Four-wheeled Velomobiles

The concept

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Abstract:

Today there is a certain standard in velomobiles:
They are three wheeled, aerodynamically shaped like a drop and mostly have a fairing
which is self-supporting. This makes them fast and simple.

The typical disadvantages of this type are limited luggage space, limited braking ability,
poor stability against overturning in curves, poor traction in winter conditions and there is
always the question where to store it safely.

The concept of the four-wheeled velomobile allows for optimizing every one of these
disadvantages with the exception that it is not optimized considering aerodynamics and
top speed. Its wider range of abilities makes it more practical for everyday's mobility
needs. So there is the chance to reach a much wider range of users, compared to the
typical velomobile owner of today.
Four-wheeled velomobiles

The concept

1. The shape of today’s velomobiles

The velomobile of today has spread mostly in the appearance of the three-wheeler, with two steered wheels at the front and one driving wheel at the rear.

This wheel arrangement permits the full fairing to be a drop-shape, seen from above. So a low drag can achieved and such velomobiles can be optimized in aerodynamics. They reach speeds up to 70 kph in races.

Most of these velomobiles have a fairing which is self-supporting to save the weight of a frame. And the general technical arrangement in particular the drive train are rather simple and cheap.

Other types of wheel arrangements usually have not been regarded as velomobiles so far:

- One driving wheel in the front (pedals in front of the wheel), two rear wheels. Articulated frame, mostly without fairing. Example: Flevo Trike.

- One steered front wheel in front of the pedals, two rear wheels, one or both driven. Example: The ultra-lightweight velomobile of Harald Winkler, presented in this seminar, too. But mostly there is no fairing or only partial fairing.

The reason of success of the drop-shape is of course high speed, achieved by good aerodynamics.

And in addition the drop is a very simple, basic shape which is considered as self-evident and “perfect”.

So this type of velomobile is perceived as a new and self-contained type of vehicle between bicycle, motorcycle and car. There is just no other type of vehicle that looks like a drop.
2. Common disadvantages of three-wheeled velomobiles

The drop shape which makes the three-wheeled velomobile so successful leads to several disadvantages. It is only a compromise in many other aspects:

- Stability against tipping sideways in curves is limited.
- Braking ability is limited because the center of gravity is closely behind the front wheels.
- There is rather poor traction on gravel paths and in winter conditions because only ca. 30% of the weight bears on the rear driving wheel.
- The drop shape leaves only little space for luggage.
- When the fairing is self-supporting there is no possibility to weaken it by a large access hatch. So getting in and out through a rather small opening is neither comfortable nor quick.
- Transport over stairs and storage indoors or even in cellars is difficult or impossible because the fairing is so bulky and long.

Is there a different type of vehicle that is a compromise in fewer and other aspects?

3. The four wheeled Velomobile

The concept of the four-wheeled velomobile allows for optimizing every one of the disadvantages or compromises of the three wheeled velomobile, with the exception that it is not optimized considering aerodynamics and top speed.

It has a wider range of abilities which makes it more practical for everyday's mobility needs. So there is the chance to reach a much wider range of users, compared to the typical velomobile owner of today.

On the following pages there is made the comparison of the four-wheeler to the three-wheeler in the essential aspects.

The comparisons are only schematic, just to show the principles of the concept. Compared are the following aspects:

- typical dimensions
- safety
- (cornering) speed
- braking ability
- traction
- luggage capacity
- storage
There is no comparison made, however, in other technical aspects or details, as

- material of the fairing
- head out, or canopy
- mirrors
- lighting
- suspension
- wheel sizes
- wheels inside the fairing and covered / inside but uncovered / outside of the fairing
- drive train
- ventilation
- etc.

because they are not distinctive for only one of the types.

4. Typical dimensions

In my comparison I set the track width of the front wheels of the three- and the four-wheeler equal, 70 cm.

The wheelbase of a three-wheeled velomobile is rather short, about 110 to 130 cm.

The overall length of its fairing, however, is rather long, up to 280 cm.
The wheelbase of a four-wheeled velomobile can be (and should be!) much longer, up to 150 cm.
The fairing does not need to be much longer than the wheelbase, for example 210 to 230 cm. So the overall length is considerably shorter.

5. Safety / road holding

The three-wheeled velomobile is always a compromise in safety.
When the front wheels are arranged far ahead it will brake well but is not very stable against overturning in curves.
When the front wheels are arranged more to the back, near the center of gravity, safety against overturning is much better but braking ability is poor. It will lift its tail easily.

The 4-wheeler can be optimised for both aspects:
It can apply both considerable braking power AND is very stable in tight and fast curves as well. This is achieved by the front wheels arranged much more forward and a rear wheel track which is equal or only a little narrower than the front wheel track.

Maximum stability against overturning is provided by the fact that a four wheeler can employ its full track width. A three wheeler has an „effective track width“ which is narrower than its track. Compared to a 3-wheeler of the same width the 4-wheeler is less likely to turn over.

And with its longer wheelbase it will run more smoothly and less bumpy and nervous at higher speeds.
Three-wheeled velomobiles are not as stable against overturning as they seem to be, regarding their track width. They will tip over a line which runs from one front wheel contact point to the rear wheel contact point. This is the “tipping line”. Its effective width is not the track width but its width near the centre of gravity. So the effective width is only 70 to 60 % of the track!

Four-wheeled velomobiles of the same track width of the three-wheeler are much more stable against overturning. The tipping line equals the track width.
6. Speed / energy efficiency

What does speed mean? Is it the top speed?

In daily use speed is only a means to get from A to B. The time it really takes to get from A to B depends on average speed.

High average speed is not necessarily guaranteed by reaching maximum speed.

But the most efficient means to rise the average speed is to avoid to be slow!

Because of its higher stability in curves the 4-wheeler can also corner with higher speeds!

In addition it is possible to arrange the track so wide and the centre of gravity so low that a four-wheeler will no more turn over in curves but merely slips away sideways, even on tarmac. This would be a crucial gain in safety!

With the ability of a higher cornering speed it is not necessary to decelerate so much before curves. After the curve it is more efficient to accelerate from e.g. 20 kph to cruising speed again, instead from e.g.15 kph.

This saves a lot of energy and leads to a higher average speed.

But this always depends on how many and how tight curves are on the typical route, of course.

7. Braking ability


Distribution of wheel loads when braking: At maximum deceleration nearly all the weight bears on the front wheels. Danger of lifting the rear wheel and losing directional stability.
Position of centre of gravity in four-wheeled velomobiles. Typical distribution of wheel loads. More load on the rear wheels than on the front wheels.

Distribution of wheel loads when braking. There is always enough load on the rear wheels. So maximum deceleration can be transferred to the ground without the danger to lose directional stability.

Optimised braking can be achieved by positioning the front wheels much more to the front. This allows to transfer maximum braking power to the ground through front and rear wheels.

8. Traction

Traction of three-wheeled velomobiles. Only a small percentage of the weight bears on the driving wheel. Poor traction on loose ground and in winter conditions.

50 to 70 % of the weight are bearing on the driving rear wheels. This results in good traction on loose ground and in winter conditions which makes the 4-wheeler an all season vehicle.
9. **Luggage capacity**

Typical luggage capacity of three-wheeled velomobiles:

By the drop shape of the fairing there are only leftover volumina available for luggage.

Typical luggage capacity of four-wheeled velomobiles:

Between the two rear wheels there is lots of space available in one luggage compartment. This can pick up for example one or two crates of beverages, shopping, luggage or a child's seat. This makes it a competitor to the car!
10. Getting in and out / comfort / acceptance:

In three-wheeled Velomobiles in a self-supporting fairing getting in and out through a rather small opening takes some time and may not be accepted by less agile people. May be in some cases this reason is the only reason why people don’t buy a velomobile!

If the fairing is only a fairing and the frame is the main structure, the fairing can be opened wide. So very easy access can be provided. Thus more (elder) people which are less agile (but have enough money) can accept to use a velomobile!

Also shopping tours with many stops become much more attractive if getting in and out is quick and easy. This is a very important point to integrate velomobile use into daily life!

11. Storage

A 4-wheeler has a cut off rear end and can be built short (down to 2.0 m). Both features allow to store it vertical, sitting on its tail, even in cellars or trains.
12 Shape, design and acceptance

The drop-shaped three-wheeled velomobile has been successfully installed in public perception as a self-contained shape. It is a new but distinctively different type of vehicle between bicycle, motorcycle and car.

If someone encounters a drop-like vehicle he can assume: This must be a velomobile.

For the four-wheeled velomobile things are much less settled. By the four wheels it resembles the car. In its perception there is always the danger to be mistaken as a toy-car or a pedal-car because it is small. And so even to be a bit ridiculous in some people’s minds.

Concerning acceptance it seems to me that there are two opposing views on the vehicle:

Many people who are practising an ecological and sustainable way of life reject „the car“. They (try to) substitute it by bicycle, recumbent or velomobile. Maybe they would reject a four-wheeled velomobile, too, because in their opinion it comes too close to the disliked car. They would perhaps accept only the three-wheeled velomobile.

On the other hand there are many car-driving people who would not want to be seen on a recumbent or on a three-wheeled velomobile. For them this is too „eco“ and too „alternative“.

So they are more likely to accept a four-wheeler as an alternative to the car and as a „green“ means of transport. Here is the potential of a new group of customers who wouldn’t buy a three-wheeled velomobile but perhaps a four-wheeled one. There is a chance that car-users change their vehicle. This still has to be verified.

Crucial to the success of the four-wheeled velomobile is to solve its yet unsettled perception. This can only be done by design! A distinctive shape still has to be developed. The four-wheeled velomobile must look

- cool !!!
- like a racing car
- promising prestige
- and it must be practicable and useful in daily life at the same time.

On the following pages there are some examples how the few existing four-wheeled velomobiles look like.

After that there are some design studies about the shape of future four-wheeled velomobiles.
Curry Landskiff
Manfred Curry, Germany 1926
Rowing drive, also available as unfaired tandem
Mochet „Velocar“ , France
over 1000 produced between
ca. 1927 and ca. 1948

Pictures: Radfahrgalerie
Burgdorf, 2004
Robert Bundschuh, 1974 USA
hanging lever drive, 5 gears,
no hub gears

Pictures: www.geocities.com
„Muscar“ 2, FH Köln, Prof. Schöndorf, Germany ca. 1976


Picture: Gerhard John Liegerdreirad-Katalog 1985
„Alternativer Leichttransporter“ AL 2 of Union Fröndenberg and Luigi Colani, Germany 1982

Pictures „Radfahren“ 5/1982
„Turo“
Paul Rinkowski
DDR 1984
French four-wheeler seen in Wolverhampton ca. 1992
Kingsbury Racing
Velomobile, GB
With linear drive and four-wheel steering
ca. 1990

Photos: Heiko Stebbe, Germany
Picture: Velo Vision 17, 2005

Pedalcar racing in Hong Kong, 2005
Hong Kong Human Powered Vehicle Association
www.hkhpva.org
2006 BRITISH PEDAL CAR CHAMPIONSHIP EVENTS

Picture: Velo Vision 21, 2006

British pedal car, 2006
www.pedalcars.info
Picture: Velo Vision 21, 2006

Greenspeed four-wheeled racing velomobile
Australia, 2006
Design study
Ingo Kollibay
1996
Design study
Ingo Kollibay
1998

Design study
1996
Harald Kutzke
Ecomotion Design
ecomotion.com
Design studies
"racing car"
Ingo Kolibay
2008
Design study „racing car“  Ingo Kollibay 2008
13. Conclusion

The four-wheeled velomobile is more versatile than the three-wheeler, it is an allrounder. It has a wider range of abilities which makes it more practical for everyday’s mobility needs. It can perform several jobs which people usually „need“ a car for.

So there is the chance to reach a much wider range of users, compared to the typical velomobile owner of today.

The four-wheeled velomobile is the real

\[
\text{Sports Utility Vehicle} !
\]
For about 20 Years he has been working as an architect (building and town planning).

Building his own recumbents started in 1983.
Over the years he developed an built many recumbents with long, middle and short wheelbase, tricycles, trailers, folding recumbents, some tandems and special needs vehicles.

Serial products are
- the **Brompton Recumbent Conversion Kit** which makes the Brompton folder to a folding recumbent. Developed together with Juliane Neuss, Hamburg, company Junik Spezialfahrräder who also produced it.
- the running scooter „**Sauseschritt**“ (scooter with a saddle), also developed with Juliane Neuss and produced by Patria. Red Dot design award.

In 2002 he founded the company „Velo.Saliko“ together with three other HPV-enthusiasts which developed and produces the circular seven seater HPV „**ConferenceBike**“. The company is situated in Hannover, Germany.
See [www.saliko.de](http://www.saliko.de) and [www.conferencebike.de](http://www.conferencebike.de)

He is interested in velomobiles for many years, has made a lot of sketches and design studies but does not own one yet.

On the 5th Velomobile Seminar held in Germersheim in 2004 he gave a lecture on the Cyclodyne, a forgotten early velomobile from the US.
Juliane Neuß developed the “growing” children´s-Bike SKIPPY in 1994, which is built by PATRIA. She also developed the Brompton Recumbent Kit and the running scooter “Sauseschritt”.

She is specialized at bike ergonomics and has started to write a book about it.

Her One-woman-company Junik is running since 1998 with the Brompton Recumbent, with 8-Speed Bromptons and special bike constructions, but she is still working as a Technical Assistant for Material science in a small Laboratory at the University of Federal Armed Forces in Hamburg.

Juliane Neuß, Material Science
Born 1962

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