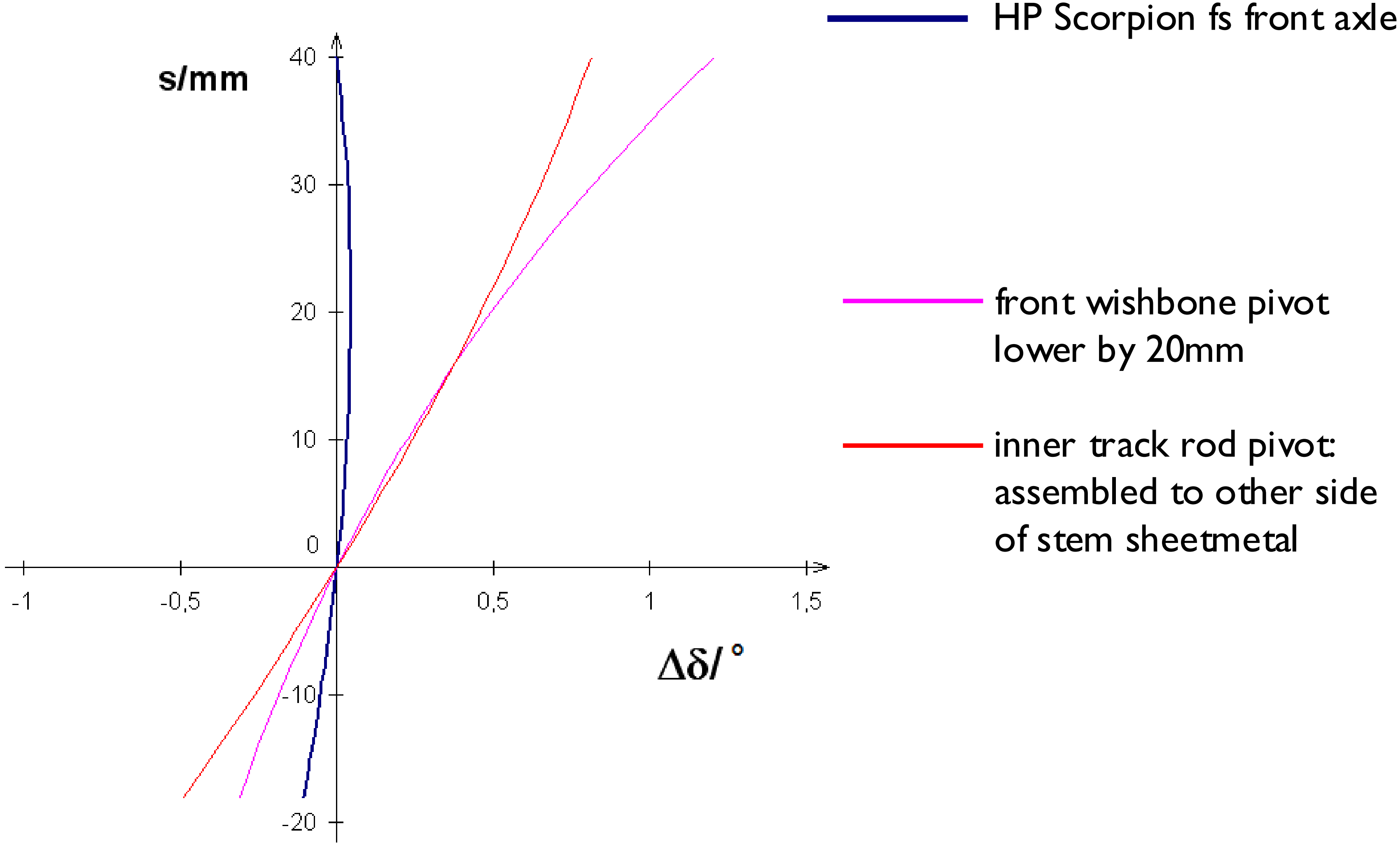
2) resulting line of possible neutral connection points between steering lever and connection rod

3) actual position of connection point



Kinematic parameter changes

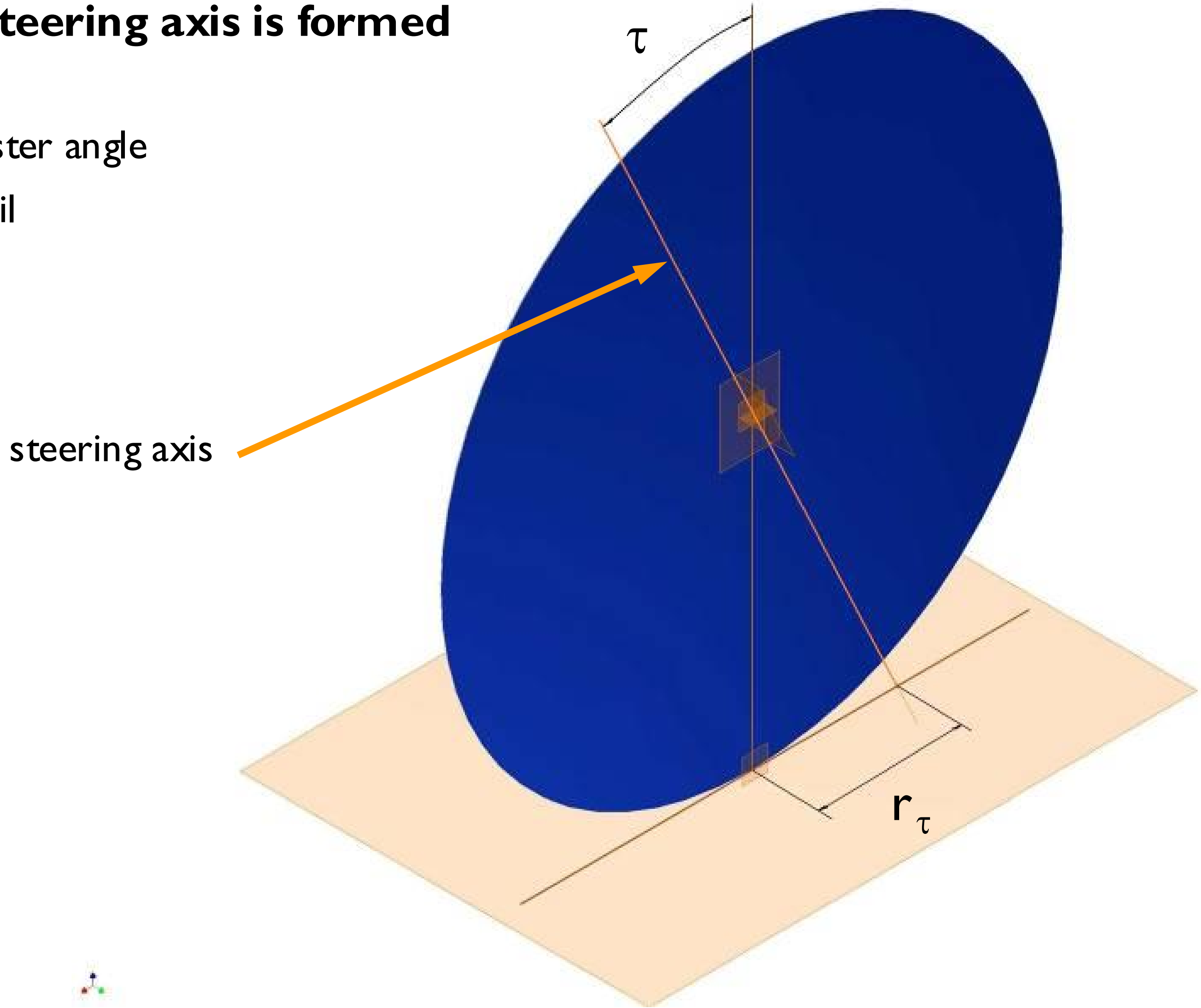
Toe



How a steering axis is formed

τ caster angle

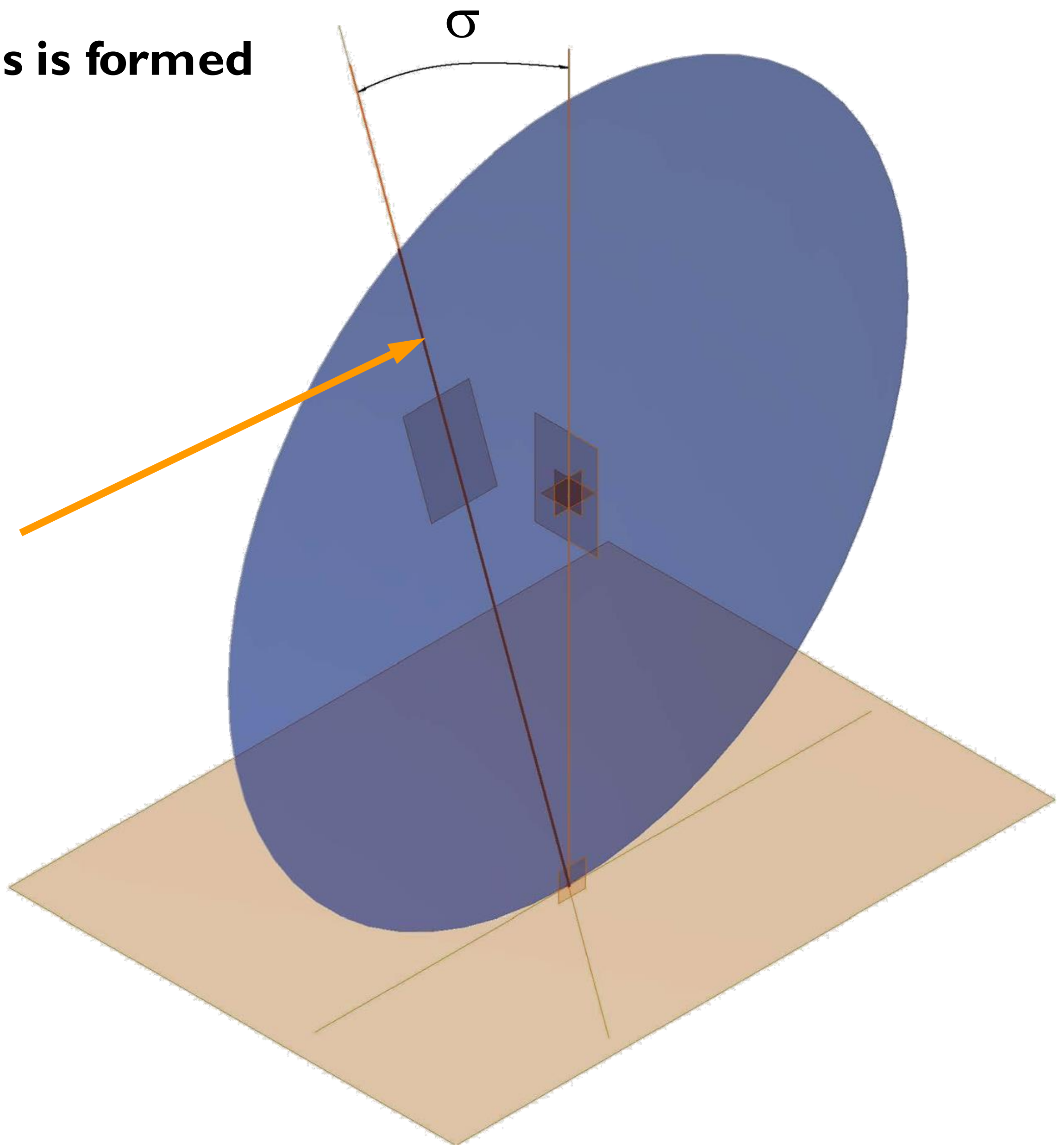
r_τ trail



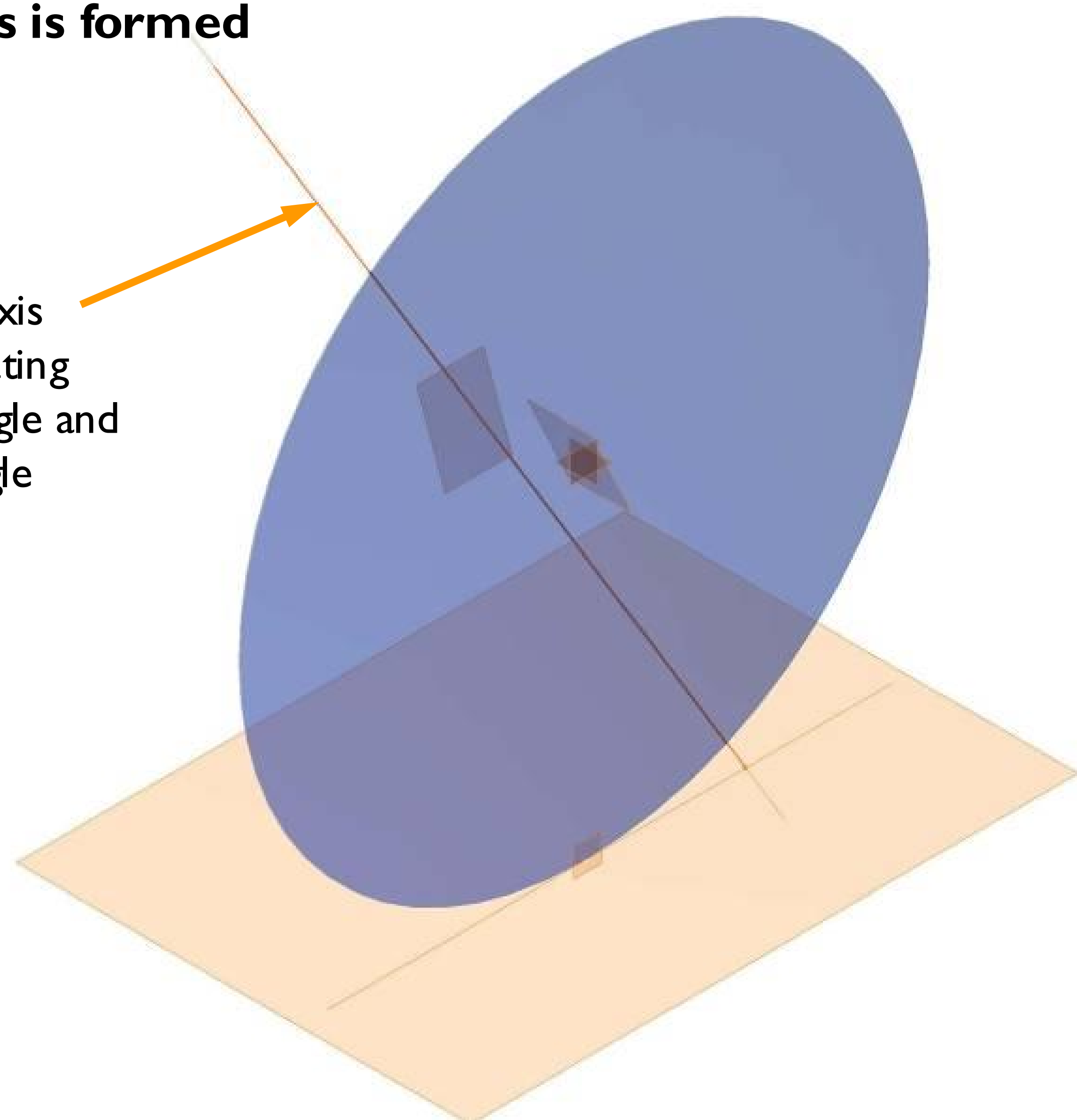
How a steering axis is formed

σ spread angle

steering axis



How a steering axis is formed

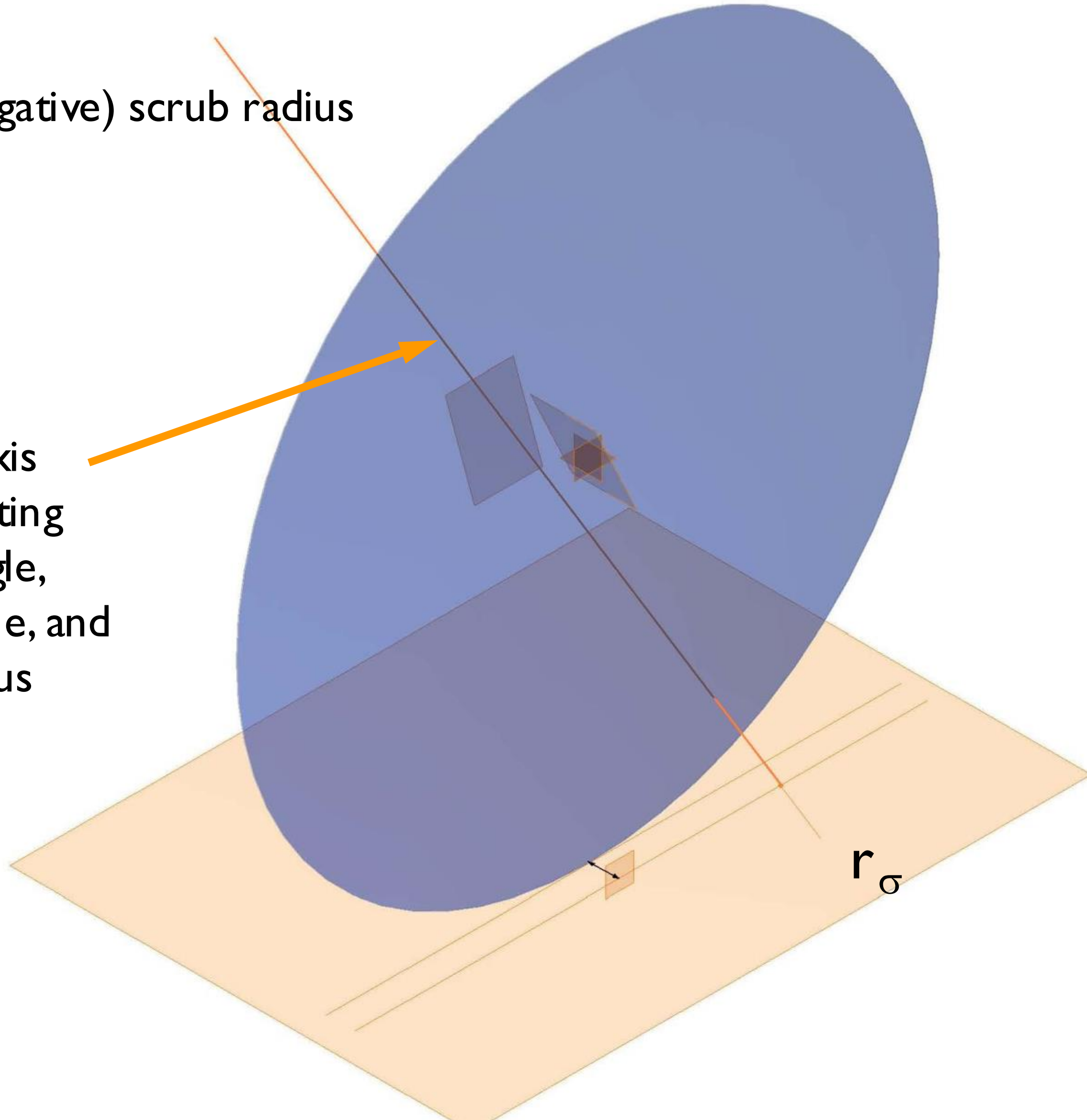


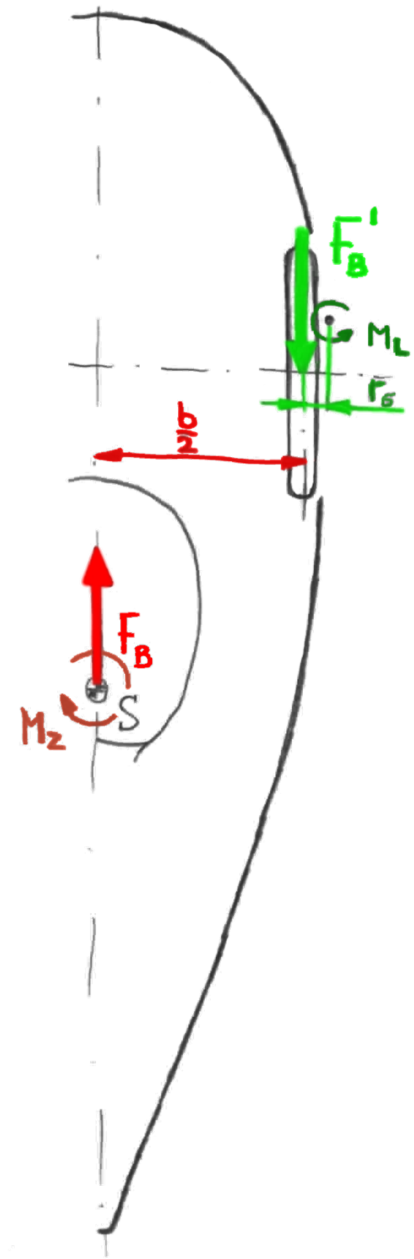
steering axis
incooperating
spread angle and
caster angle

How a steering axis is formed

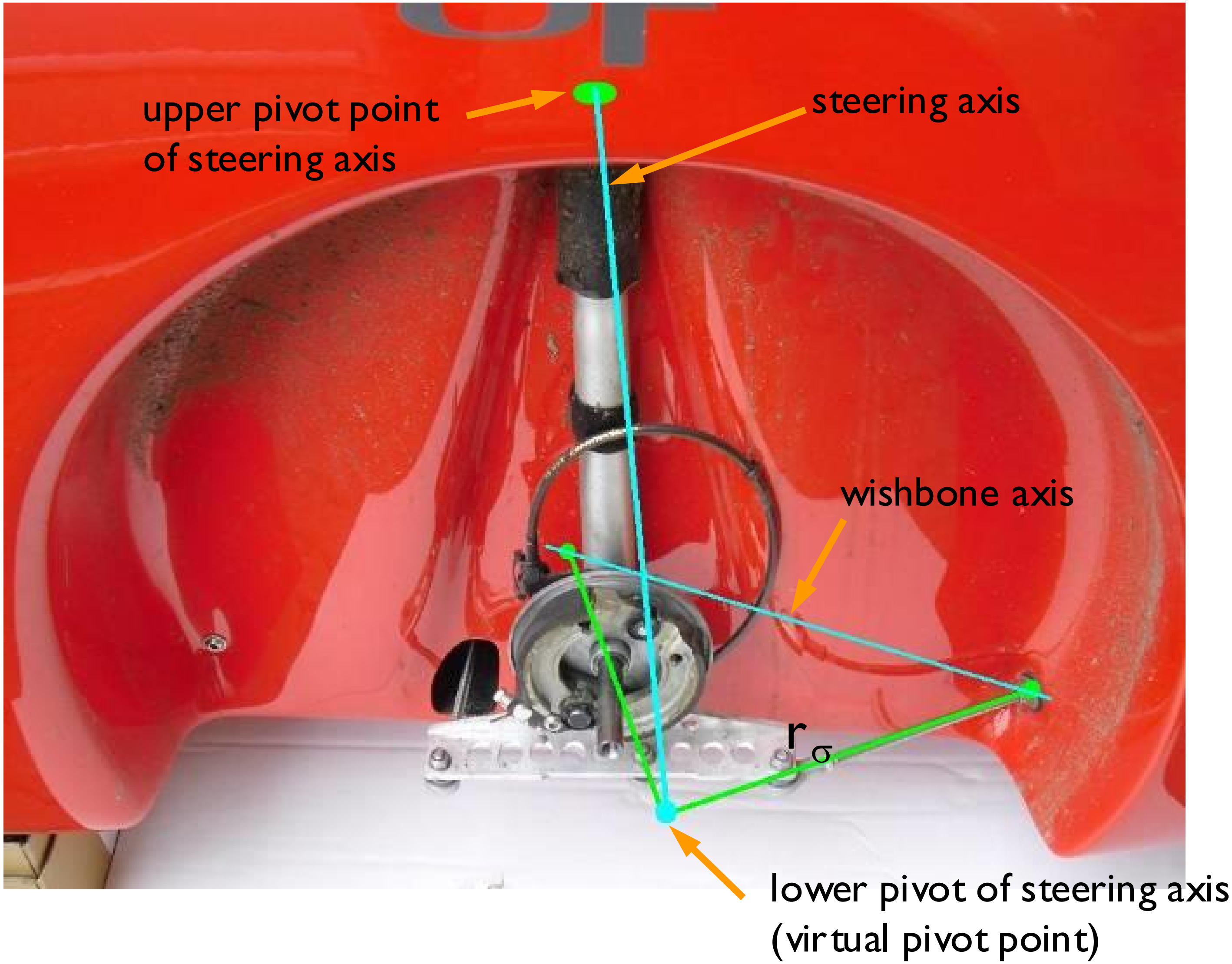
r_σ (negative) scrub radius

steering axis incooperating spread angle, caster angle, and scrub radius



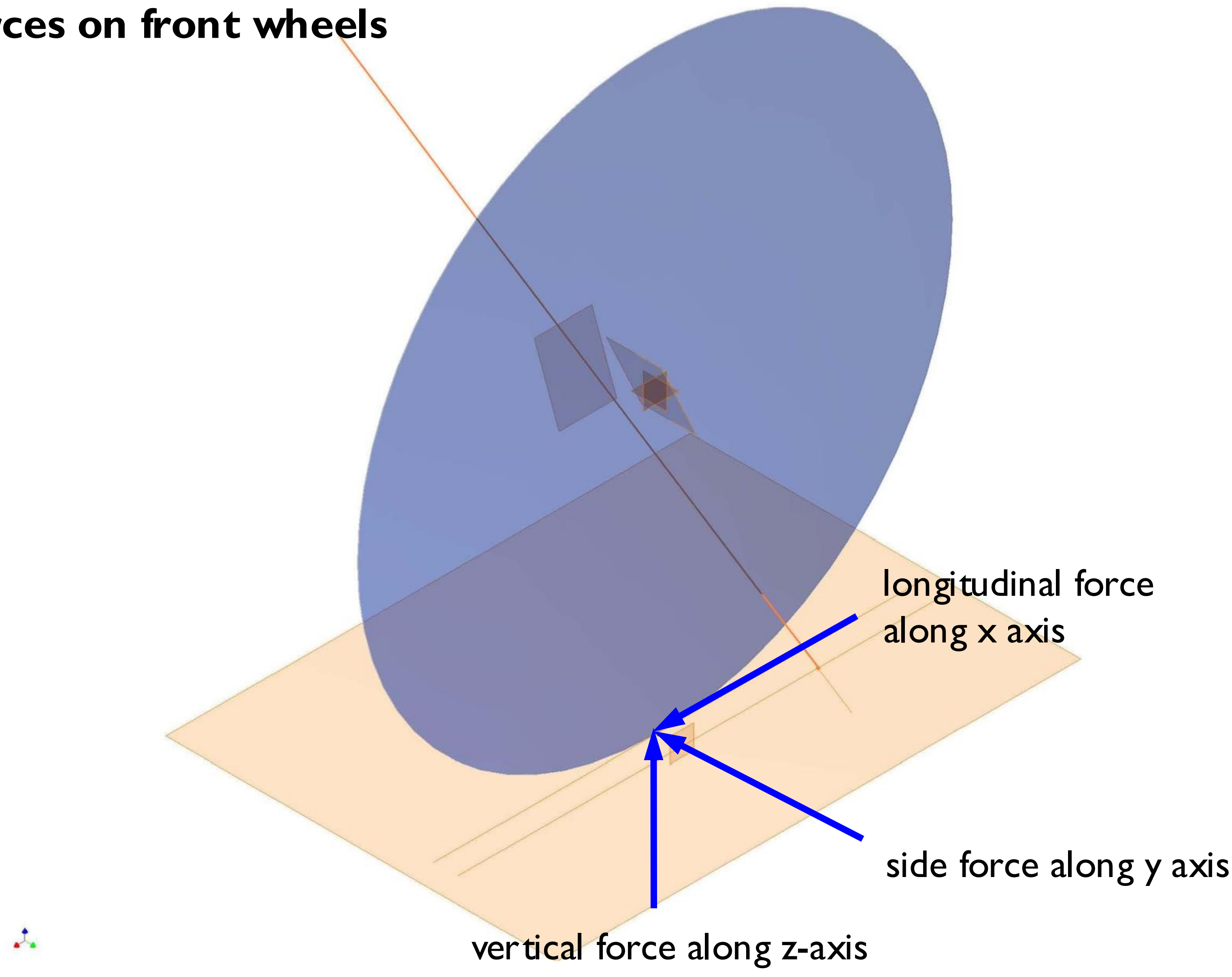


Steering axle at most velomobiles

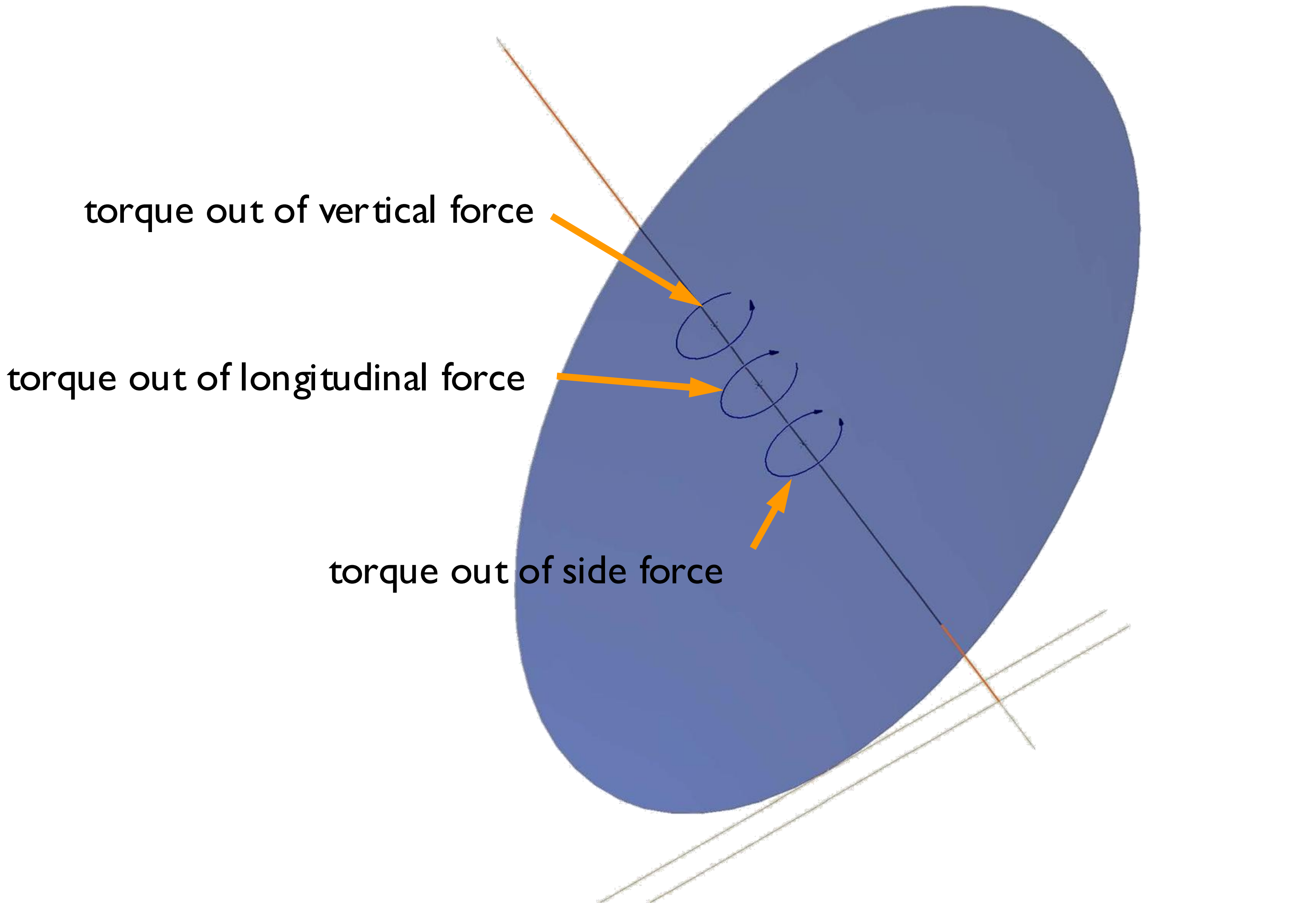


Forces on front wheels

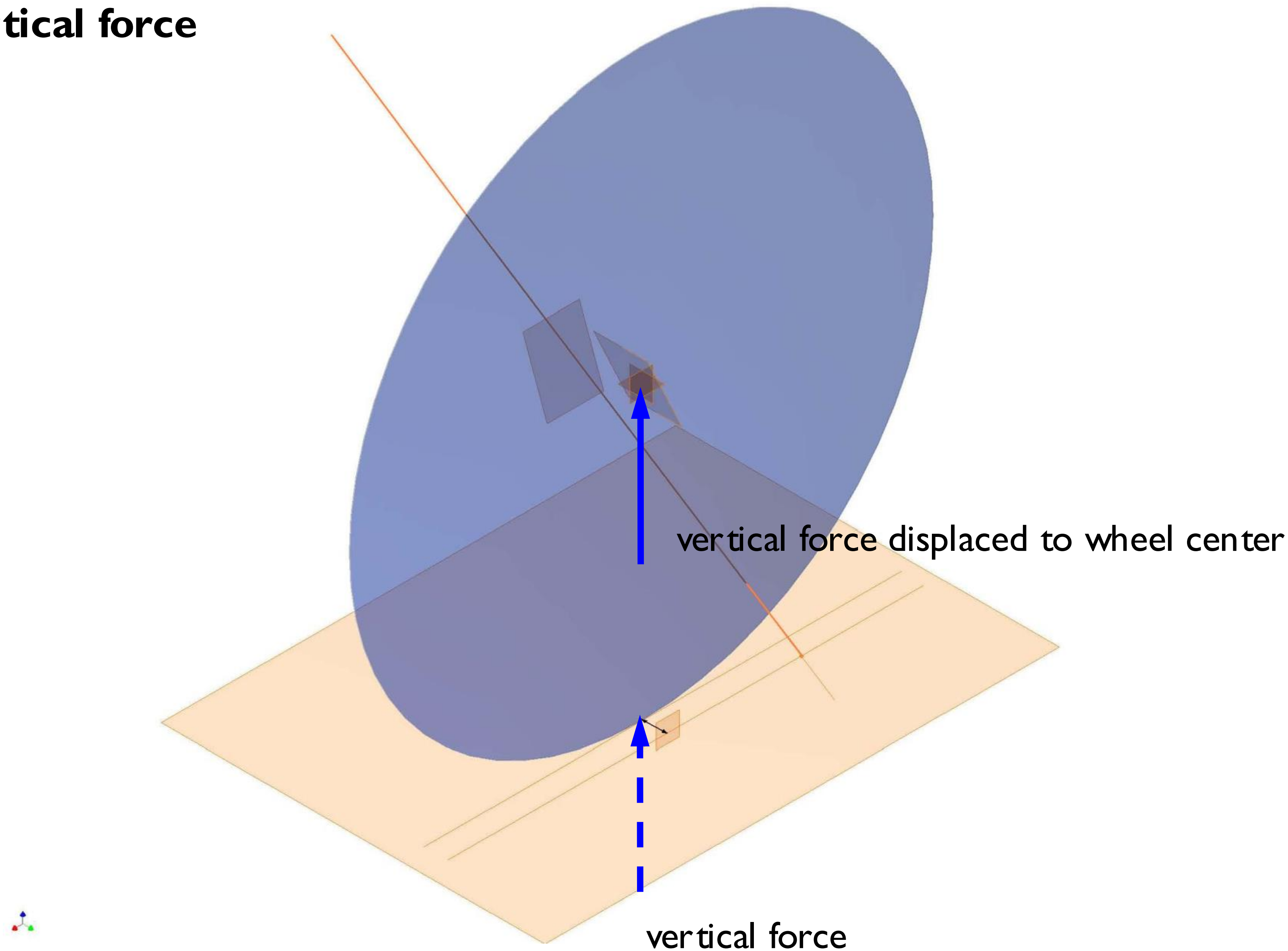
Forces on front wheels



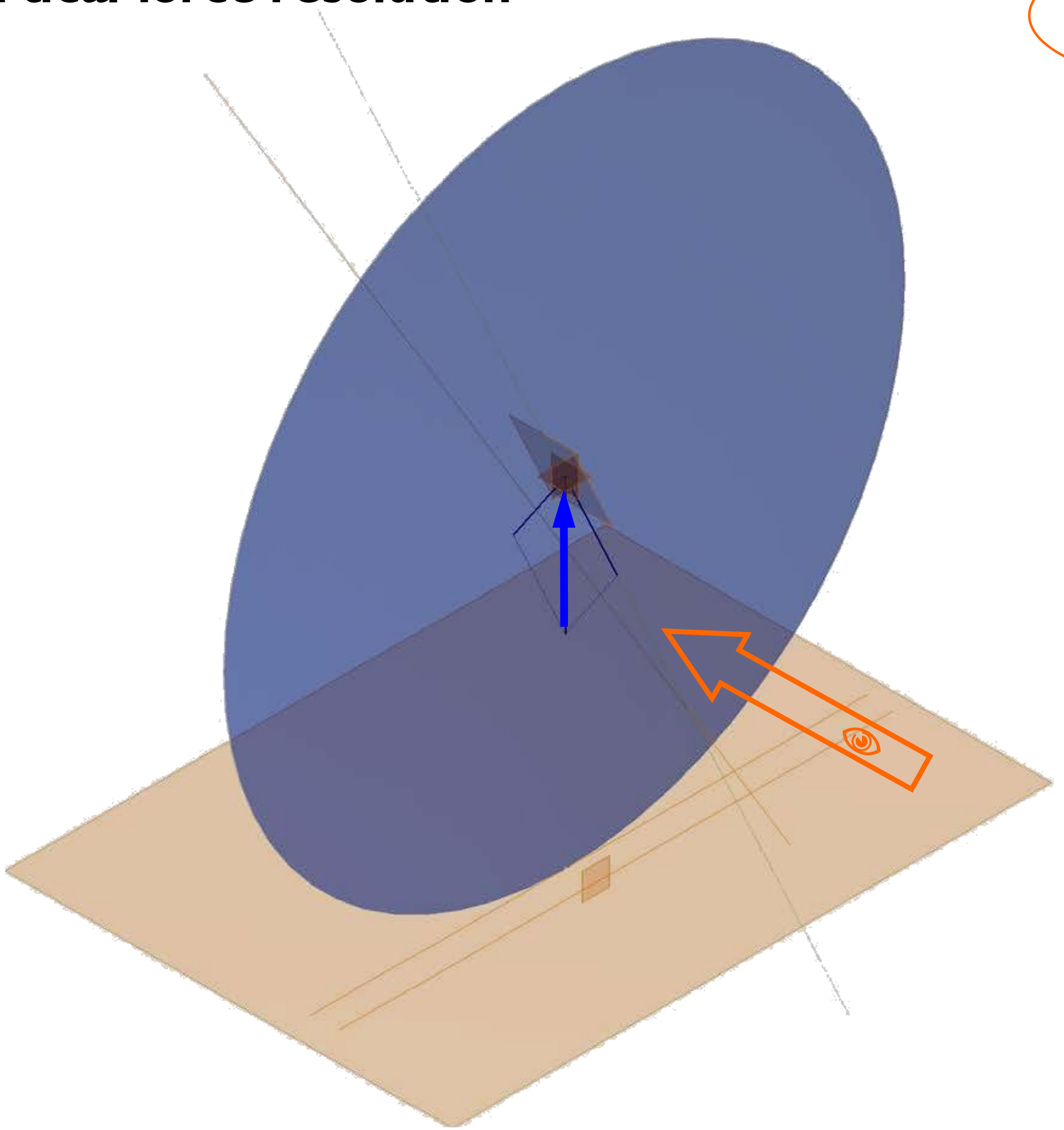
Torques around steering axis

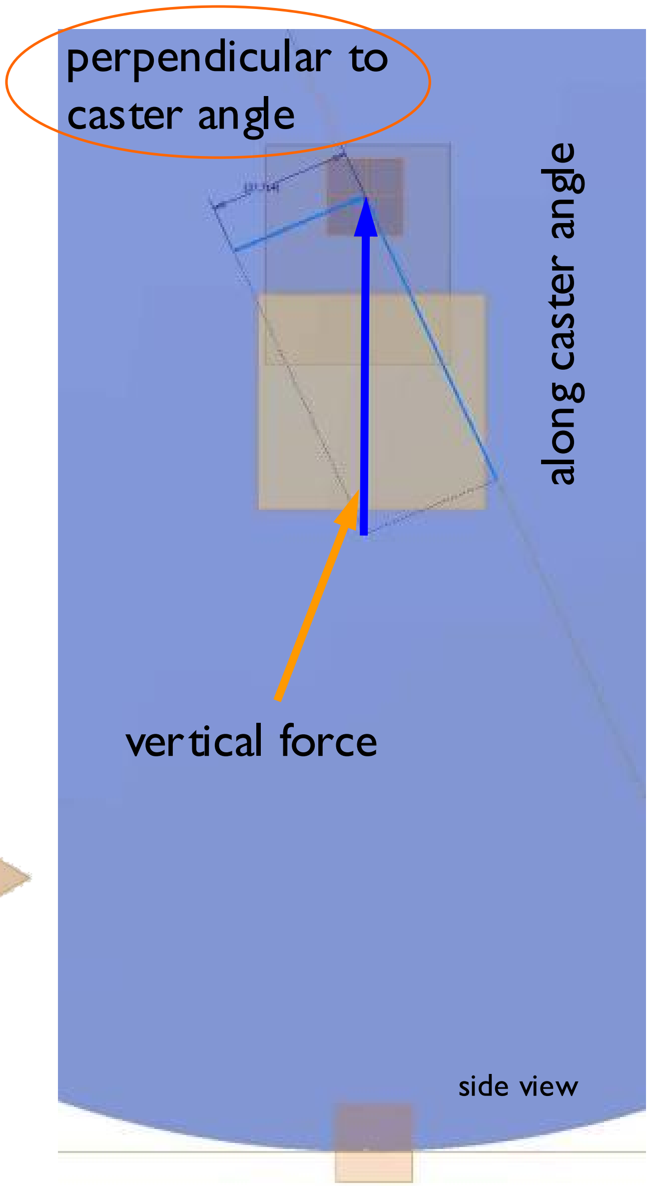


Vertical force

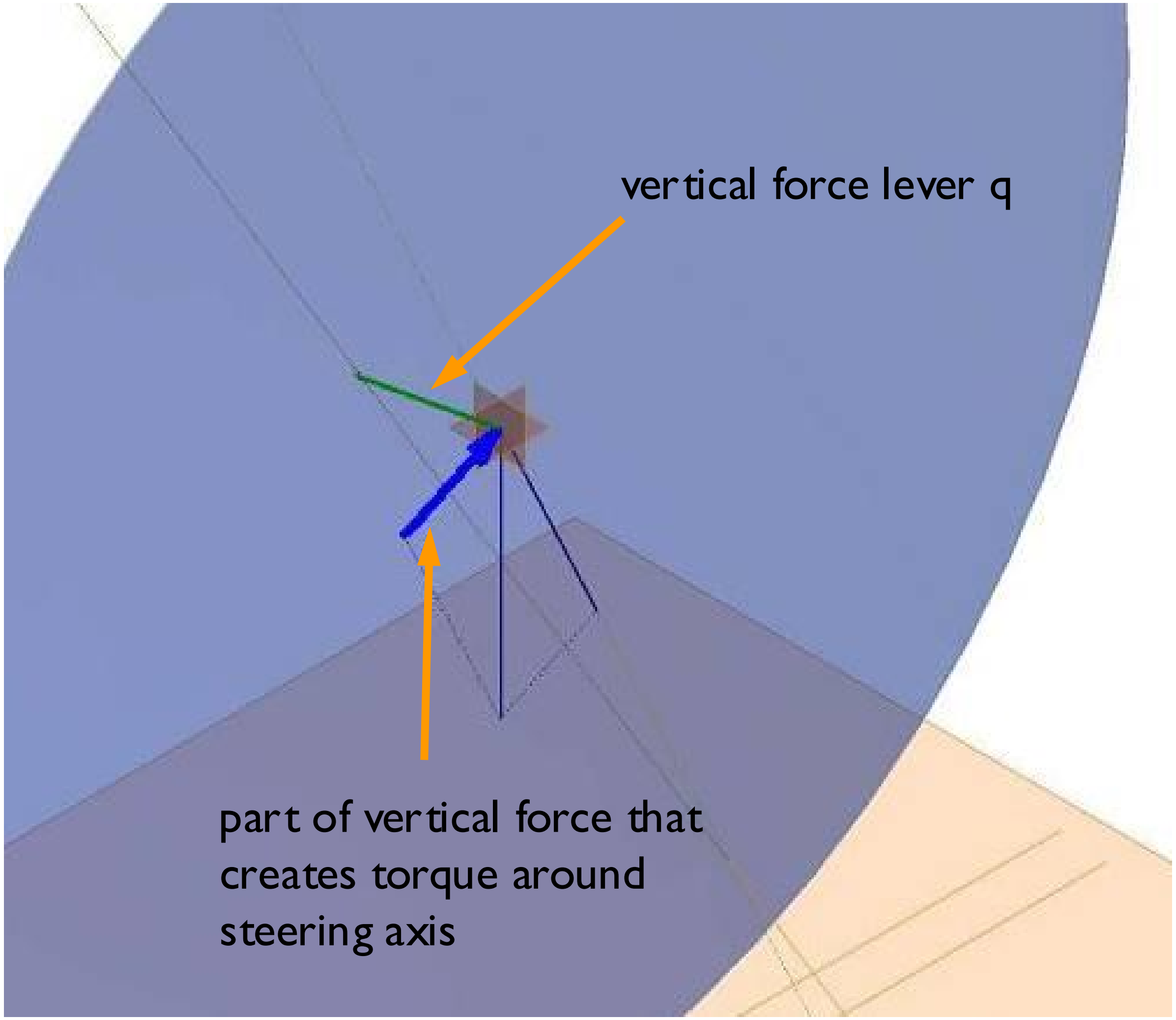


Vertical force resolution

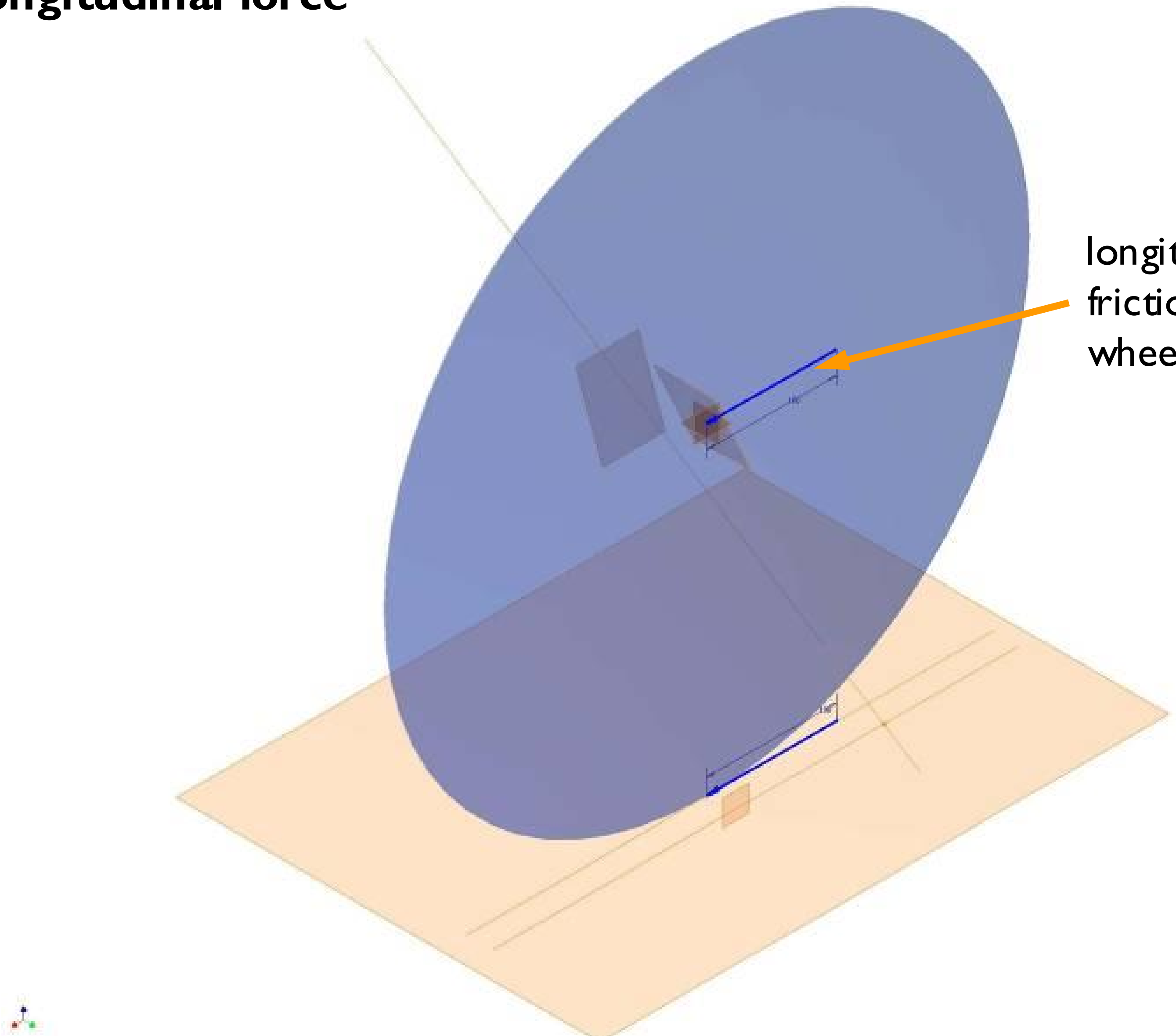




Lever arm of vertical force

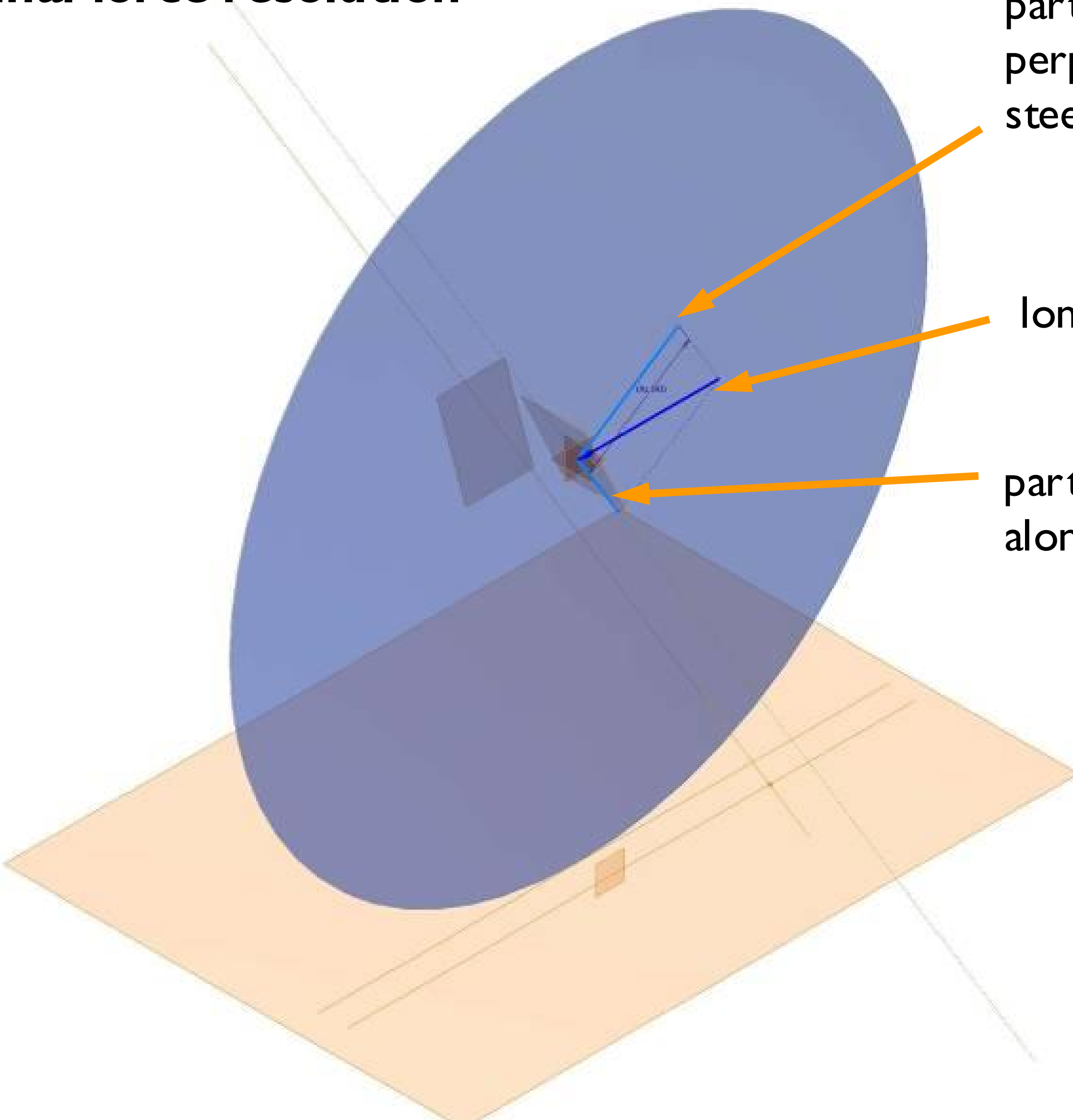


Longitudinal force

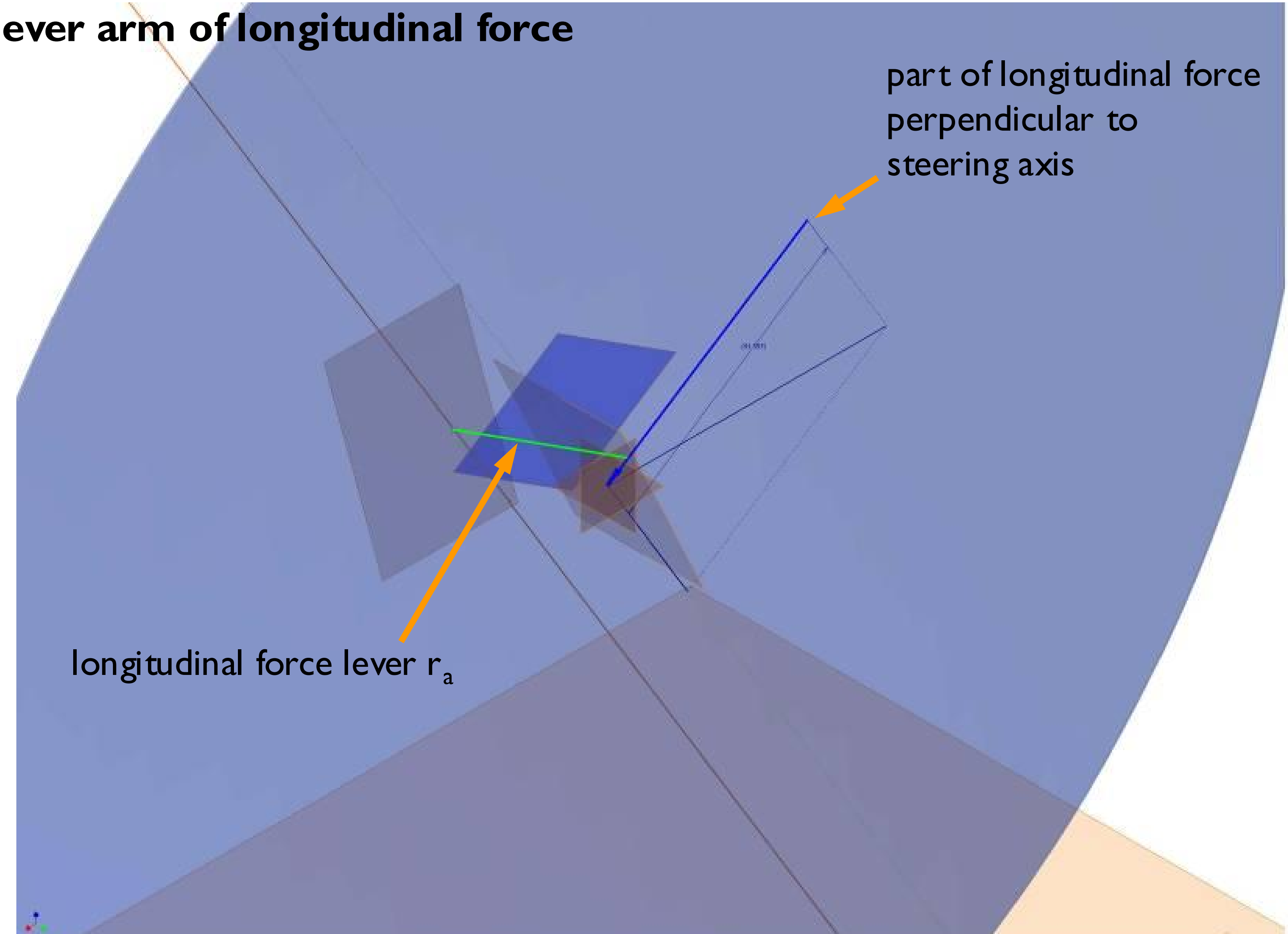


longitudinal force from friction acts on wheel center

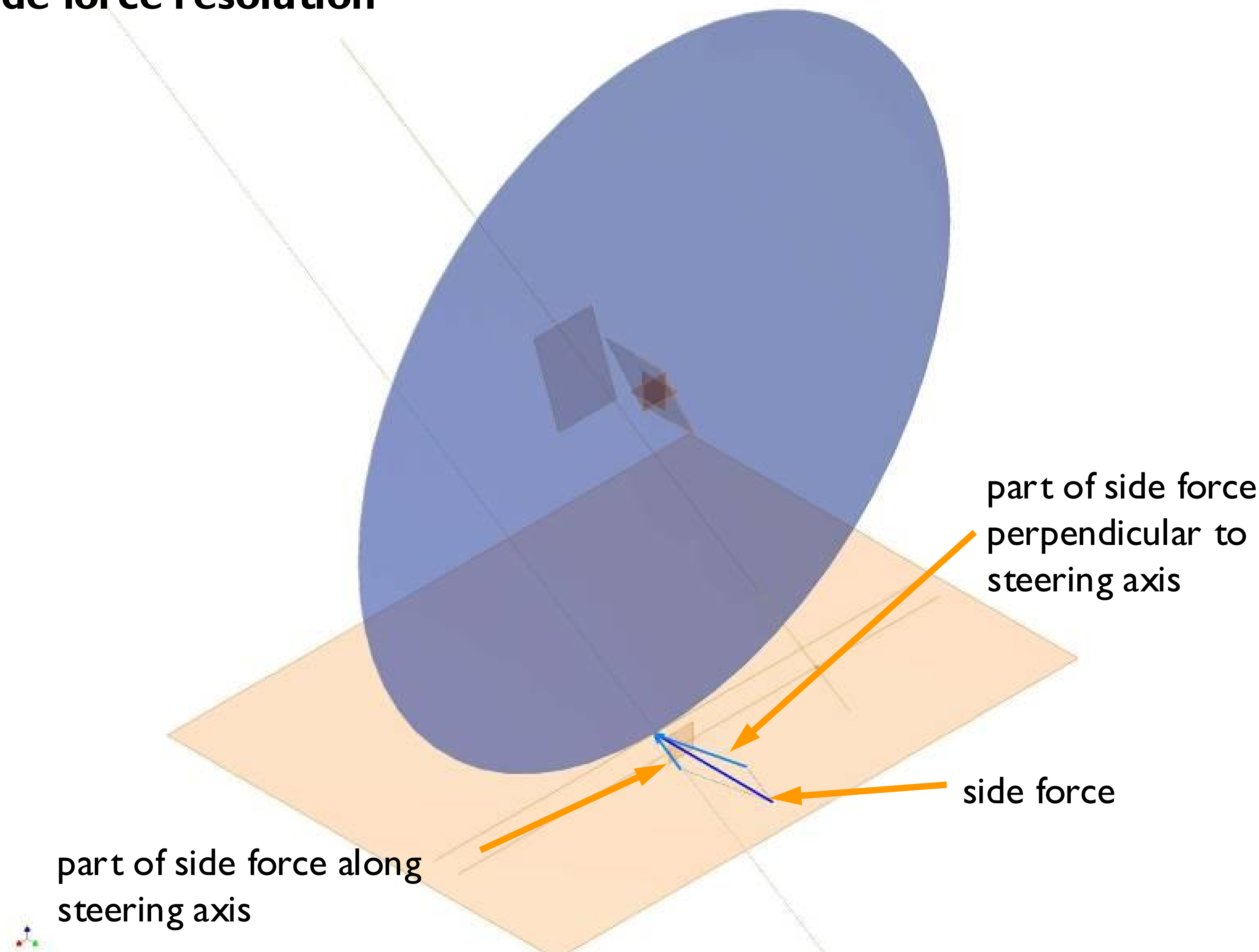
Longitudinal force resolution



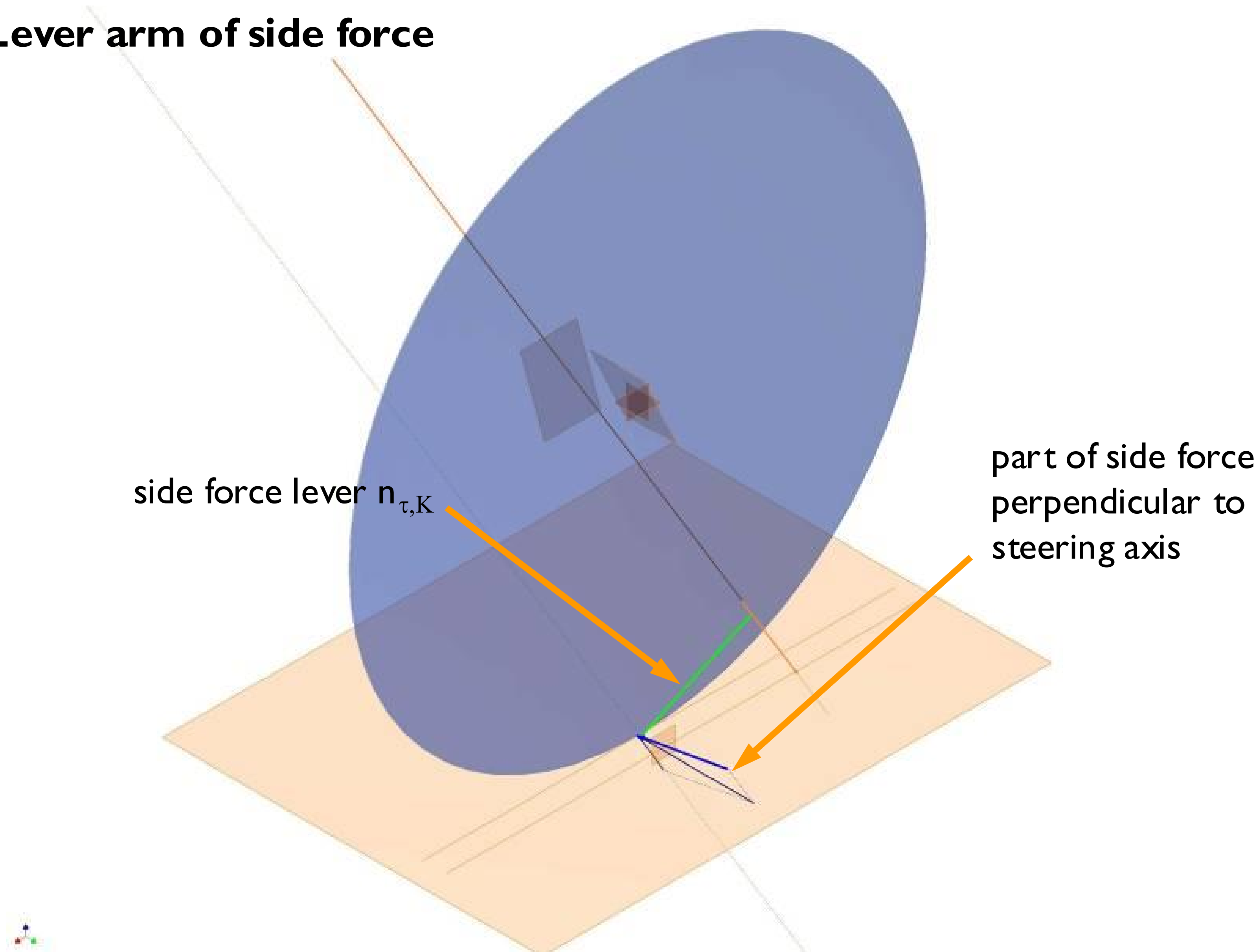
Lever arm of longitudinal force



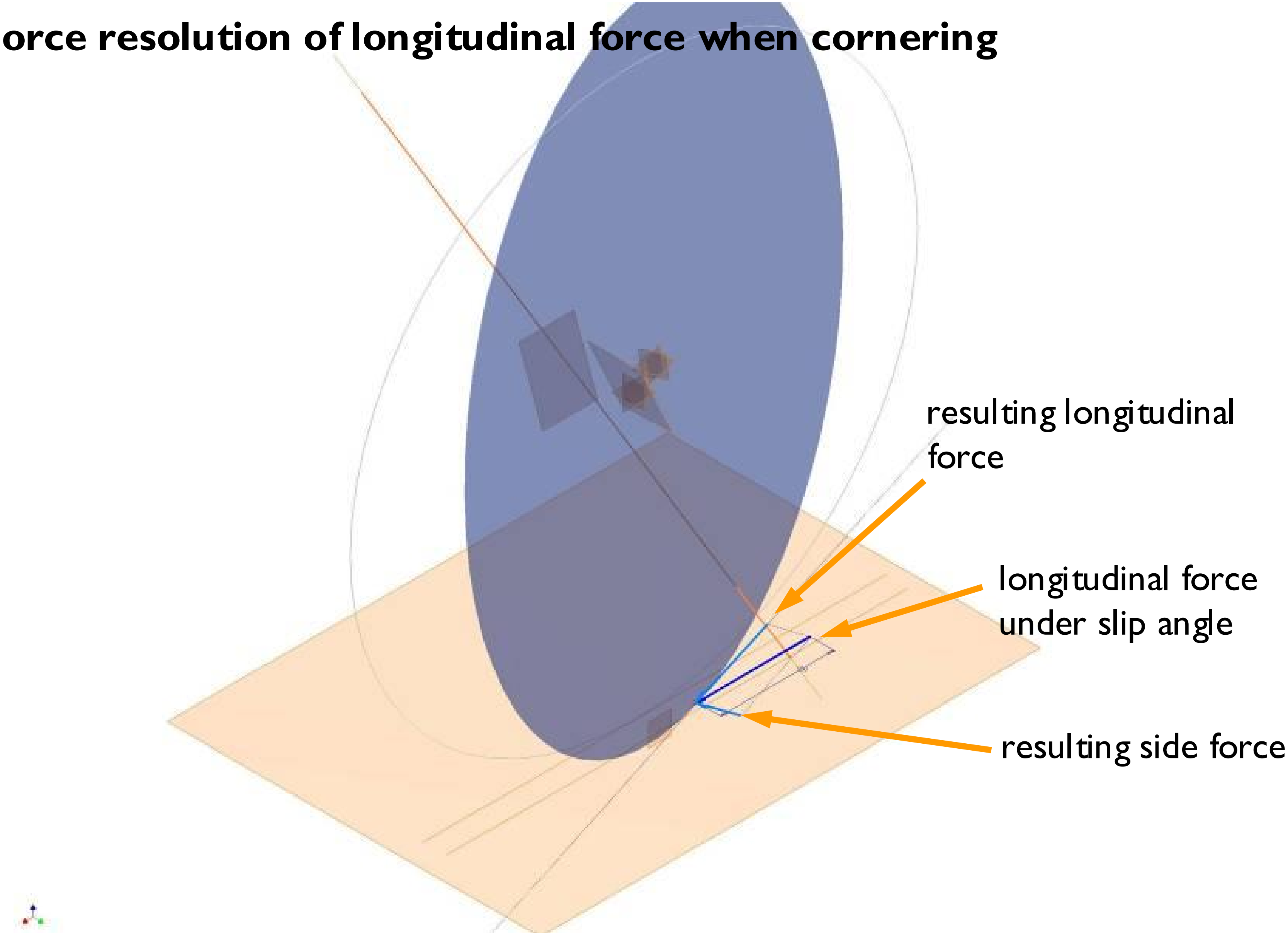
Side force resolution



Lever arm of side force



Force resolution of longitudinal force when cornering



Conclusion

If the sum of all torques both around left and right steering axis have the same value but opposite direction, the torques level each other to zero via longitudinal forces in the track rods.

Different values or same direction lead to turning into of the front wheels.

Causes of such differences are:

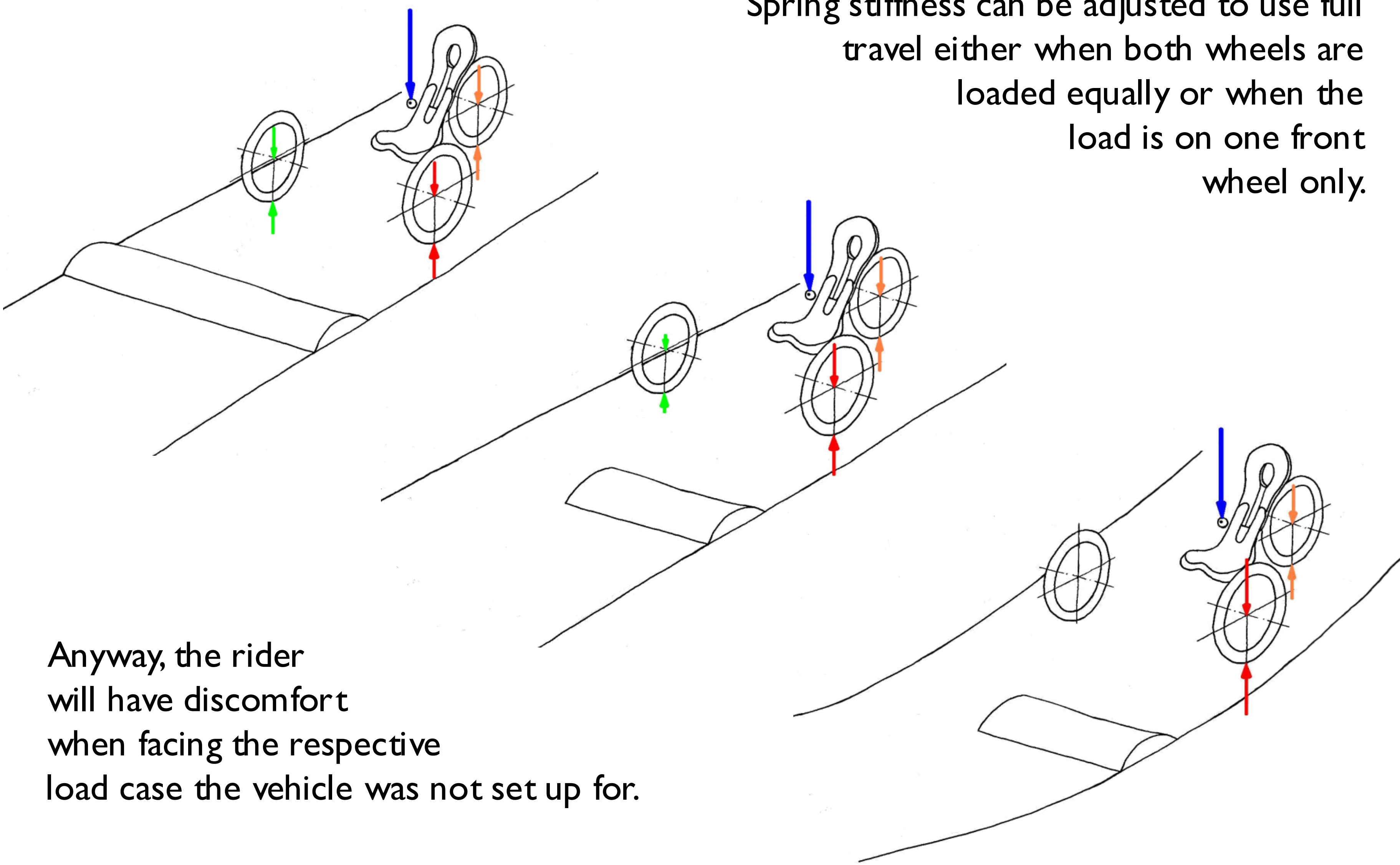
- different vertical, longitudinal, or side forces left and right
→e.g. caused by leaning, tire pressure differences, cornering

- different angles or lever arms left and right
→needs to be corrected by axle setup

Front axle suspension

Front axle suspension

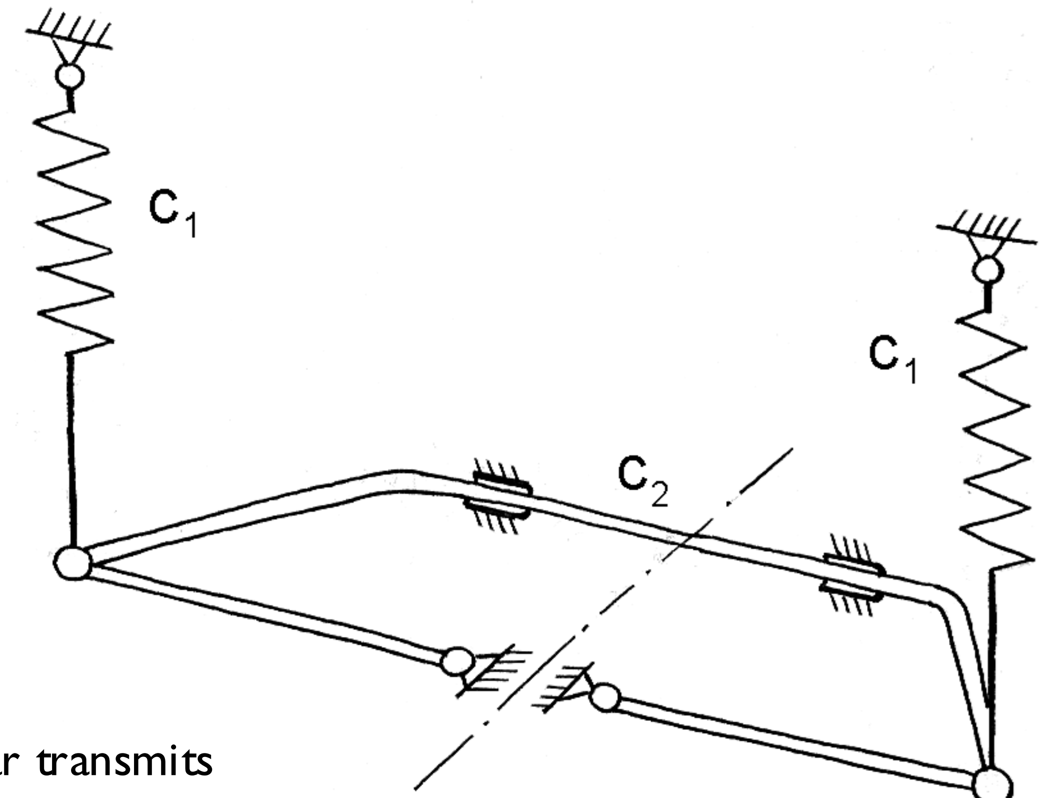
Spring stiffness can be adjusted to use full travel either when both wheels are loaded equally or when the load is on one front wheel only.



Anyway, the rider will have discomfort when facing the respective load case the vehicle was not set up for.

Front axle suspension

A stabilizer bar can level the differences.



A stabilizer bar transmits
force from the loaded wheel
to the unloaded wheel and thus
makes the loaded wheel side stiffer.
It reduces rolling and provides higher riding comfort.

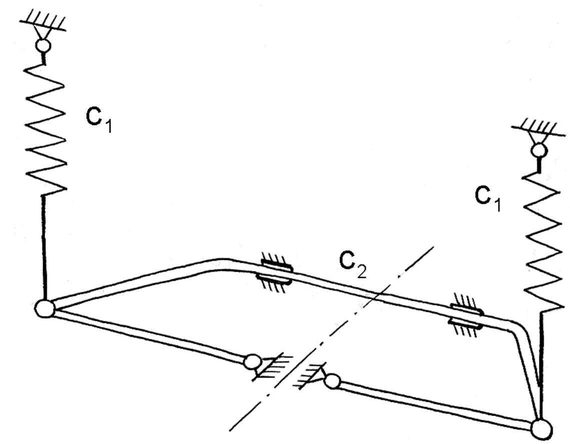
Front axle suspension

spring stiffness $$c = \frac{F}{s}$$

resulting spring stiffness of front axle when both wheels deflect $$c_{ges} = 2c_1$$

resulting spring stiffness of front axle when only one wheel deflects $$c_{ges} = 1c_1$$

resulting spring stiffness of front axle when only one wheel deflects using a stabilizer bar of the same spring stiffness as the main springs $$c_{ges} = 1,5c_1$$



Steering

Steering design goals

- direct feedback from road
- stability at high speeds
- low influence of pedaling

➔depends very much on front axle parameters and kinematics

- small turning radius
- low tire wear

➔depends very much on steering geometry

- general design goals such as low weight, low wear, low maintenance…

Steering design

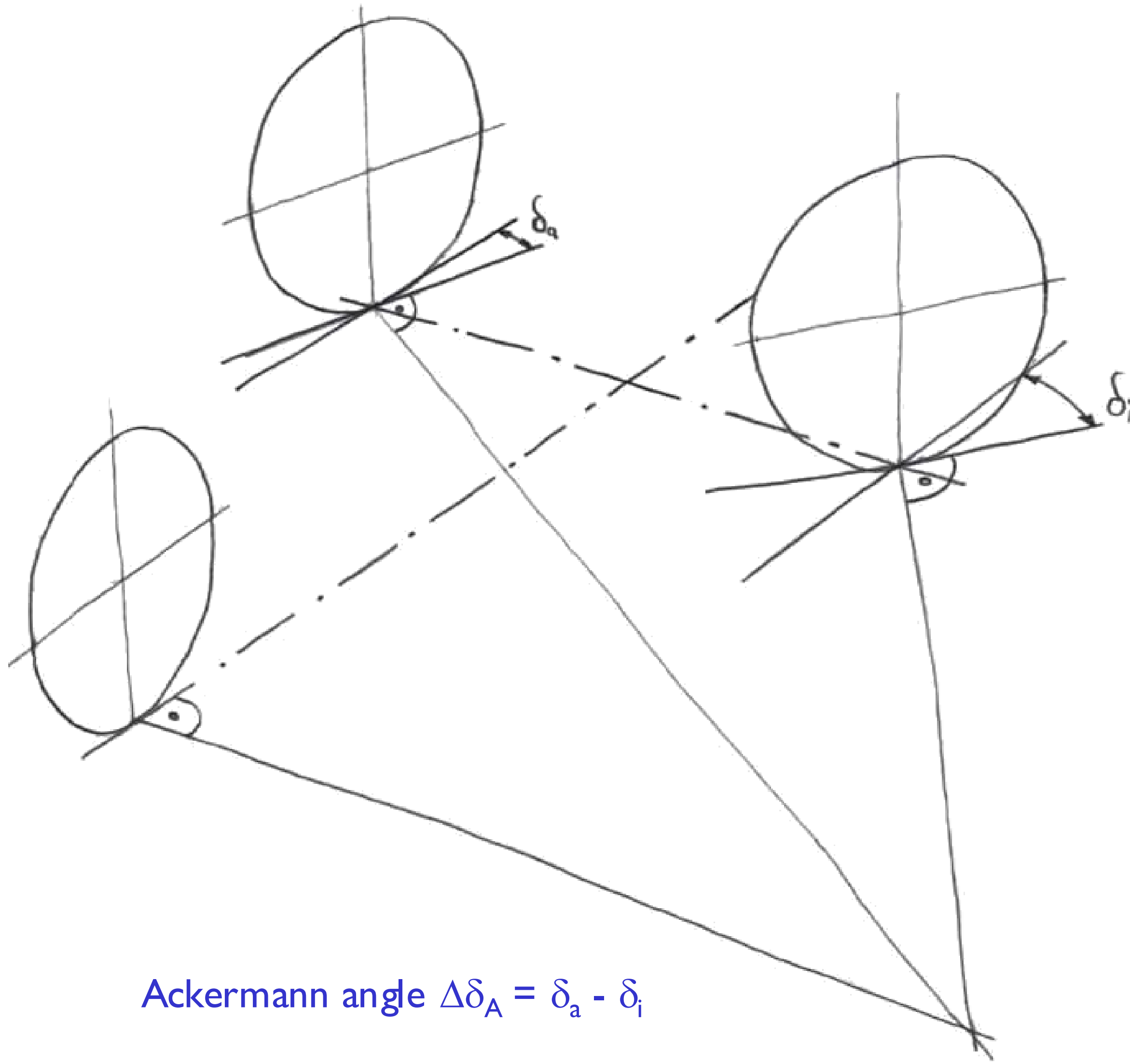
Ackermann condition

- makes it possible to calculate the corresponding inner wheel angle to a given outer wheel angle

- is only valid when cornering side force free, i.e. at very low speeds

- has only little effect at high speeds

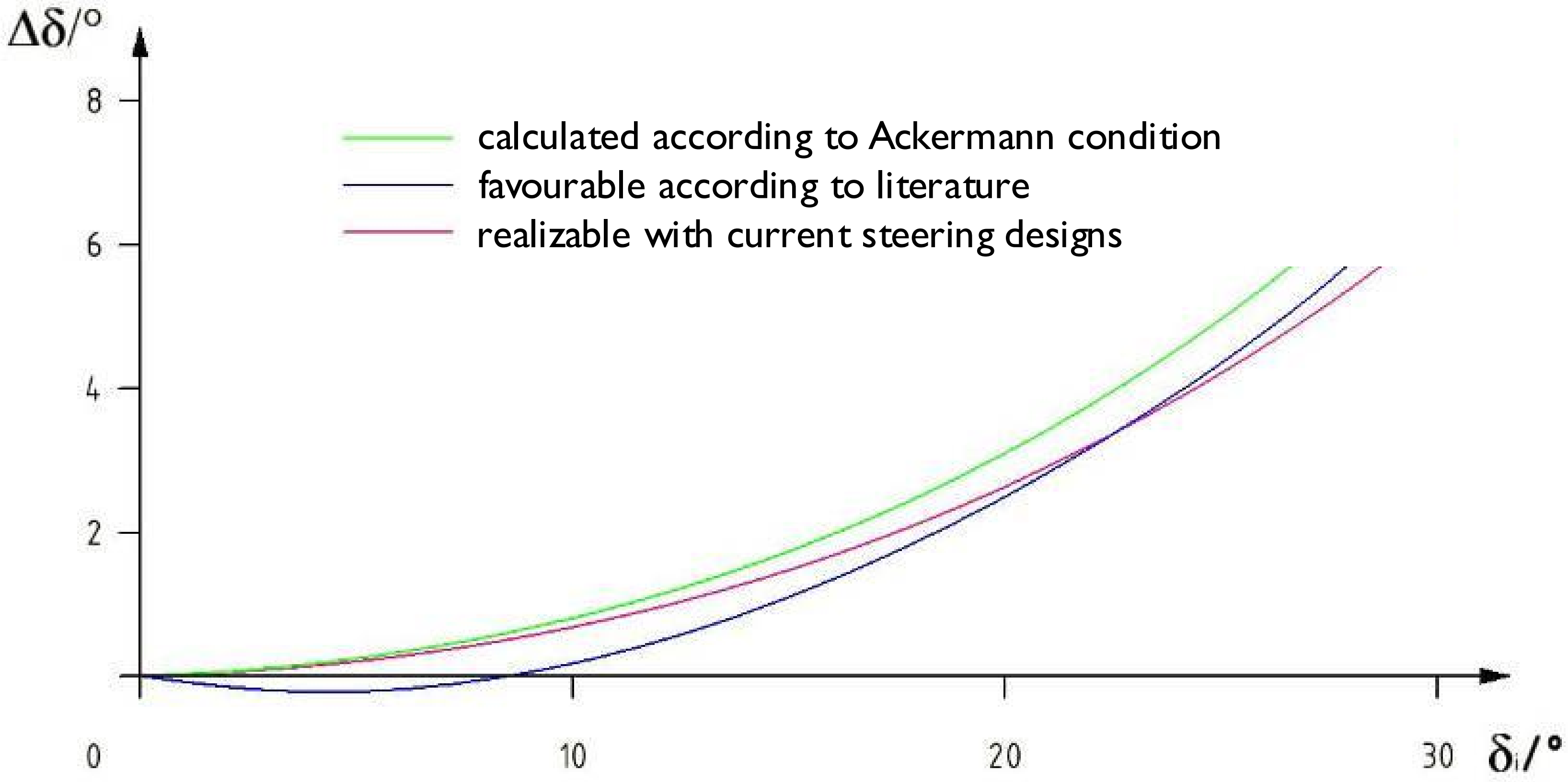
- can be neglected to a certain degree in order to save design space (width between wheel shells, overall width)



Ackermann angle $\Delta\delta_A = \delta_a - \delta_i$

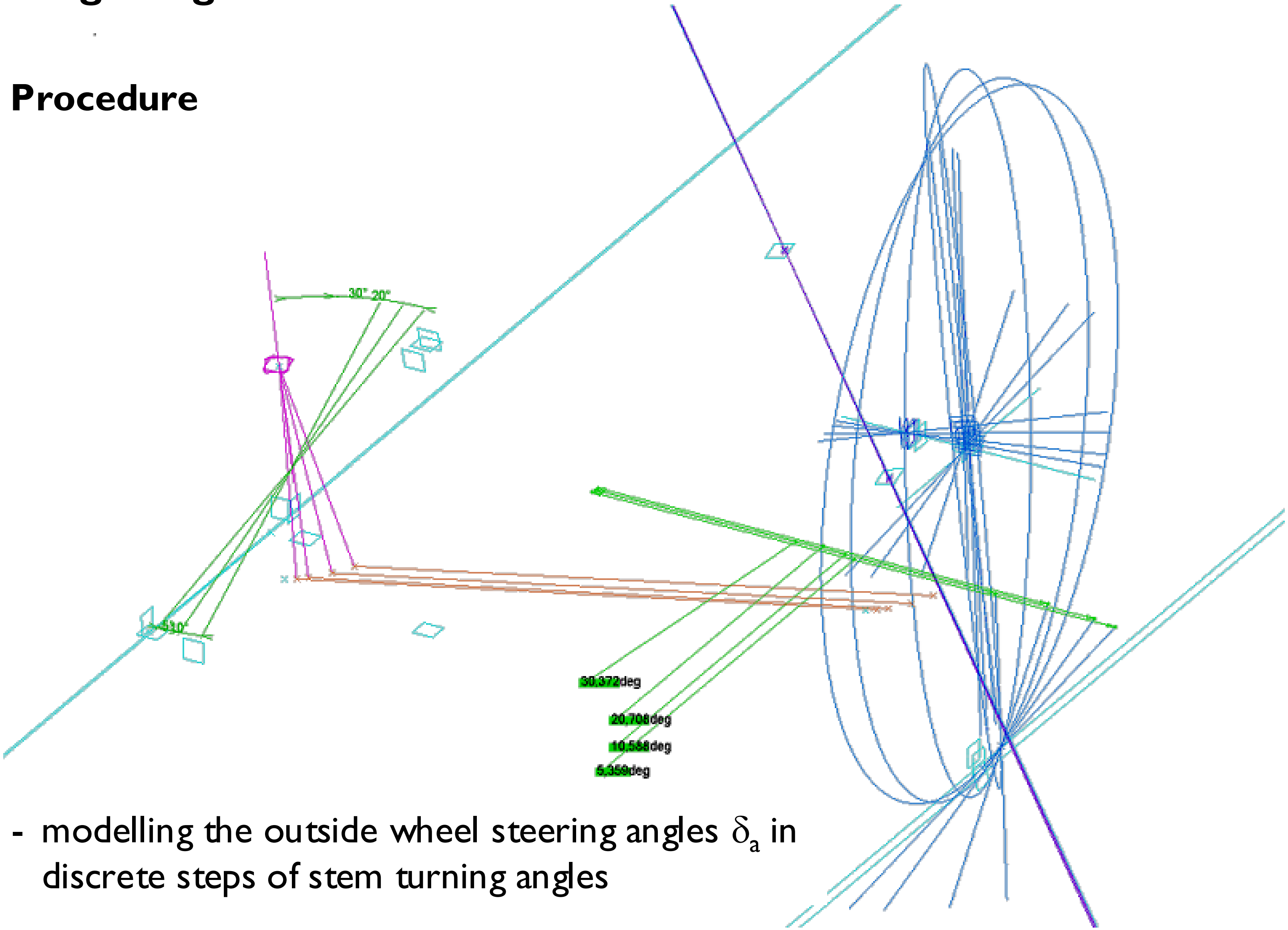
Steering design

Ackermann condition



Steering design

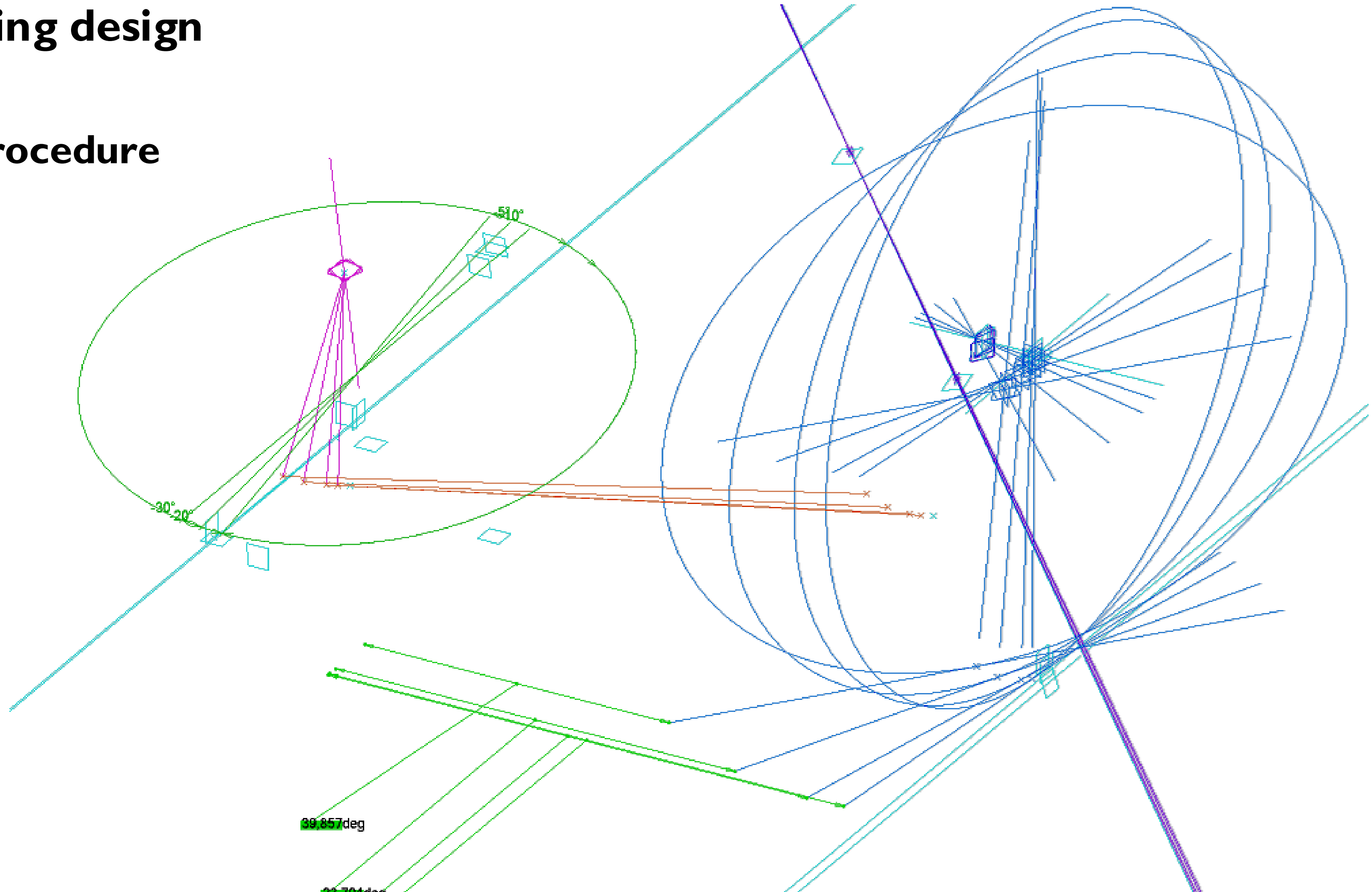
Procedure



- modelling the outside wheel steering angles δ_a in discrete steps of stem turning angles

Steering design

Procedure



- modelling the inside wheel steering angles δ_i in opposite discrete steps of stem turning angles

Steering design

Radträger ist SFS ab 2012 (ASG-Radträger)

87/33/2grad

Lenkwinkel	Radw. innen	Radw.außen	Radw. außen nach ACK	LDW model	LDW ACK
0	0	0	0	0	0
5	5,402	5,29	5,01	0,11	0,40
10	10,956	10,489	9,45	0,47	1,50
20	22,829	20,659	17,27	2,17	5,56
30	37,284	30,525	24,90	6,76	12,39

87/38/2grad

Lenkwinkel	Radw. innen	Radw.außen	Radw. außen nach ACK	LDW model	LDW ACK
0	0	0	0	0	0
5	5,57	5,421	5,15	0,15	0,42
10	11,341	10,722	9,74	0,62	1,60
20	23,925	21,018	17,91	2,91	6,02
30	40,526	30,917	26,44	9,61	14,09

87/43/2grad

Lenkwinkel	Radw. innen	Radw.außen	Radw. außen nach ACK	LDW model	LDW ACK
0	0	0	0	0	0
5	5,743	5,555	5,30	0,19	0,45
10	11,741	10,959	10,03	0,78	1,71
20	25,098	21,385	18,57	3,71	6,53
30	45,026	31,318	28,52	13,71	16,51

77/43/2grad

Lenkwinkel	Radw. innen	Radw.außen	Radw. außen nach ACK	LDW model	LDW ACK
0	0	0	0	0	0
5	5,178	5,004	4,81	0,17	0,36
10	10,569	9,855	9,16	0,71	1,41
20	22,338	19,123	16,98	3,22	5,36
30	37,285	27,772	24,90	9,51	12,39

87/43/-5grad

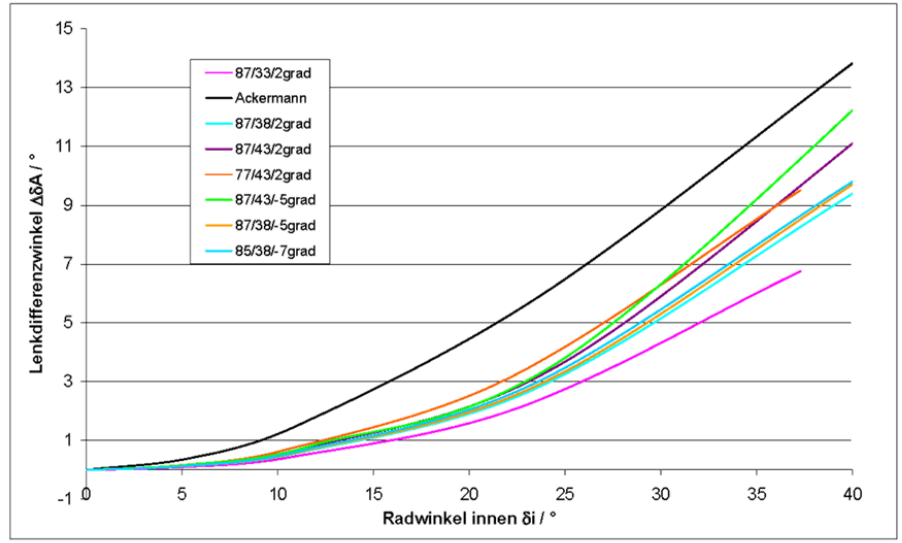
Lenkwinkel	Radw. innen	Radw.außen	Radw. außen nach ACK	LDW model	LDW ACK
0	0	0	0	0	0
5	5,813	5,609	5,36	0,20	0,46
10	11,905	11,056	10,15	0,85	1,75
20	25,629	21,541	18,87	4,09	6,76
30	49,418	31,5	30,50	17,92	18,92

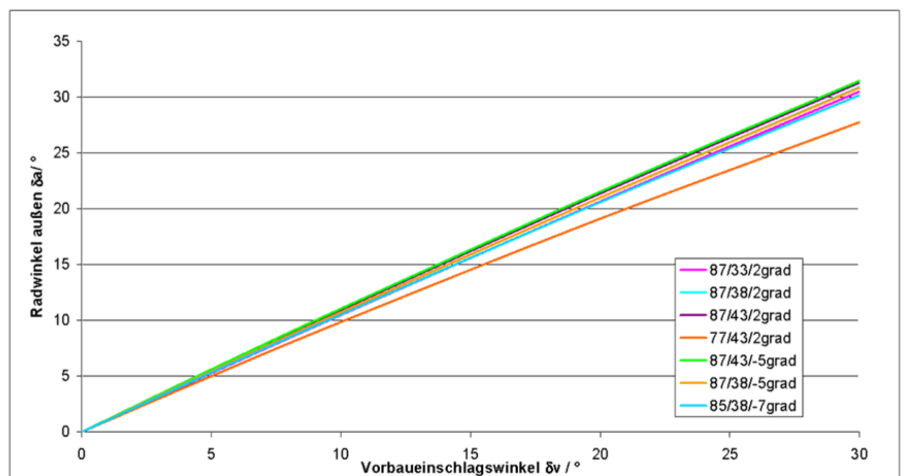
87/38/-5grad Mittelpunkt von x220 auf x210

Lenkwinkel	Radw. innen	Radw.außen	Radw. außen nach ACK	LDW model	LDW ACK
0	0	0	0	0	0
5	5,585	5,43	5,16	0,16	0,42
10	11,379	10,735	9,77	0,64	1,61
20	24,045	21,02	17,97	3,03	6,07
30	41,01	30,874	26,67	10,14	14,34

85/38/-7grad Mittelpunkt von x220 auf x210

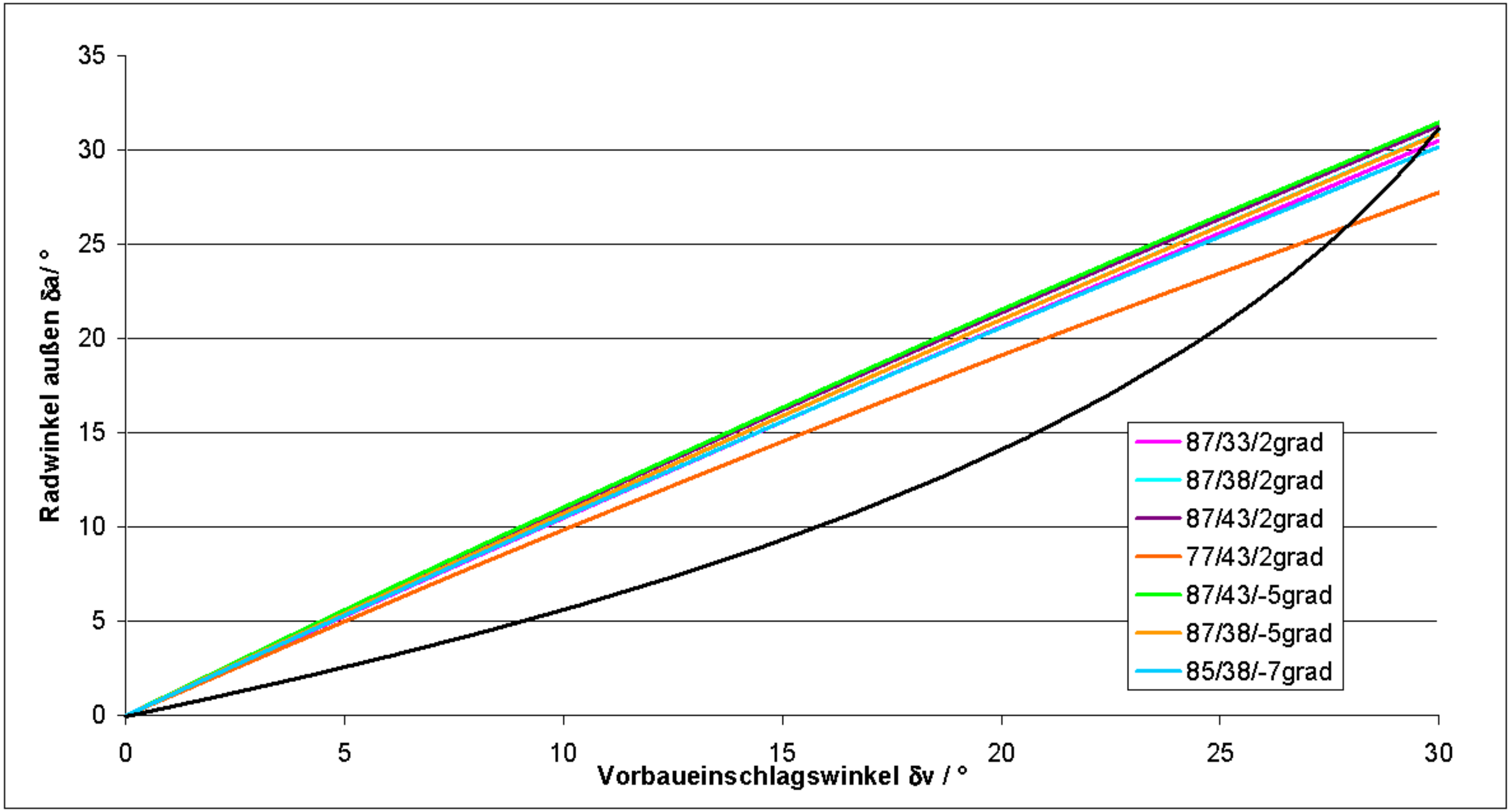
Lenkwinkel	Radw. innen	Radw.außen	Radw. außen nach ACK	LDW model	LDW ACK
0	0	0	0	0	0
5	5,489	5,333	5,08	0,16	0,41
10	11,183	10,537	9,62	0,65	1,56
20	23,613	20,603	17,73	3,01	5,89
30	40,014	30,204	26,20	9,81	13,81





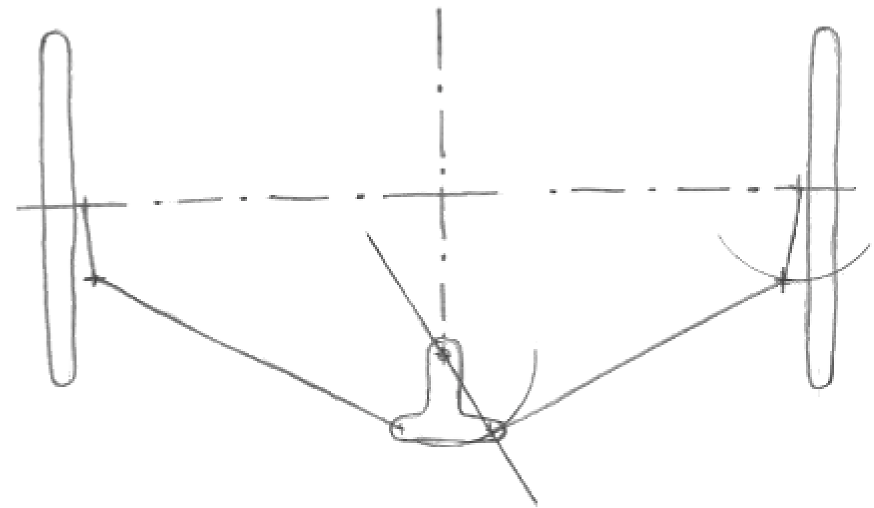
Steering design

Steering ratio

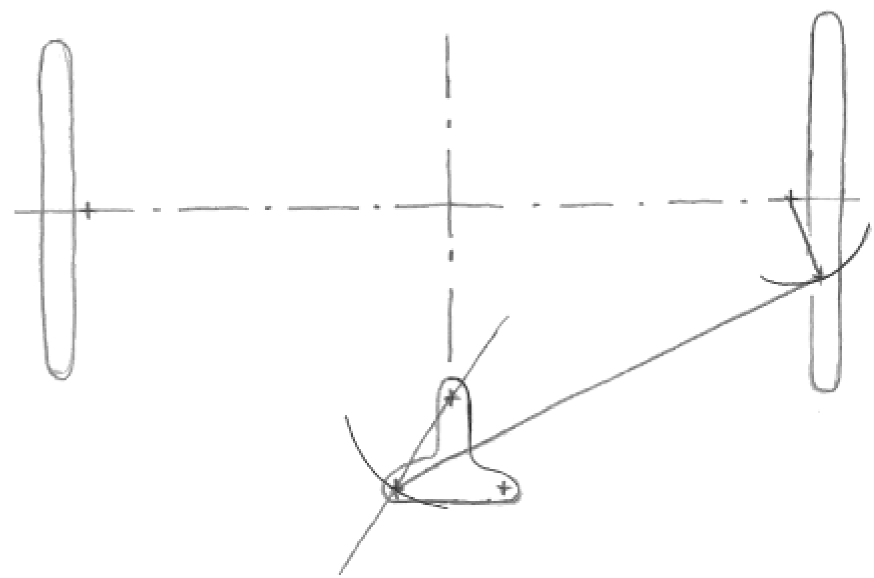


Steering design

Steering ratio



conventional track rod setup
- unfavorable ratio in the beginning
- easy to build



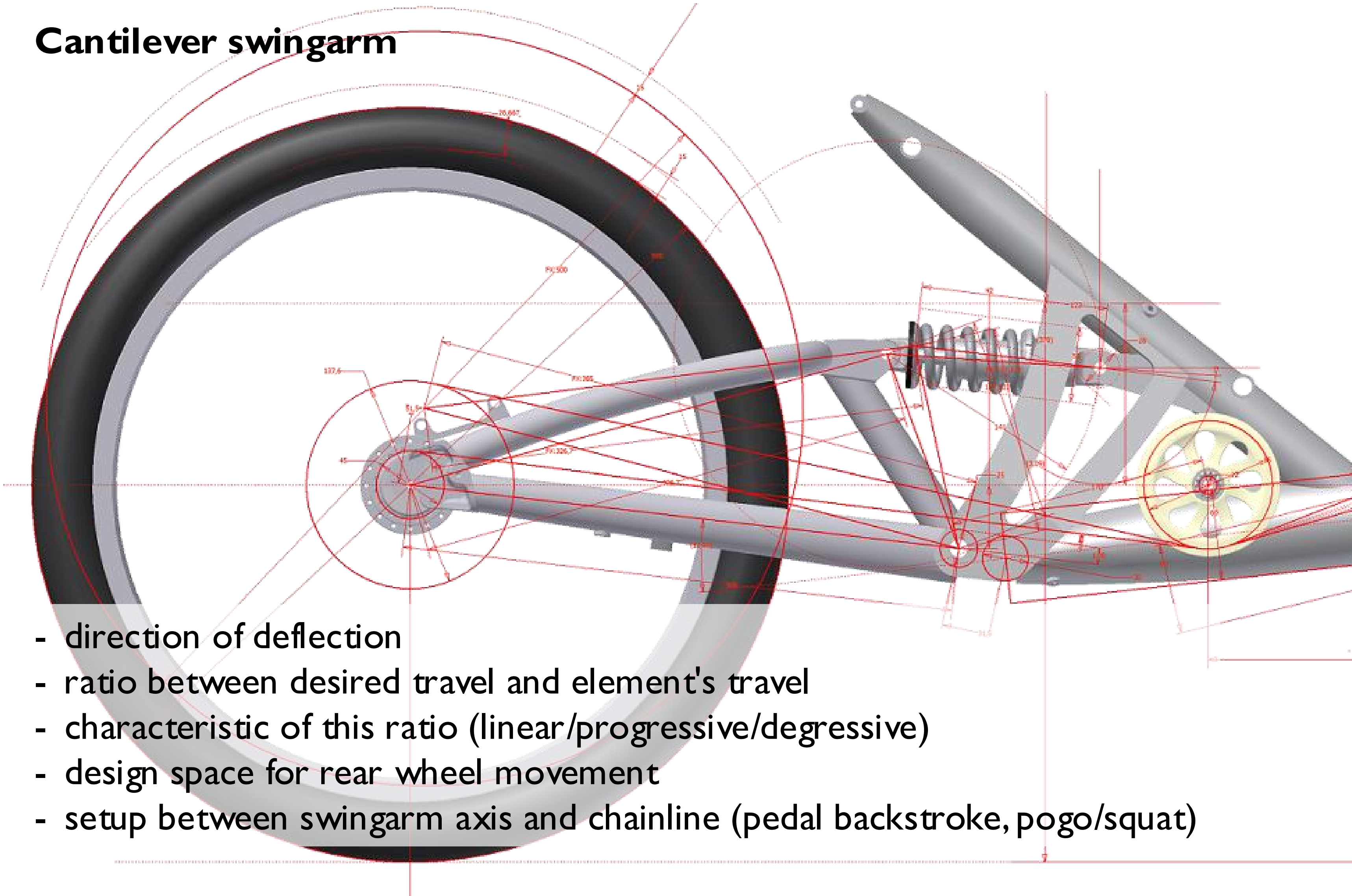
criss-crossed track rod setup
- low ratio in the beginning
- high ratio at the end
- complicated, especially with suspended front axle

alternatively: rack-and-pinion steering

Rear axle

Rear axle

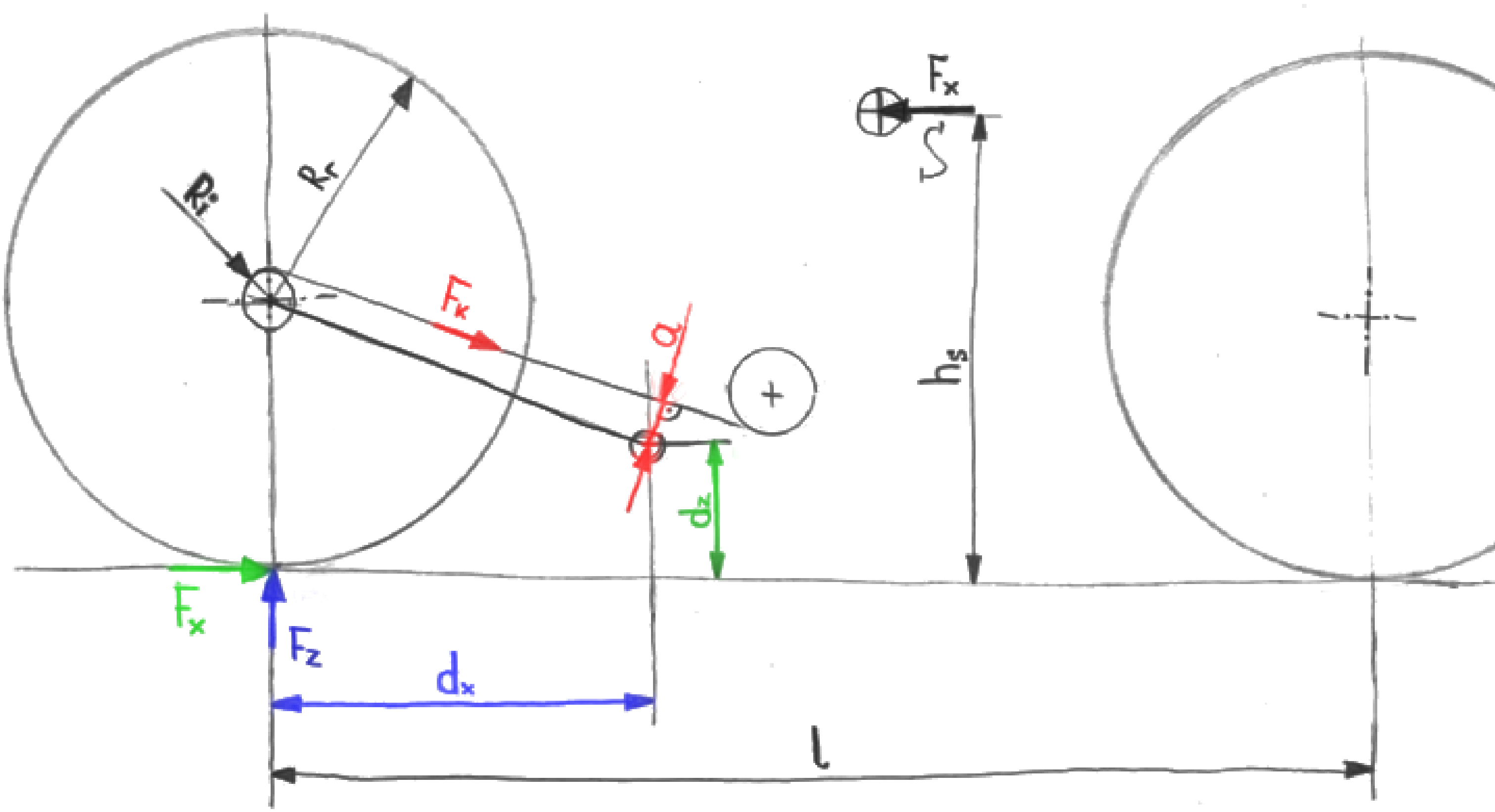
Cantilever swingarm



- direction of deflection
- ratio between desired travel and element's travel
- characteristic of this ratio (linear/progressive/degressive)
- design space for rear wheel movement
- setup between swingarm axis and chainline (pedal backstroke, pogo/squat)

Rear axle

No squat design



- 3 forces and their levers form torques around the swingarm pivot
- value "a" must be chosen in a way that the resulting torque is close to 0

Rear axle

No squat design

$$0 = -F_K \cdot a - F_z \cdot d_x + F_x \cdot d_z$$

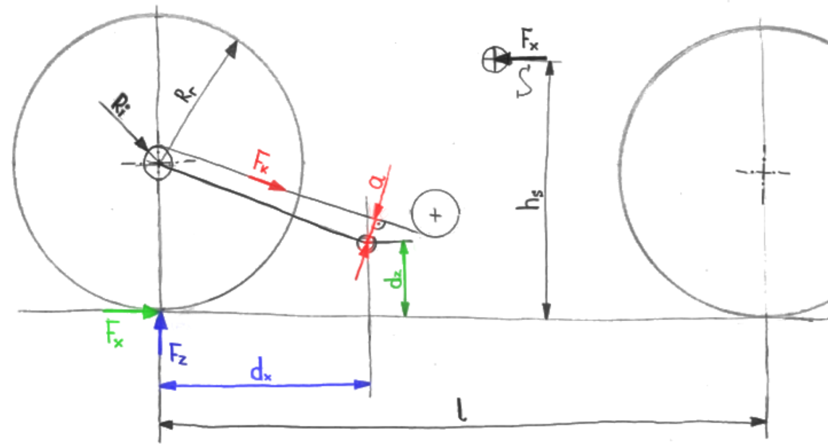
$$F_x = F_K \cdot \frac{R_i}{R_r}$$

$$F_z = F_x \cdot \frac{h_S}{l} = F_K \cdot \frac{R_i}{R_r} \cdot \frac{h_S}{l}$$

$$0 = -F_K \cdot a - F_K \cdot \frac{R_i}{R_r} \cdot \frac{h_S}{l} \cdot d_x + F_K \cdot \frac{R_i}{R_r} \cdot d_z$$

$$0 = F_K \cdot \left(-a - \frac{R_i}{R_r} \cdot \frac{h_S}{l} \cdot d_x + \frac{R_i}{R_r} \cdot d_z\right) \Big| \div F_K$$

$$0 = -a - \frac{R_i}{R_r} \cdot \frac{h_S}{l} \cdot d_x + \frac{R_i}{R_r} \cdot d_z$$



This term should be as close to 0 as possible.

Rear axle

No squat design

spreadsheet to check the results for all sprockets.

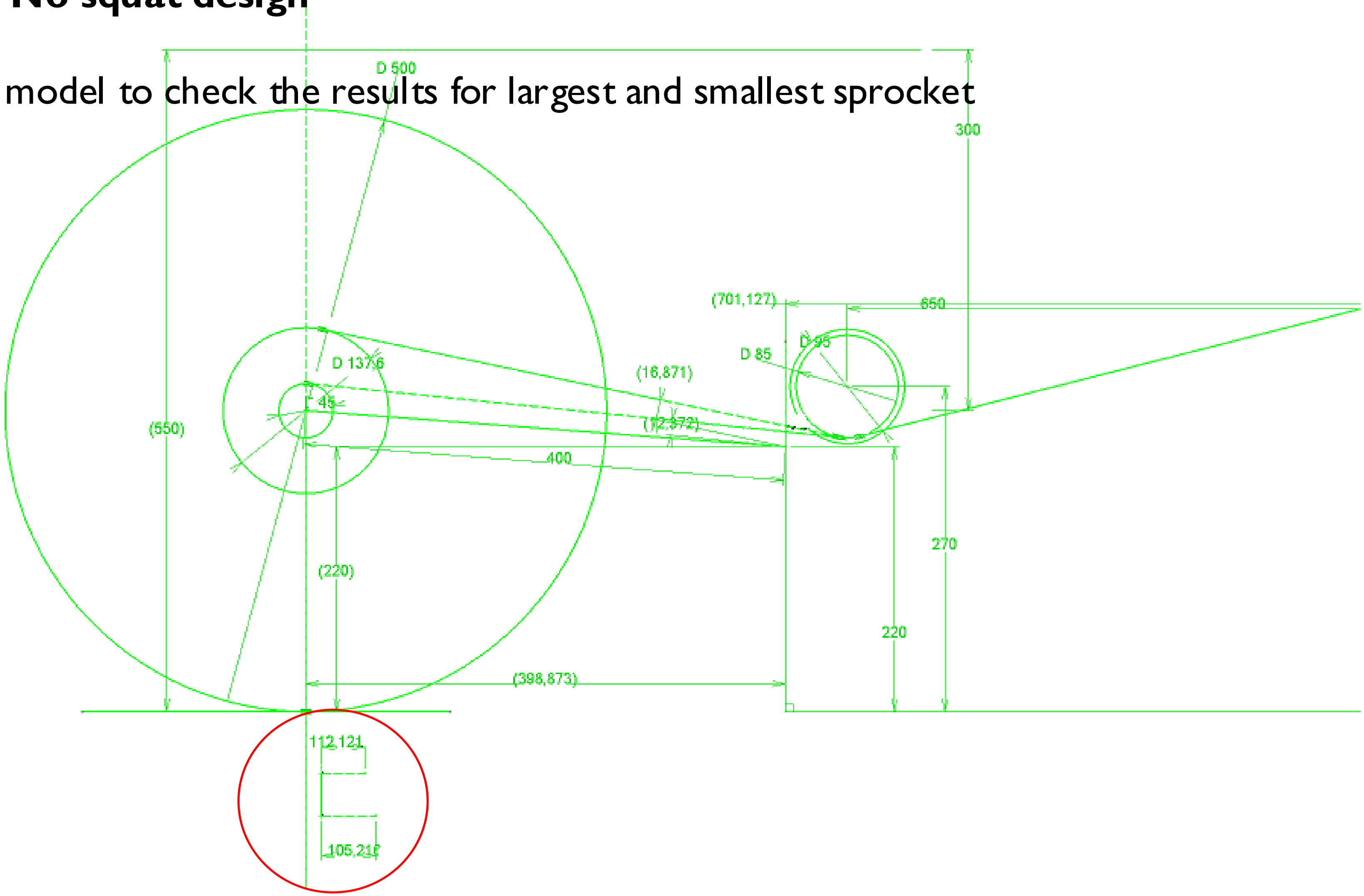
VM Test **WLM2** Werte aus check_squat, Stand 0912

Drehpunkt der Schwinge		Schwerpunkt höhe	Radradius		Ritzelradius	Drehpunkt-Lot auf Kette	Radstand	Squadradius
dx	dz	hs	Rr	Zähne	Ri	a	l	r
489	140	385	242,5	32	63,5	-29,1	1270	-26,94
489	140	385	242,5	28	55,5625	-30	1270	-28,20
489	140	385	242,5	25	49,609375	-31	1270	-29,15
489	140	385	242,5	21	41,671875	-32	1270	-30,41
489	140	385	242,5	19	37,703125	-32	1270	-31,04
489	140	385	242,5	17	33,734375	-33	1270	-31,67
489	140	385	242,5	15	29,765625	-33	1270	-32,30
489	140	385	242,5	11	21,828125	-34,3	1270	-33,56

Rear axle

No squat design

model to check the results for largest and smallest sprocket



Thanks for your attention and have a good time!

recommended literature

- Reimpell/Betzler: Fahrwerktechnik Grundlagen
- Reimpell/Betzler/Stoll: The Automotive Chassis
- Fred Puhn: How To Make Your Car Handle

Aufgaben der Zahnriemen-Rekuperation im VM

Heinrich Schlack

Aufgaben der Zahnriemen-Rekuperation im VM

- **Entlastung der Trommelbremsen bergab**
- **Rückwärts-Rangierfahrt**
- **Effizienter durch gleichmäßigere Geschwindigkeiten**
- **Nutzung der Bremsenergie für**
  - **Laden des Akkus für Elektrik**
  - **Unterstützung bis 25 +ε km/h bergauf**
  - **Beschleunigen aus niedrigen Geschwindigkeiten**
- **Weiterhin ein Fahrrad ohne Einschränkungen (Pedelec-konform)**

Maximale Bremsleistung ca. 1kW

10km leichte Steigung mit 20km/h + 20km relativ eben mit 40km/h

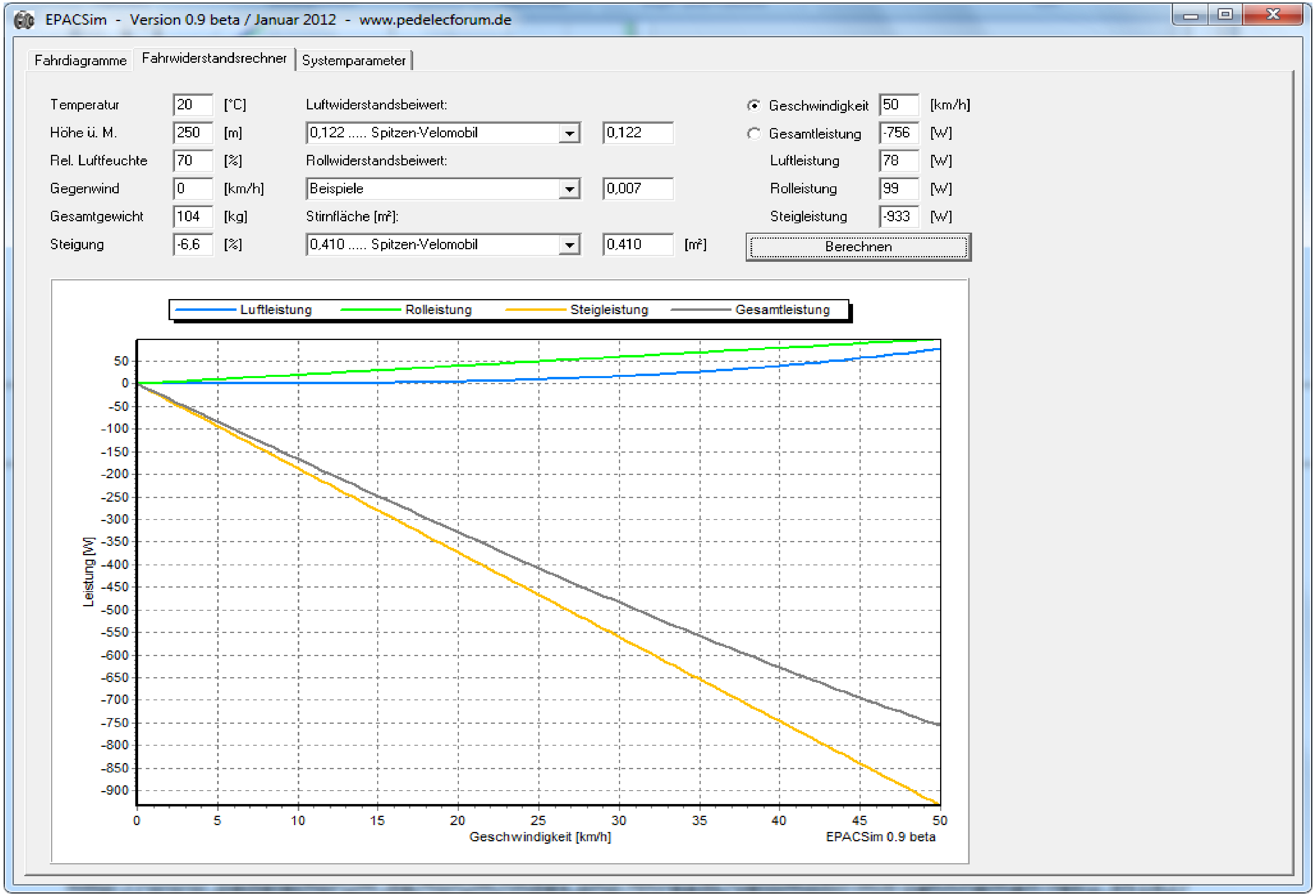
=> 30km in 1/2+1/2=1h also Schnitt 30 km/h

$1/2 * 20^3 + 1/2 * 40^3 = 36000$ Energieeinheiten für Luftwiderstand

$1/3 * 30^3 + 2/3 * 30^3 = 1 * 30^3 = 27000$ Energieeinheiten

– ein Viertel weniger

Fahrwiderstände



Ziele: leicht

Kettenschaltung mit Kasettenritzel

wenig Leerverluste

Zahnriemenscheibe montiert

Ritzel mit Zusatzlager

Im Zahnriemenritzel wurden zwei weitere Kugellager eingebaut, welche die Kraft zusätzlich aufnehmen – im SWXU-Getriebenabenmotor tritt diese Kraft nicht auf, da sich die Motorwelle allseitig am Planetengetriebe abstützt.

Übersetzung Zahnriemen-Scheibe zum –Ritzel 180:32 = 5,625; im Planetengetriebe 81:15 = 5,4

Jedoch Betrieb mit 48V statt 36V-Akku

Zahnriemenverluste ohne Kraftübertragung verschwindend – ca. 1/3 des Rollwiderstands

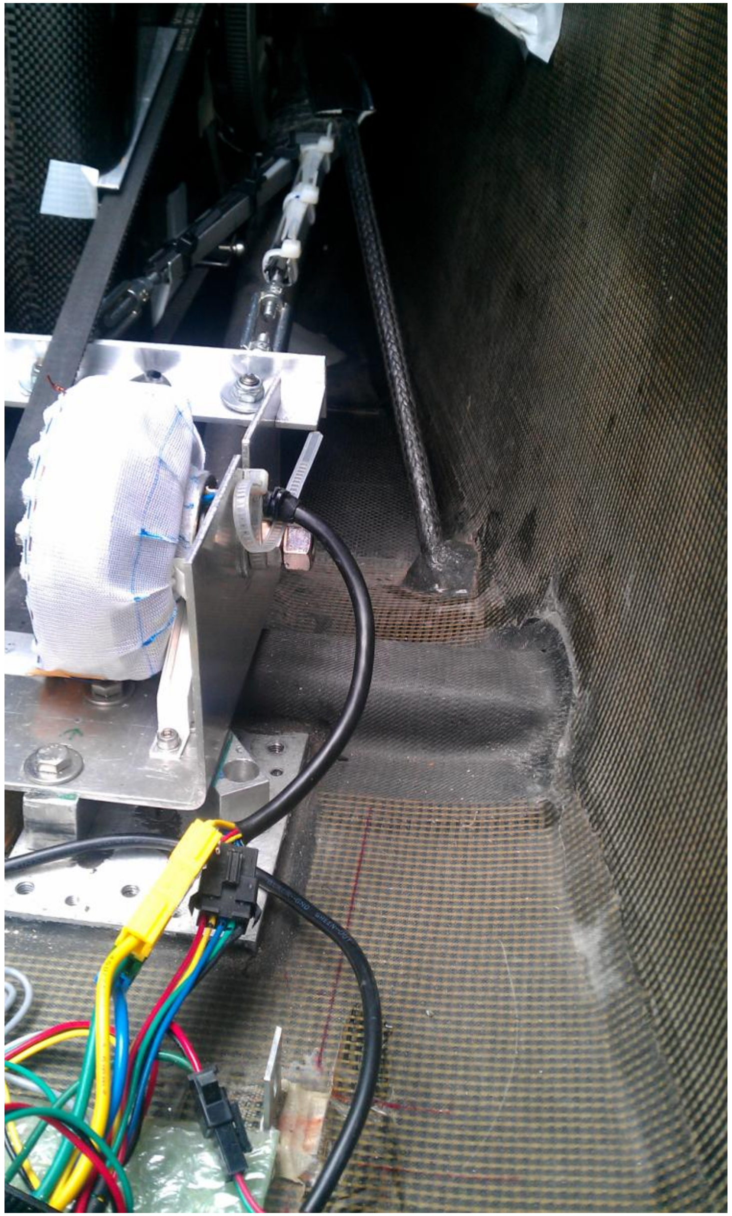
Maximale Reku-Leistung ca. 0,75kW; zusammen mit Verlustleistung ca. 1kW Bremsleistung


Schmutzschutz Ritzelseite

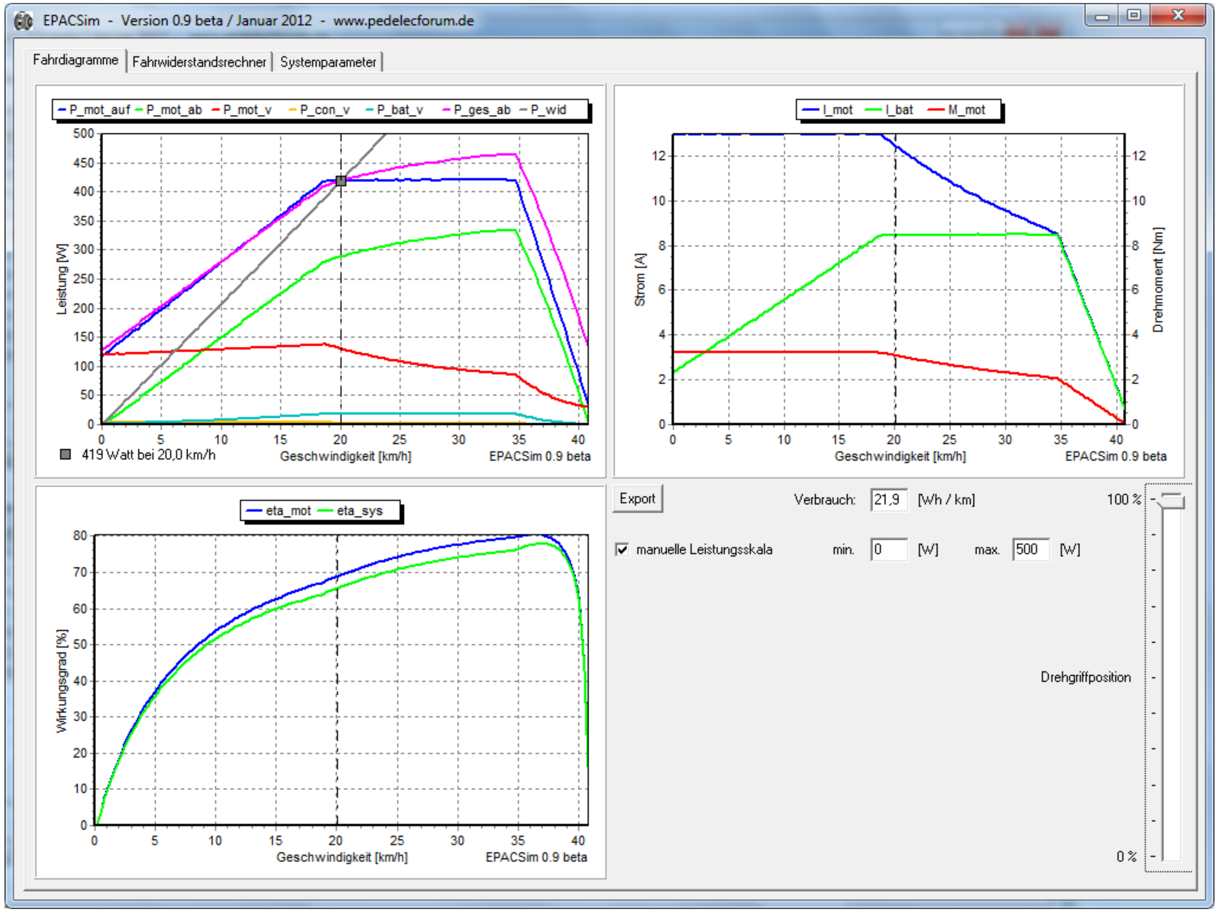
Der jetzt offene Motor kann die Wärme natürlich besser abführen. Wegen der Befürchtung, dass im Inneren des VM doch Schutz nie komplett vermeidbar ist, wurde ein Schmutzschutz aus einem Sockenwaschbeutel gebastelt.

Zahnriemenspannvorrichtung

Bei einem Zahnriemen benötigt man im Gegensatz zur Kette eine hohe Riemenkraft – das doppelte der zu übertragenden Kraft, sonst springt er über.


Zahnriemenantrieb gesamt


LiFePO-Akku A123 16s1p



Bergauf-Simulation 6,6% 130W Eigenleistung

Gewichte:

Zahnriemenscheibe 112g

Radnabenmotor ohne Getriebe und ohne Gehäuse 991g

Motorhalterung plus sonstige Befestigungen 485g

Summe Mechanik 1588g

Akku mit Kabel, Befestigung etc. 1519g

Sonstige Elektronik 559g

Summe alles 3666g

Wasser in den Wein:
Leider verschleißt das Alu-Motorritzel offenbar doch relativ schnell – der Durchmesser nimmt um ca. 1/10mm pro 1000km ab. Man bräuchte ein gehärtetes Stahlritzel.

Leider finde ich keinen Controller bei welchem ich den Reku-Motorstrom und damit das maximale Bremsmoment bzw. die übertragene Riemenkraft einstellen kann, um bei allen Bremsvorgängen Energie zurückzugewinnen.

Weitere und aktualisierte Infos auf
http://www.pedelecforum.de/forum/index.php?threads/velomobil-mit-zahnriemen-reku.35182/