Human Powered individual transport systems

Feasibility Report

Project 3a (64ET6918_1213_9)

By Jack Robinson

10298859
0.0 Summary

The following report aims to address the key issues surrounding human powered vehicles and analyse them in such a way as to outline the existing benefits, flaws and bring focus to potential improvements.

Using the past as a spring-board, this report will critically analyse the growth and evolution of this mode of transport. Then moving forward, it will assess and criticise current options available finally looking at the potential for future growth and evolution.

The further stages of this project will revolve around velomobiles; a great deal of primary and secondary research has been conducted to give the reader a full understanding of their construction and purpose.

Great care has been taken to ensure that I have feedback and responses from the market that velomobiles appeal to by using specific cycling forums and contacts.

Taking a critical standpoint this report utilises mistakes from the past to influence and redesign the future.
0.1 Acknowledgements

Contacts:

Undercover Cycling – Go-one - Mosca@go-one.us

Ymte Sijbrandij – Owner of Velomobiel.nl

Rollin Nothwehr – recumbent bicycle designer and manufacturer

Dr Graham Sparey-Taylor – British Human Powered Forums

Shimano bicycles – Bicycle and fishing company

British Human Power forum - users

Bentrider online forum – users

The recumbent bike forums – Users

Surveymonkey
# Contents

## Table of Contents

Contacts: ........................................................................................................................................... 3

1.1 Introduction .................................................................................................................................. 10

1.2 What are human powered vehicles? ......................................................................................... 10

1.3 Inspiration ................................................................................................................................... 11

1.4 The interest behind the project ................................................................................................. 11

2.1 The Creation ............................................................................................................................. 12

2.2 The Invention of Pedals ........................................................................................................... 12

2.3 The First Recognizable Modern Bicycle .................................................................................... 13

2.4 The Penny-Farthing ................................................................................................................... 13

2.5 The Beginning of Today’s Bicycles ............................................................................................. 14

2.6 The Future of Human Powered Transport? ............................................................................. 14

2.7 The Invention of Velocars ......................................................................................................... 16

3.1 Social and cultural ....................................................................................................................... 17

3.11 Environmental Impact ............................................................................................................. 17

3.13 Kinetic energy and motors ....................................................................................................... 18

3.2 Ergonomics ............................................................................................................................... 21

3.21 Velomobile Comparison ......................................................................................................... 21

Go-One³ ........................................................................................................................................... 21

The Quest ......................................................................................................................................... 22

3.22 Improving Safety ..................................................................................................................... 24

3.23 Suspension and Steering Set-up .............................................................................................. 25

Suspension Introduction .................................................................................................................. 25
Dr Graham Sparey-Taylor – British Human Powered Forums ............................................ 53

4.1 What has been established from my findings and research ........................................ 54

4.11 Finding a suitable HPV ................................................................................................. 54

4.12 Social and cultural research ......................................................................................... 54

4.13 Ergonomics research .................................................................................................. 54

4.14 Fitness for purpose research ......................................................................................... 55

4.15 Market research ........................................................................................................... 55

4.16 Contacts and advice .................................................................................................... 55

Ymte Sijbrandij .................................................................................................................. 55

Shimano .............................................................................................................................. 56

Rollin Nothwehr .................................................................................................................. 56

Dr Graham Sparey-Taylor – British Human Powered Forums ........................................... 56

5.1 Assessments of the research and findings ..................................................................... 57

5.2 Recommendations against the original aims and objectives ...................................... 57

5.21 Looking Back at Preliminary Aims and Objectives ................................................... 57

Design Aims ....................................................................................................................... 57

Research Aim ..................................................................................................................... 57

Objectives ......................................................................................................................... 58

5.22 Analysis of preliminary aims and objectives .............................................................. 58

Objective analysis: ............................................................................................................. 58

5.3 Design Brief .................................................................................................................. 59

5.4 Product Design Specification ......................................................................................... 60

5.5 Product Choice and Assessment Criteria ...................................................................... 62

7.1 Image links .................................................................................................................... 64

8.1 Literature survey ......................................................................................................... 66
Books.............................................................................................................................................66
Government Reports .........................................................................................................................66
Educational Reports ............................................................................................................................66
Online newspaper articles ..................................................................................................................66
Online publications ............................................................................................................................67
Websites ........................................................................................................................................076
Videos.............................................................................................................................................69
Tutor and supervisor contact:.............................................................................................................70
Preliminary Feasibility Report ............................................................................................................71
1.0 Introduction .................................................................................................................................72
2.0 Statistics and Information ............................................................................................................72
3.0 Aims and Objectives ....................................................................................................................72
4.0 Development Plan .......................................................................................................................72
5.0 Literature Survey ..........................................................................................................................72
1.1 Introduction ................................................................................................................................73
1.2 What are human powered vehicles? ............................................................................................73
1.3 Inspiration ....................................................................................................................................74
1.4 The interest behind the project ....................................................................................................74
1.5 History and Future of Human Powered Transportation ...............................................................74
     The Creation ................................................................................................................................74
     The Invention of Pedals ................................................................................................................75
     The First Recognizable Modern Bicycle ......................................................................................75
     The Penny-Farthing .......................................................................................................................75
     The Beginning of Todays Bicycles .................................................................................................76
     The Future of Human Powered Transport? ................................................................................76
Improving Safety ......................................................................................................................... 77
2.1 Statistics to show all road traffic ......................................................................................... 78
2.2 Statistics to show how road traffic has changed (1970-2010) ...................................... 79
Design Aims ................................................................................................................................. 80
Research Aim ............................................................................................................................. 80
Objectives .................................................................................................................................. 80
Books ......................................................................................................................................... 82
Government Reports .................................................................................................................. 82
Online newspaper articles ........................................................................................................... 82
Websites ....................................................................................................................................... 82
0.3 Nomenclature

**HPV**

Abbreviation for “Human Powered Vehicle”, a HPV could be a bicycle, tricycle or anything else that’s powered by a human and not an engine or motor.

**Recumbent Bicycle**

A two wheeled form of transportation similar to a bicycle only the user leans back and lies on the seat, the pedals are often more horizontal to you instead of being below you.

![Recumbent Bicycle](Figure 1 Recumbent Bicycle)

**Velomobile**

A recumbent human-powered tricycle usually fully enclosed in a streamlined shell. They often travel at higher speeds compared to bicycles and offer more protection.

**“Tadpole” Trike or Velomobile**

Tadpole refers to the shape of the vehicle, 2 wheels at the front and 1 at the rear.

**Velonaught**

An avid velomobile owner/ frequent user.
Human Powered individual transport systems

1.0 Introduction

1.1 Introduction
This report aims to inform the reader about different forms of individual human powered transport. The key areas that will be assessed include:

- The history of human powered transport and the huge innovations that have changed the way we think about transport.
- The decline of renewable resources, in addition to the progression of environmentally powered and sustainable ways of commuting.
- The aims and objectives that this project hopes to achieve through its entirety.
- A time plan for the design portion of the project outlining key deadlines and objectives that needs to be achieved.
- The huge range of existing concept and futuristic designs, which range from simplistic bicycles to complex and beautiful sports cars plus how the shaping of them will influence this project.
- A breakdown of Britain’s current selected modes of transport and how they have changed within the last few decades.
- A detailed review of current human powered vehicles and how they work.

1.2 What are human powered vehicles?
This project named “human powered individual transport systems” will look at the many ways that humans commute using their own energy and how they can be improved.

The areas in which existing designs may have room for improvement include:

- Radical aesthetic changes to give a more modern look.
- Different mechanical and ergonomic setups.
• A versatile cover system that will protect the user from collisions and different weather conditions
• Greater stability when riding compared to the typical bicycle

Although the project will focus on human powered transportation, it is important that the aesthetics are inspired from a broader range of designs that will include concept and futuristic cars, bicycles and motorbikes.

1.3 Inspiration
Experienced gained from years of riding bicycles and examining other types of human powered transportation has brought up many issues that could easily be resolved by design. For example in bad weather conditions the user can fall injuring themselves. Although injury is a key issue there is also discomfort in conditions like rain, simply giving the bicycle an impact absorbing transparent cover would improve the aesthetics as well as solve these two issues.

The inspiration and the visual fuel for this project will come from many smooth, elegant and simplistic current concept car, motorbike and bicycle designs.

1.4 The interest behind the project
Anyone who has built, maintained and has ridden a bicycle will tell you that the simple and very efficient mechanics are very adaptable and fun to experiment and work with. Because of this, there are already very interesting concept designs being generated.

The interest that comes from bicycles and other forms of human powered transport is that they have the ability to transfer minimal energy put in from the user into the bicycle that using that energy can propel someone much faster than any human can run.
2.0 Background and Future of Human Powered Transportation

2.1 The Creation

Human powered transportation has been around for many centuries however the first resemblance of a modern day bicycle was constructed around 1790 by a Frenchman named Comte Mede de Silvrac. Called “a celerifere”, it was much more basic than a bicycle from today. With no steering or pedals, it relied on the user’s feet pushing off the ground to roll forwards. It was tailored for very smooth and perfectly groomed pathways to roam down that only the most privileged citizens of the time had access to.

The first major innovation was in 1816, German Baron Karl von Drais designed a similar model only this time including a steering mechanism attached to the front wheel. This allowed for the user to be able to dictate the direction that the bicycle traveled in. He called it a Draisienne, after himself, though many people later dubbed it a hobby horse.

2.2 The Invention of Pedals

Historians widely believe that the invention of the pedal bicycle, made reality by Kirkpatrick Macmillan, a Scottish Blacksmith. After analyzing the current model where the user would push off the ground with their feet he realized there was improvement that could be made and set to work designing his bicycle. Around 1939 he introduced his model that not only had the ability to steer but also had a set of simplistic pedals fixed to the rear wheel that greatly improved the efficiency in which humans could get more of a power output.
2.3 The First Recognizable Modern Bicycle

Most believe father and son Pierre and Ernest Michaux to be the true inventors of the modern bicycle. Their invention, the Vélocipède, was produced in 1867 and was propelled and steered from the front wheel by a set of cranks and pedals.

In 1866, his design was patented in the United States when one of the Michaux’s employees named Pierre Lallement went over and filed for one. Although the Vélocipède was revolutionary it was named as the “boneshaker” because of the extremely rough ride the user experienced, this was due to the lack of suspension and the stiff iron frame and wooden wheels wrapped in an iron rim.

2.4 The Penny-Farthing

Eventually by 1870, bicycles were constructed completely out of metal with a much larger front wheel known as a penny-farthing or a high wheel bicycle. The reason behind this was that the larger the wheel the faster the bicycle would move.

The rider is constantly at risk however; hitting even a tiny stone could launch the user forwards often making them land on their head. This led to the origin of the term “breakneck speed”.

Figure 4: Patent for Lallement’s Vélocipède

Figure 5: The Penny-Farthing
2.5 The Beginning of Todays Bicycles

In 1855, designers began to recognise the limitations of the high wheel bicycles and set to work designing the safety bicycle. The safety bicycle would be a huge step forward in human powered transport. Most importantly it allowed people of all ages and sizes too comfortably and safely commute. This of course expanded the buyer market considerably.

In 1885, John Kemp Starly designed a bicycle that has two similar sized wheels. Together with a sprocket and chain, the basic diamond shaped frame and inflated rubber tyres cycling became enjoyable and safe. This later led to a golden age of cycling and the birth of bicycle racing, with many people being able to afford riding them for both pleasure and practical means.

2.6 The Future of Human Powered Transport?

Looking at the radical changes that have happened in the history of human powered transport it is hard to believe that such little has changed in the last century. With today’s modern and affordable material choices and the shapes that we can achieve via rapid prototyping who knows what kind of advancements we can make. The picture on the left is a hybrid that combines human energy and motor that charges its 300watts with kinetic energy to then later power it up to 50kmh!

There are already advancements in the area that this project may continue in, these vehicles are called velomobiles and are derived from recumbent bicycles, they have a smooth shell like exterior and therefore have major aerodynamic benefit compared to a bicycle. They
offer weather and collision protection, but even with all these advantages there are very few manufacturers of velomobiles and therefore a gap in the market.

Velomobiles are capable of integrating roll protection and user harnesses that greatly improves safety. Headlights and turn signals (indicators) can be equipped on these vehicles that would make them a lot more visible on the roads especially at night. This is important because of the numerous amounts of cars on the road and the hazard they present to the rider.

Figure 9 Interesting concept recumbent bicycle

Above is an image of a concept recumbent bicycle that could be used as a base for a velomobile.
2.7 The Invention of Velocars

The first well documented velomobile is the “velocar” produced by Georges Mochet. He produced around 6000 from as early as 1925 through to 1944.

The initial concept of a Velocar (or “pedal car” as it was also known) came to Mochet when his son requested a bicycle, unfortunately they lived in the middle of Paris and the traffic was very dangerous and because of this his wife forbids young Georges to ride around on such an open, unprotected vehicle. Mochet set to work designing an enclosed recumbent bicycle for his son and eventually came up with the lightweight Velocar.

He soon noticed that his son was overtaking and going much faster than other children his age and decided in 1925 to explore the commercial potential that was to produce the Velocar. A Velocar was almost the same initial cost to buy as a motorbike but had many advantages such as no fuel was needed, there was a much less maintenance to carry out and most users appreciated the exercise.
3.0 Main Body

3.1 Social and cultural

3.11 Environmental Impact

In essence, a velomobile is the environment’s best friend. One great quality of a velomobile is that it offers very good performance with extremely low emissions (if any at all) due to an optional electric or kinetic motor.

Because of the velomobiles aerodynamic and streamlined nature it can reach higher and more consistent speeds drawn from much less human input (energy) almost eliminating the need for an emission producing car engine.

Consideration of the environment and sustainability must be a key priority in all future design.

Figure 11 Do we take the environment for granted?
3.13 Kinetic energy and motors

Below are two BionX motors. On their website they claim “when the brake lever or one of the four recovery levels of the motor is activated, the energy is converted into electricity and charges the battery when the rider drives on again.”

**SL Motor**

A new BionX™ development offering significant weight reduction, 25% lighter, but with the same performance characteristics as the G1 motor.

- Nominal power: 350W
- Torque: 9/40 Nm (6.6/29 lb-ft)
- Noise and vibration free
- Weight: 3.5kg (7.7 lb)

**PL Motor**

The classic BionX rear wheel motor with integrated power measurement. Brushless DC rear wheel motor-generator ensures that your wheel stays a wheel.

- Nominal power: 350W
- Torque: 9/40 Nm (6.6/29 lb-ft)
- Noise and vibration free
- For 7, 8 or 9-speed ring gears
- Weight: 4.7 kg (10.4 lb)

*Figure 12 - The two different types of BionX motors*
Like the majority of power assists, additional to the motor, BionX systems also require a battery and a console to allow the user to have full control and influence over their vehicle.

According to the Swedish author Frederik from his blog that promotes hybrid velomobiles (http://www.waw-bionx.blogspot.co.uk/) you can get “40% more range by using regeneration” – This is based on a test report where he placed a BionX electrical assist motor and generator on his prototype Waw velomobile.
Frederik explains that velomobiles are extremely efficient when traveling on level ground or downhill due to their advanced aerodynamics but when it comes to traveling uphill velomobiles struggle simply because of extra weight they have compared to a standard recumbent or normal bicycle.

To solve the struggle of climbing uphill he chose to incorporate a BionX motor. He did so for numerous reasons:

“- it could be mounted easily on any bicycle and also in my velomobile

- It was a light system, adding only 8 kg so interfering little when cycling

- possibility to choose the level of assist without the jerkyness of an on-off like behaviour of other systems

- most prominently, the regenerative braking: applying the brakes gently activates the assist engine as a generator, charging the batteries and hopefully increasing range”

– Frederik, Blogger.

To the right shows the position of each element of a BionX system in Frederik’s Waw velomobile.

He goes on to say “A BionX is not cheap, but my experience has already showed that a range of approx. 100km is possible in my area” This is outstanding considering that the unit only takes around 4 hours to charge!
3.2 Ergonomics

3.21 Velomobile Comparison

**Go-One**

Go-One is one of the most popular ranges of velomobiles, offering very high quality and aesthetically appealing HPV solutions. Below is a specification for one of their velomobiles.

<table>
<thead>
<tr>
<th>Sizes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length: 265cm</td>
<td></td>
</tr>
<tr>
<td>Width: 76cm</td>
<td></td>
</tr>
<tr>
<td>Height: 98cm</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Materials</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Fibre</td>
<td></td>
</tr>
<tr>
<td>Monocoque</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mechanical</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Removable hatch for head</td>
<td></td>
</tr>
<tr>
<td>Head is inside the vehicle</td>
<td></td>
</tr>
<tr>
<td>Method of entering: rear half of canopy hinges forward</td>
<td></td>
</tr>
<tr>
<td>Integrated head/tail lights and indicators: yes</td>
<td></td>
</tr>
<tr>
<td>No luggage space</td>
<td></td>
</tr>
<tr>
<td>Tire size 20&quot; front and 26&quot;(x1.3&quot; width)</td>
<td></td>
</tr>
<tr>
<td>Suspension: Shock absorber on front, carbon fibre swing arm on rear</td>
<td></td>
</tr>
<tr>
<td>Brakes: front drum</td>
<td></td>
</tr>
<tr>
<td>Electric system: 12v</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Misc.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight: 32kg</td>
<td></td>
</tr>
<tr>
<td>Website URL: <a href="http://www.go-one.biz">www.go-one.biz</a></td>
<td></td>
</tr>
<tr>
<td>Base price: $7000 plus shipping within the USA</td>
<td></td>
</tr>
<tr>
<td>Colours available: yellow, black, blue, red, white and any other at additional cost</td>
<td></td>
</tr>
<tr>
<td>Front wheels/ Rear wheels - 2/1</td>
<td></td>
</tr>
<tr>
<td>Security: ordinary bicycle lock</td>
<td></td>
</tr>
</tbody>
</table>

Information and image source: [http://www.velomobiles.net/buying/buying.html#goone](http://www.velomobiles.net/buying/buying.html#goone)
The Quest

This Dutch velomobile named “The Quest” has produced and sold over 100 velomobiles within two and a half years. That may not sound much but by velomobile standards it’s very successful. Most of the customers commute and ride over 10,000 km yearly!

Sizes

• Length 285cm
• Width 76.5cm
• Height 87cm

Materials

• Glass fibre/epoxy resin shell
• Aluminium subframe

Mechanical

• Seat Angle 35 - 40° (custom made)
• Crank set Shimano 105 triple 52/42/30(hollowtech)
• Pedals Shimano PDM 525 (spd)
• Integrated head/tail lights and indicators: yes
• Main chain Sachs/Sedis pc59 9sp
• Secondary chain Sachs/Sedis pc48 8sp
• Sprockets main chain Sram 9v 12-26
• Derailleurs Shimano 105
• Shifters Sram Grip shift attack
• Freewheel rear second chain Shimano BMX race 18t
• Sprocket second chain Ofmega 28t
• Brakes MBL Aluminium drum brakes (singe side mounted)
• Tyres Vredestein Monte Carlo 37-406 95psi
• Removable cover for good weather conditions

Misc.

• Weight 32.4 kg including lighting system
• Comes ready to drive with lights, on board computer, spare tyre and tyre repair set
• Base price: € 5672 (€4766 excl VAT)
• Colour: Yellow
• Prices different colours and striping on request
• Front wheels/ Rear wheels - 2/1
• Turning circle 12 m, optional open wheel covers 7m

http://www.velomobiles.net/buying/buying.html#vmnl
http://en.velomobiel.nl/quest/technische_gegevens.php
Figure 17: The Quest Interior

From this diagram, you can clearly see that The Quest is designed conventionally to be powered from the rear wheel whilst steering and brakes being operated in unison with the front two wheels.

It is interesting to see that the chain is fully enclosed to prevent wear and a simple replaceable drum break is used to make sure that the owner has to carry out as little maintenance as possible.
3.22 Improving Safety

Just because safety is being improved doesn’t mean that the aesthetics and the product have to look any worse.

A good safe design must also look the part; this is a belief that is going to be of use in this project. A great example of this is the bicycle neck airbag, an airbag that blends in with your clothes for style conscious people who do not want the unappealing aesthetics of wearing a helmet.

Taking only 0.1 seconds to inflate, when a bicyclist is unfortunate enough to be involved in a collision the sensors inside of it will detect a sudden jolt and deploy the hood shaped airbag that will surround the user’s whole head protecting it from injury.

The colour of the collar can be adapted to suit whatever outfit the cyclist wears. Made from a durable nylon fabric, it is capable of withstanding the heavy conditions that surround the bicycle user during the event of impact.

“Both myself and my colleagues are very keen cyclists, but in Sweden a law was brought in that all people must wear helmets.

A lot of people don’t like a bicycle helmet because of the way it looks and what it does to your hairstyle once you have taken it off.

So despite the law many people carried on not wanting to wear cycle helmets, and this is the same not just in Sweden but in places like the UK too.”

– Anna Haupt, designer
3.23 Suspension and Steering Set-up

Suspension Introduction

Suspension on velomobiles are completely optional but offer comfort and better road contact compared to having “rigid” or no suspension.

A post on British Human Powered Forums allowed for this response from a forum member named Squeaker:

Figure 20 A forum reply on a thread I created

Squeaker explains that he doesn’t ride a velomobile but has an automotive engineering background. He explains what the most common form of front suspension for a European velomobile is and goes on to talk about rear suspension and how vital it is for the stability of a tadpole trike or velomobile.
Suspension and Excess Wheel Wearing

The suspension set up on a velomobile is very important when compared to how the wheels contact the roads surface. With careful design, you can eliminate excess tyre wear and rolling resistance that can actually slow you down.

When the velomobile hits an uneven surface, the suspension absorbs some of the impact (represented as the blue arrow on diagram A and B) to give the user a smoother ride.

If the suspension is not attached to the frame correctly or at an uneven angle, it can cause the tyres to move away from the body every time this happens, (a good example of suspension attachment is represented on diagram A with a red arrow, a bad example on diagram B).

If the tyres are moving horizontally away from the frame, this can cause a number of issues such as the tyre wall coming in to contact with the frame/shell doing damage and causing tyre wear.
Current Front Suspension Set-Ups

The most common form of frontal struts in all types of vehicles is also one of the most basic. It’s called the MacPherson Strut. It serves the purpose of steering and absorbing impacts. Velomobile users often buy MacPherson struts suited for a recumbent trike/velomobile from the company Velomobicel.nl.

“Our struts have steel springs (you can use different ones for different characteristics), a nickel plated steel piston with a damper with polyurethane part that rubs in the aluminium body. The aluminium profile on the underside of the strut body is used for mounting on the connection links for guide and steering rods. We have two different types, one with axle in a straight angle in the strut body (mango, alleweder, waw) and one wit axle in a 6 degree angle for the Quest (we need this because there is not much room in the closed wheel boxes in top for strut and wheel, the tyre has to run close to the strut. Overall length can be adapted by using another piston tube. The rods are meant for Sturmey Archer drum brakes and 20” 406 wheels. The standard spring is meant for a weight of 35-45 kg, with a stiffer spring you can have max 60kg on it. Price is euro 105 a piece including axle and brake plate, a SA drum brake up is euro 20. Prices ex VAT, shipping to the USA will be about euro 45.”

– Velomobicel.nl
To the left, the strut is viewable in place. You can see where and how it attaches to other components such as the steering rod, top support and the lower arms.

On the left you can see a broken down (disassembled) strut that came off a Waw velomobile. This is a MacPherson strut and is extremely simple; consisting of a coil, dampener and an external body.

The diagram to the left is a well labelled representation of a current typical front shock absorber. You will find a shock absorber like this in most mid to high end velomobiles.

Figure 24 Three images to show velomobile suspension
Below is a useful diagram to show the design of an existing personalized velomobile. This gives great information regarding angles and sizes to work off when it comes to the design stage of a project.

Figure 25 Diagram to show angles and construction of a front strut
Current Rear Suspension Set-Ups

Researching Rear suspension led to this official report by Oregon Institute of Technology. (Source: http://www.oit.edu/faculty/hugh.currin/velo/Velo-RearSusp_09-10.pdf)

This report explained that successful recumbent bicycles used a single pivot swing arm that incorporates the use of a spring-operated shock to dampen the forces applied on the rider.

Below is there specification for designing a swing arm that is informative and useful:

- “The rear suspension system must incorporate a single wheel, and this wheel will be the only point of contact for the rear half of the vehicle.

- The suspension system must provide a means of mounting the rear wheel, rear sprocket cassett assembly, rear derailer, and one end of the rear shock absorber.

- The rear suspension should have enough travel to allow the center of the rear axle approximately 1 inch of vertical deflection.

- The rear suspension should incorporate a rather small, low maintenance shock absorber to dampen the suspension’s cycling, and thus insulate the rider from road surface vibrations.

- If possible, the suspension system should be designed in such a way that a standard sized shock absorber, designed and produced primarily for mountain bikes and other such vehicles, could be used in the velomobile without requiring any modifications to the vehicle or shock absorber.”
Types of Steering

Because of the construction of a tadpole HPV, there are limitations on the steering. This is caused mainly due to how handlebars on a standard bicycle work (shown on the left).

A standard bicycle has a hollow “head tube” that is part of its frame. The head tube allows the top of the forks (suspension) to pass through allowing the stem to clamp on to it creating the front end of a bicycle.

A velomobile however, has two wheels at the front that makes it impossible for this sort of steering to work.

Instead the most popular is now a tiller or “Yoke” steering mechanism.

“velomobiles from the netherlands and belgium use the U-joint control yoke steering. Some might think this is a tiller but it turns on its axis like a car steering wheel. I believe the quest, strada, mango, mango sport, mango plus, go-one 3, go-one evo all use this steering.” -Duncanjames – Bentrider online.

What Duncan was explaining related to the picture on the right. It shows a steering mechanism that works very similar to how a car is controlled. A major advantage over handlebars is that tiller styled controls saves a lot of space that can be used for such things as drinks.
3.3 Fitness for purpose

3.31 Material Choice

<table>
<thead>
<tr>
<th>Fairing</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Carbon Fibre - High price, great impact strength, light weight.</td>
</tr>
<tr>
<td>• Glassfibre/epoxy resin - Medium price, great impact strength, Medium weight.</td>
</tr>
<tr>
<td>• Aluminium - Cheap price, weak impact strength, light weight (dangerous reflection of light and heat insulation properties).</td>
</tr>
<tr>
<td>• Plastics - Variation of price, strength and typically light weight. A cheaper alternative.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Aluminium - Cheap price, good strength, light weight, good flexibility</td>
</tr>
<tr>
<td>• Steel - Varying price (depending on quality), excellent strength, heavy weight, un-flexable</td>
</tr>
</tbody>
</table>

Most modern bicycle frames are made from an aluminium or tubular steel. However high end bikes can be made from Titanium and Carbon fibre.

Aluminium is used in most entry level and mid-level bikes. Aluminium is one of the best value materials for a bike frame. It has been used in many pro teams during the 1990s. It is both lightweight and rigid (but heavier than carbon fibre)

Drawbacks of Aluminium
• Lower life expectancy, can suffer from metal fatigue

Advantages of Steel
• Steel frames can be easily repaired
• Looks Good
• Easy to fabricate and add to
• Classic feel – pleases the traditionalist

Drawbacks of Steel
• Rusts easily.
• Steel frames can be quite heavy (common for cheap bikes on the market)

The benefits of Carbon fibre frames
• Lightweight with no compromise in strength or stiffness.
• Carbon fibre is four times stronger than steel for the same weight
• Rust proof
• This quality of stiffness which enables you to absorb shocks in the road means that it is a particularly good material for forks.
Drawbacks of Carbon fibre frames.
- Most expensive type of frame (although coming down in price)
- Tends to come in limited colours black and grey
- Difficult to repair once crashed
- Prolonged flexing can lead to vulnerability and weakness in the material that can cause it to break

Titanium Frames
- Titanium frames are similar to carbon fibre frames
- They are light, but strong and stiff giving a comfortable ride
- It is rust proof

Drawbacks of titanium
- More expensive than carbon fibre
- Difficult to repair
- Tends to come in limited colours (grey)
- Other materials found on a standard bicycle are: rubber, plastics and foam
3.32 Drum Brakes VS Disc Brakes and Drivetrain Ratios

“The front wheels on a bicycle are far more important for stopping than the rear wheels. On the Mango you have two front wheels, so potentially double the stopping power of a conventional bike. Now that they work correctly, I find the drums to be adequate. 70 mm drums potentially can suffer from "fade" if they become too hot on very long descents, but this has not affected me.” - author (http://www.hembrow.eu/personal/sinnermango.html)

The author who wrote the paragraph above worked with Velomobiel.nl producing Mango Velomobiles. A very experienced “velonaught” he understands the optimal brakes and drivetrain to be used.

Disc brakes are more expensive but more effective than drum brakes, however in winter they require adjusting around every 500km.

A velomobile preferably must be low maintenance therefore; drum brakes are much more feasible.
Why a rear brake is a very bad idea

“When I worked for Sinner, potential customers would often ask if they could have a rear brake on their Mango. This request was always turned down.

There is actually a very good reason why you don’t want a rear brake on a Mango or indeed on any velomobile or recumbent tricycle which has two wheels in the front and one at the back (some people call this a "tadpole" trike).

One of the most dangerous situations you can ever find yourself in on a tricycle like this is that of losing grip with the rear wheel while you’re already moving. The reason why is that the rear end of the tricycle will try to overtake the front. When this happens, the trike spins around. It may slip sideways for a while, but when the tyres have traction again then the trike will roll.

You don’t want a rear brake.”

- author (http://www.hembrow.eu/personal/sinnermango.html)

Drivetrain Ratios

“Depends somewhat on the drive wheel size and type of drive train but the most common configuration on stock commercially available recumbent is 170 mm cranks with 3 rings 130/74. That isn’t necessarily the best configuration as many prefer shorter cranks or smaller rings but it is the most common commercial configuration.”

Zach Kaplan - LinkedIn
### 3.3.3 Efficiency: Bicycle VS Velomobile

**Table 2: Comparison of speed is differing conditions between typical bicycles and velomobiles**

<table>
<thead>
<tr>
<th>(Speed in km/h)</th>
<th>(Neglected bicycle)</th>
<th>Good, regular bicycle</th>
<th>Standard velomobile (Flexobike)</th>
<th>Racing bicycle UCI compliant, deep racing posture</th>
<th>Best Practice velomobile (Velomobile Quest)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat road, 250W</td>
<td>(23.5)</td>
<td>29</td>
<td>41</td>
<td>37.5</td>
<td>50</td>
</tr>
<tr>
<td>Flat road, 100W</td>
<td>(15)</td>
<td>26.5</td>
<td>28</td>
<td>27</td>
<td>34</td>
</tr>
<tr>
<td>5% uphill, 150W</td>
<td>(6.5)</td>
<td>9.7</td>
<td>8.6</td>
<td>11.6</td>
<td>9</td>
</tr>
<tr>
<td>2% downhill, 100W</td>
<td>(25)</td>
<td>29.5</td>
<td>59</td>
<td>38.5</td>
<td>63.8</td>
</tr>
<tr>
<td>Strong head wind, 150W</td>
<td>(3.9)</td>
<td>5.5</td>
<td>12.1</td>
<td>9.3</td>
<td>17.4</td>
</tr>
<tr>
<td>Power required to ride 30 km/h</td>
<td>(444W)</td>
<td>271W</td>
<td>115W</td>
<td>137W</td>
<td>79W</td>
</tr>
</tbody>
</table>

Figure 32 Graph to show comparison between HPVs

The table above (Source: [http://users.telenet.be/fietser/fotos/VM4SD-FVDWsm.pdf](http://users.telenet.be/fietser/fotos/VM4SD-FVDWsm.pdf)) shows the power output that is required to achieve a speed of 30km/h (18.6mph). To put it in perspective the average long term power output for a male adult is 75 watts.

**Diagram to show the possible power output of a fit human body:**

It is clear to see that it’s incredibly easier to reach constant higher speeds in a velomobile; in fact 3.5 times less energy is used with a velomobile when compared to a standard bicycle!

Going flat out will (250 watts) will give you a speed of 29km/h on a normal bicycle and an astonishing 50km/h on a velomobile.
3.34 User Review of Different Velomobiles

“Go-One Evo

The Evo feels really big inside with all the clear plastic, but is actually quite tight for space, especially when you are 1.92m with big feet. There is quite limited luggage space, but some very well organised compartments. The fan in the nose is really efficient at keeping you cool. A really well designed and well thought out machine that simply didn't suit my body shape/size.

Quest

Really good all-round machine; plenty of luggage space, excellent suspension etc., but I didn't much like it. Slowest of the three machines; I found it hardest to get into & out of; I could make it rock side to side under power; & least comfortable driving position. I recognise that these are personal rather than objective & am happy to accept that it's probably the best all-round machine, just not my personal cup of tea.

Milan

What a machine! Feels tiny inside, especially when the roof is closed, but actually quite spacious. I think the comparative lack of clear plastic made it feel smaller. Saying that, visibility is no problem at all. Unbelievably fast: 52kmh on the flat at nowhere near full power & way off full fitness. The Panzer steering was also something I really liked compared to the tiller on the other two. I got out of the Milan with a huge smile on my face I couldn't lose. I'm seriously wanting one, I just now need to persuade my wife that it's a good plan....”

Richie_B – British Human Powered Forums.

This information from Richie shows good and bad points for each tested velomobile. Later in the project this will come in handy when trying to avoid past velomobile mistakes.
### 3.35 Velomobile Problems

There are various design problems with existing velomobiles that will be analyzed in this section.

<table>
<thead>
<tr>
<th>Tricky to get into</th>
<th>Impression of being closed in</th>
<th>Noisy compared to standard Bicycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra weight slows</td>
<td>Extra weight makes climbing up-hill much harder</td>
<td>Expensive</td>
</tr>
<tr>
<td>acceleration initially</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Luggage Space</td>
<td>Ventilation</td>
<td>Rear wheel skipping or sliding out around corners</td>
</tr>
<tr>
<td>Wheel/tyre rub</td>
<td>Ground clearance</td>
<td>Safety</td>
</tr>
<tr>
<td>Roll protection</td>
<td>Maintinence of moving parts</td>
<td>Front and rear lighting</td>
</tr>
<tr>
<td>Visibility of HPV</td>
<td>Reversing</td>
<td>Storage and parking</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.4 The market

3.41 Statistics to show all road traffic

![Department for Transport statistics](http://www.dft.gov.uk/statistics/series/traffic)

**Table TRA0204**

Road traffic (vehicle kilometres) by vehicle type and road class in Great Britain, annual 2011

<table>
<thead>
<tr>
<th></th>
<th>Cars and taxis</th>
<th>Motorcycles</th>
<th>Buses &amp; coaches</th>
<th>Light vans</th>
<th>Goods vehicles</th>
<th>All motor vehicles</th>
<th>Pedal cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Motorways</strong></td>
<td>75.0</td>
<td>0.4</td>
<td>0.4</td>
<td>12.5</td>
<td>11.2</td>
<td>99.5</td>
<td>-</td>
</tr>
<tr>
<td><strong>Rural 'A' roads:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trunk</td>
<td>44.3</td>
<td>0.4</td>
<td>0.3</td>
<td>7.9</td>
<td>5.2</td>
<td>56.1</td>
<td>-</td>
</tr>
<tr>
<td>Principal</td>
<td>66.2</td>
<td>0.8</td>
<td>0.6</td>
<td>11.4</td>
<td>4.1</td>
<td>83.1</td>
<td>0.2</td>
</tr>
<tr>
<td>All rural 'A' roads</td>
<td>110.5</td>
<td>1.1</td>
<td>0.9</td>
<td>19.3</td>
<td>9.3</td>
<td>141.2</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Urban 'A' roads:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trunk</td>
<td>43</td>
<td>-</td>
<td>-</td>
<td>0.7</td>
<td>0.3</td>
<td>6.4</td>
<td>-</td>
</tr>
<tr>
<td>Principal</td>
<td>80.5</td>
<td>0.8</td>
<td>1.1</td>
<td>9.2</td>
<td>2.3</td>
<td>73.9</td>
<td>0.7</td>
</tr>
<tr>
<td>All urban 'A' roads</td>
<td>84.7</td>
<td>0.8</td>
<td>1.2</td>
<td>9.9</td>
<td>2.6</td>
<td>79.3</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>All major roads:</strong></td>
<td>250.3</td>
<td>2.4</td>
<td>2.5</td>
<td>41.7</td>
<td>23.0</td>
<td>319.9</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Minor roads:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minor rural roads</td>
<td>52.0</td>
<td>0.8</td>
<td>0.5</td>
<td>10.6</td>
<td>1.4</td>
<td>66.3</td>
<td>1.1</td>
</tr>
<tr>
<td>Minor urban roads</td>
<td>84.3</td>
<td>1.5</td>
<td>1.7</td>
<td>14.0</td>
<td>1.2</td>
<td>102.7</td>
<td>2.9</td>
</tr>
<tr>
<td>All minor roads</td>
<td>137.1</td>
<td>2.3</td>
<td>2.1</td>
<td>24.9</td>
<td>2.6</td>
<td>169.0</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>All roads</strong></td>
<td>387.4</td>
<td>4.6</td>
<td>4.7</td>
<td>66.6</td>
<td>25.6</td>
<td>488.9</td>
<td>4.9</td>
</tr>
</tbody>
</table>

Above is an insight to just how many people use pedal cycles compared to motorised vehicles. It is clear to see that with only 4.9 bicycles per kilometre compared to 387 cars, something is putting people off cycling.

This shocking information tells us that in order to change these figures and get people on bicycles we must look at what could be causing people to drive instead of cycle.

**The danger of cycling on the road along with many bigger and heavier vehicles**

People are put off cycling because the danger of being hit by a much larger vehicle. There is less protection and there could be a bigger chance of fatality when using open vehicles such as a bicycle. This could be resolved by introducing an exterior, or an outer shell to the vehicle and a roll cage to protect the user.
The effort that someone has to put in to power a bicycle compared to driving a car

There is an obvious advantage when it comes to driving a car: that it requires very little effort. The concept of riding a bicycle to work/school every day may become more appealing if there was a motor that would activate when going uphill or when fully charged.

Wet and windy weather conditions

The weather is a huge condition that will influence if someone takes the bicycle or the car when travelling. With a simple cover over the bicycle, the user will feel much more like pedalling to where ever they are going instead of having to pay for petrol and damaging the environment.
3.42 Statistics to show how road traffic has changed (1970-2010)

<table>
<thead>
<tr>
<th>Year</th>
<th>Buses &amp; coaches</th>
<th>Cars, vans &amp; taxis</th>
<th>Motor cycles</th>
<th>Pedal cycles</th>
<th>All Road</th>
<th>Rail</th>
<th>All (IHS)</th>
<th>All modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>60</td>
<td>29</td>
<td>4</td>
<td>4</td>
<td>365</td>
<td>59</td>
<td>2</td>
<td>403</td>
</tr>
<tr>
<td>1971</td>
<td>60</td>
<td>31</td>
<td>4</td>
<td>4</td>
<td>361</td>
<td>59</td>
<td>2</td>
<td>419</td>
</tr>
<tr>
<td>1972</td>
<td>60</td>
<td>32</td>
<td>4</td>
<td>4</td>
<td>585</td>
<td>54</td>
<td>2</td>
<td>431</td>
</tr>
<tr>
<td>1973</td>
<td>61</td>
<td>34</td>
<td>4</td>
<td>4</td>
<td>414</td>
<td>58</td>
<td>2</td>
<td>452</td>
</tr>
<tr>
<td>1974</td>
<td>61</td>
<td>33</td>
<td>5</td>
<td>4</td>
<td>403</td>
<td>36</td>
<td>2</td>
<td>441</td>
</tr>
<tr>
<td>1975</td>
<td>60</td>
<td>32</td>
<td>6</td>
<td>4</td>
<td>401</td>
<td>36</td>
<td>2</td>
<td>430</td>
</tr>
<tr>
<td>1976</td>
<td>58</td>
<td>34</td>
<td>7</td>
<td>5</td>
<td>418</td>
<td>33</td>
<td>2</td>
<td>452</td>
</tr>
<tr>
<td>1977</td>
<td>58</td>
<td>35</td>
<td>7</td>
<td>6</td>
<td>425</td>
<td>34</td>
<td>2</td>
<td>461</td>
</tr>
<tr>
<td>1978</td>
<td>56</td>
<td>36</td>
<td>7</td>
<td>5</td>
<td>436</td>
<td>35</td>
<td>3</td>
<td>474</td>
</tr>
<tr>
<td>1979</td>
<td>56</td>
<td>35</td>
<td>7</td>
<td>5</td>
<td>433</td>
<td>35</td>
<td>3</td>
<td>478</td>
</tr>
<tr>
<td>1980</td>
<td>52</td>
<td>38</td>
<td>7</td>
<td>5</td>
<td>453</td>
<td>35</td>
<td>3</td>
<td>491</td>
</tr>
<tr>
<td>1981</td>
<td>48</td>
<td>39</td>
<td>8</td>
<td>5</td>
<td>458</td>
<td>34</td>
<td>3</td>
<td>495</td>
</tr>
<tr>
<td>1982</td>
<td>48</td>
<td>40</td>
<td>10</td>
<td>6</td>
<td>470</td>
<td>31</td>
<td>3</td>
<td>504</td>
</tr>
<tr>
<td>1983</td>
<td>48</td>
<td>41</td>
<td>9</td>
<td>6</td>
<td>474</td>
<td>34</td>
<td>3</td>
<td>511</td>
</tr>
<tr>
<td>1984</td>
<td>48</td>
<td>42</td>
<td>9</td>
<td>6</td>
<td>495</td>
<td>35</td>
<td>3</td>
<td>533</td>
</tr>
<tr>
<td>1985</td>
<td>49</td>
<td>44</td>
<td>8</td>
<td>6</td>
<td>564</td>
<td>37</td>
<td>4</td>
<td>543</td>
</tr>
<tr>
<td>1986</td>
<td>48</td>
<td>45</td>
<td>9</td>
<td>6</td>
<td>525</td>
<td>37</td>
<td>4</td>
<td>566</td>
</tr>
<tr>
<td>1987</td>
<td>47</td>
<td>50</td>
<td>8</td>
<td>6</td>
<td>560</td>
<td>39</td>
<td>4</td>
<td>603</td>
</tr>
<tr>
<td>1988</td>
<td>45</td>
<td>53</td>
<td>6</td>
<td>5</td>
<td>595</td>
<td>40</td>
<td>5</td>
<td>640</td>
</tr>
<tr>
<td>1989</td>
<td>47</td>
<td>58</td>
<td>6</td>
<td>5</td>
<td>640</td>
<td>40</td>
<td>5</td>
<td>685</td>
</tr>
<tr>
<td>1990</td>
<td>46</td>
<td>68</td>
<td>6</td>
<td>5</td>
<td>645</td>
<td>40</td>
<td>5</td>
<td>650</td>
</tr>
<tr>
<td>1991</td>
<td>44</td>
<td>68</td>
<td>6</td>
<td>5</td>
<td>637</td>
<td>39</td>
<td>5</td>
<td>681</td>
</tr>
<tr>
<td>1992</td>
<td>43</td>
<td>68</td>
<td>6</td>
<td>5</td>
<td>635</td>
<td>38</td>
<td>5</td>
<td>678</td>
</tr>
<tr>
<td>1993</td>
<td>44</td>
<td>69</td>
<td>7</td>
<td>6</td>
<td>619</td>
<td>37</td>
<td>5</td>
<td>701</td>
</tr>
<tr>
<td>1994</td>
<td>44</td>
<td>61</td>
<td>7</td>
<td>6</td>
<td>666</td>
<td>36</td>
<td>5</td>
<td>707</td>
</tr>
<tr>
<td>1995</td>
<td>43</td>
<td>61</td>
<td>7</td>
<td>6</td>
<td>669</td>
<td>37</td>
<td>5</td>
<td>712</td>
</tr>
<tr>
<td>1996</td>
<td>45</td>
<td>62</td>
<td>6</td>
<td>6</td>
<td>672</td>
<td>39</td>
<td>6</td>
<td>719</td>
</tr>
<tr>
<td>1997</td>
<td>44</td>
<td>63</td>
<td>6</td>
<td>6</td>
<td>684</td>
<td>40</td>
<td>6</td>
<td>734</td>
</tr>
<tr>
<td>1998</td>
<td>45</td>
<td>62</td>
<td>6</td>
<td>6</td>
<td>685</td>
<td>42</td>
<td>6</td>
<td>750</td>
</tr>
<tr>
<td>1999</td>
<td>46</td>
<td>66</td>
<td>6</td>
<td>6</td>
<td>699</td>
<td>44</td>
<td>7</td>
<td>770</td>
</tr>
<tr>
<td>2000</td>
<td>46</td>
<td>64</td>
<td>5</td>
<td>4</td>
<td>695</td>
<td>47</td>
<td>7</td>
<td>760</td>
</tr>
<tr>
<td>2001</td>
<td>47</td>
<td>65</td>
<td>5</td>
<td>4</td>
<td>710</td>
<td>48</td>
<td>8</td>
<td>785</td>
</tr>
<tr>
<td>2002</td>
<td>47</td>
<td>67</td>
<td>6</td>
<td>5</td>
<td>733</td>
<td>48</td>
<td>8</td>
<td>790</td>
</tr>
<tr>
<td>2003</td>
<td>47</td>
<td>67</td>
<td>6</td>
<td>5</td>
<td>731</td>
<td>50</td>
<td>9</td>
<td>790</td>
</tr>
<tr>
<td>2004</td>
<td>45</td>
<td>67</td>
<td>6</td>
<td>5</td>
<td>738</td>
<td>50</td>
<td>10</td>
<td>784</td>
</tr>
<tr>
<td>2005</td>
<td>45</td>
<td>67</td>
<td>6</td>
<td>5</td>
<td>730</td>
<td>52</td>
<td>10</td>
<td>792</td>
</tr>
<tr>
<td>2006</td>
<td>43</td>
<td>68</td>
<td>6</td>
<td>5</td>
<td>735</td>
<td>55</td>
<td>10</td>
<td>800</td>
</tr>
<tr>
<td>2007</td>
<td>45</td>
<td>68</td>
<td>6</td>
<td>5</td>
<td>740</td>
<td>59</td>
<td>10</td>
<td>808</td>
</tr>
<tr>
<td>2008</td>
<td>44</td>
<td>68</td>
<td>6</td>
<td>5</td>
<td>732</td>
<td>61</td>
<td>9</td>
<td>802</td>
</tr>
<tr>
<td>2009</td>
<td>45</td>
<td>68</td>
<td>6</td>
<td>5</td>
<td>728</td>
<td>61</td>
<td>8</td>
<td>805</td>
</tr>
<tr>
<td>2010p</td>
<td>45</td>
<td>65</td>
<td>4</td>
<td>5</td>
<td>709</td>
<td>64</td>
<td>8</td>
<td>781</td>
</tr>
</tbody>
</table>

Figure 34 Change in road traffic

This graph is both interesting and useful to see just how fast and intense the rise of motor vehicle was, consequently how it caused the decline of human powered vehicles.

There is a shockingly low number of pedal cycles on the road and with everyone becoming more environmentally aware and the price of petrol rising, it is a figure that can only go up.
3.43 Forum Activity

To understand the users of human powered vehicles it is necessary to sign up and explore the many forums available as they offer a rich information exchange between experienced cyclists.

The Recumbent Bike Forums


This recumbent specific forum was used to gather data for the conducted survey and scan for general information.


A thread I created to advertise my survey.

'BentRider Online

http://www.bentrideronline.com

I mainly used this forum to get in personal contact with velomobile riders and find out about events in which I could see one in the flesh. Unfortunately due to the time of year I couldn’t achieve this but will attempt to throughout the remainder of the project.

After I used the “shout box” to request information it led to the following thread being created for me by another user, on the next page are several of the replies I received from the thread: http://www.bentrideronline.com/messageboard/showthread.php?t=91263
Hey! For anyone who owns or had experience with a velomobile I would really appreciate it if you could inform me on the following:

What velomobile you own?
What kind of steering you have?
Do you have full suspension or just front/rear?
What your velomobile is made out of?

Most importantly I would like to know if you could change anything about your velomobile what would it be?

Ideally if anyone lives in the north west of England it would be such a boost for my project if I could meet up and see (maybe test out) a velomobile, if I'm honest I've never seen one in the flesh.

Thanks,
Jack

Edit: In response to Craftgeek I would like the opinion of anyone!

1. Quest, by velomobiel.nl
2. Tiller, esp. designed for velomobiles (same as in Mango, Strada, Go-One, Allweder)
3. Full suspension
4. Carbon shell
5. Hub generator, battery buffered

Josef

Mango + Velomobile
Velomobile Tiller-type steering
Full Suspension
Carbon Fiber (with one layer of fiberglass for crash protection/crack resistance)

Integrated lighting would be nice. I have turn signals but didn’t get the full self-contained lighting kit.

Trey1940

I own three velomobiles at the moment:
Mango Sport
Mango Tour
Quest carbon

they all have tiller steer, full suspension.
Mango Sport is made from glassfibre with bits and pieces of carbon.
Mango Tour is a laminate of carbon and glassfibre.
Quest carbon is made of carbon.

My velomobiles have very different features, which leaves me little to wish for. I do want to make them all around fully air suspended/foil dampened soon.

fjarimer

I am the third owner of an older WAW
Side stick steering with split brakes
Front suspension only
Its made of carbon/kevlar with removable front and rear shells.

What would I change? One way to answer that is to list what I’ve changed so far.

1. 12v/LiPO lighting system with highlight, tail/brake light, turtle deck mounted turn signals with running lights.
2. The highlight is faired into the body shell behind a clear lens.
3. Ventilation fan mounted at the top of the coaming.
5. Added a rear fender inside the shell for better chain protection.
6. Replaced two return idlers with a chain tube back to the RD cage.
   A bonus is a quieter, slightly more efficient drive train.
7. Air Zound horn with remote button and remote fill tube.
8. In the works: USB power for an automatice DVR camera system with front and rear cameras.
9. Magnet secured rain cover when parked in open cockpit mode.
10. Open cockpit wind screens.

I’d like to change is switch to the new Cabriolet race cap available on the new WAW’s.
I’d also like a hatch to the front nose area with a storage area inside.
3.4 The market | MMU

This forum was a rich source of information from past posts and information that was posted in my own threads. I also used this to get the majority of my survey replies as it has more traffic than the other two.

A thread I made on the BHP forums to promote my survey and request information.

A personal message I sent to “grey dog”.


3.44 Questionaire

Intro
A survey to find out the basic user preferences was conducted under the web address: http://www.surveymonkey.com/s/5DPR6HN. This survey would gather information from bicycle/velomobile users that were targeted through specific forums that are listed in section 3.43.

Results

**Response Summary**

<table>
<thead>
<tr>
<th>1. Age?</th>
<th>2. Height of User?</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-24</td>
<td>4'5&quot; - 5'0&quot;</td>
</tr>
<tr>
<td>25-34</td>
<td>5'1&quot; - 5'6&quot;</td>
</tr>
<tr>
<td>35-44</td>
<td>5'7&quot; - 6'2&quot;</td>
</tr>
<tr>
<td>45-54</td>
<td>6'2+</td>
</tr>
<tr>
<td>55+</td>
<td>Skipped</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Type of community?</th>
<th>4. Frequency of Riding a Bicycle or HPV?</th>
</tr>
</thead>
<tbody>
<tr>
<td>City or Urban</td>
<td>Every Day</td>
</tr>
<tr>
<td>Suburban</td>
<td>A few Times a Week</td>
</tr>
<tr>
<td>Rural</td>
<td>Once a Week</td>
</tr>
<tr>
<td>Skipped</td>
<td>Once a Month</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th>15-24</th>
<th>25-34</th>
<th>35-44</th>
<th>45-54</th>
<th>55+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent</td>
<td>7%</td>
<td>10%</td>
<td>29%</td>
<td>29%</td>
<td>25%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Height</th>
<th>4'5&quot; - 5'0&quot;</th>
<th>5'1&quot; - 5'6&quot;</th>
<th>5'7&quot; - 6'2&quot;</th>
<th>6'2+</th>
<th>Skipped</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent</td>
<td>2%</td>
<td>0%</td>
<td>15%</td>
<td>5%</td>
<td>78%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Community Type</th>
<th>City or Urban</th>
<th>Suburban</th>
<th>Rural</th>
<th>Skipped</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent</td>
<td>27%</td>
<td>51%</td>
<td>20%</td>
<td>2%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency of Riding</th>
<th>Every Day</th>
<th>A few Times a Week</th>
<th>Once a Week</th>
<th>Once a Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent</td>
<td>42%</td>
<td>10%</td>
<td>45%</td>
<td>3%</td>
</tr>
</tbody>
</table>
5. Distance of Commute to Work or Education?

- Extremely Far: 45%
- Very Far: 13%
- Moderately Far: 36%
- Slightly Far: 6%

6. How environmentally responsible are you?

- Very Responsible: 31%
- Responsible: 51%
- So-So: 15%
- Not Responsible: 3%

7. Reasons To Not Cycle

- Weather: 20%
- Arrive at Location Uncomfortable and Sweaty: 36%
- Protection From Bigger Vehicles: 13%
- Extra Effort Compared to Driving: 16%
- Theft: 12%
- Skipped: 3%

8. Would You Cycle to Work with Protection from Weather and Collisions?

- Yes: 12%
- No: 22%
- Skipped: 66%

9. Would You Spend More Money If It Had Such Protection (Q8)?

- Yes: 15%
- No: 12%
- Skipped: 73%
10. Would You Prefer a Vehicle Aided By a Self Charging Motor?

Extra Questions

1. Other answers for reasons that would stop people cycling to work or for social reasons:

- social only, I commute to work daily
  24/11/2012 12:28
- I do bike to work in my velo
  22/11/2012 4:20
- workload at the job if I do full hours I have 35km to ride in the dark
  21/11/2012 10:57
- tiredness
  21/11/2012 6:38
- Nothing!
  20/11/2012 21:50
- I do
  20/11/2012 20:38
- Lack of suitable space to lock bike up at work
  15/11/2012 11:14
- I'm retired....further questions relate to my commute to the nearest decent gym
  10/11/2012 17:58
- Lack of facilities at work
  10/11/2012 13:58
- I ride all year round
  9/11/2012 19:29
- I ride a velomobile
  9/11/2012 6:49
- don't work at the moment , but did commute when was
  8/11/2012 9:37
- Requirement to visit multiple sites when working
  8/11/2012 8:14
- I ride if it is safe
  7/11/2012 23:12
- Distance
  7/11/2012 21:58
2. Average shoe size (all replies added up divided by number of replies) = **10.03 (10)**

- Highest and lowest shoe size recorded: **6 - 13**

3. How much (if at all) would you spend on a HPV that offers rain and collision protection?

- **10K**
  - 22/11/2012 4:20
  - 1000 Euro is my limit and has been so far.... I owned a velomobile for that amount of money
- **20/11/2012 10:57**
  - already got several
- **21/11/2012 6:38**
  - <$5k
- **20/11/2012 21:50**
  - **€10000**
- **20/11/2012 20:32**
  - Currently aiming to spend about 6000 gbp
- **20/11/2012 18:51**
  - 10000
- **14/11/2012 20:04**
  - 3000£
- **11/11/2012 22:51**
  - I have done so with the purchase of a Mango Velo
- **10/11/2012 13:58**
  - £2000
- **8/11/2012 9:37**
  - As little as possible
- **7/11/2012 21:35**
  - 500-1500
- **1/11/2012 13:47**

External survey to show users age:

According to another survey on Bent Rider forums showed 61.4% of velomobile users are over the age of 50.
3.45 Questionnaire Evaluation

From the questionnaire carried out I can assume the following:

- Velomobile user’s age vary greatly however the majority of velomobile users are typically mid to old age (45+).
- I should design ergonomically for people around the height of 5’7” to 6’2”.
- Users mainly live in a suburban area (built up roads, possibly not much traffic).
- Users will be using the HPV every day or at least a few times a week.
- Around 80% of people believe they have to commute a moderate distance or less.
- The majority of people asked think they are responsible or at least neutral in terms of looking after the environment.
- The number one thing that stops people cycling to work is bad weather such as rain.
- 66% of people would consider cycling to work if they had better protection from weather and collisions.
- Almost 3/4 of people asked would spend more money on a HPV with weather and collision protection.
- Almost 3/4 of people asked would prefer an electric or kinetic motor to assist them.

This information could help when deciding a final product or even well into the design stage of this project.
3.5 Contacts

3.51 Ymte Sijbrandij

A very successful champion in velomobile racing provided a lot of professional information to this project. Co-founder of Velomobiel.nl, himself and a few others are responsible for extremely well known velomobiles such as the Quest, Mango and Strada.

---

Hi, I am a 3rd year student studying product design in England at Manchester Metropolitan University and I am passionate to design a vehicle similar to a velomobile.

I have seen that your company designed the Quest and have been researching quite a lot in to it. I would greatly appreciate any help that you could offer.

It would be fantastic if you could take a minute to tell me about any problems you face in your design process.

I have already learnt quite a lot about your products but if you could help me on any other the following it would be a great help to me:

- The manufacturing processes that you use.
- Who your target buyers are.

If you feel there is any other information or advice that you could give me, I am more than willing to listen!

Thank you very much for your time,

Hello Jack,

The Quest design is quite practical. Once decided for a three wheeler with two wheels front to fit people with a certain length and shoulder width we made the best possible aerodynamic shape. Challenge is to make it fit for as well bigger as smaller people. People vary a lot, also leg length compared to body length, upper leg compared to lower leg, shoe size etc. To make it better optimized for different people we have now 2 sizes for the quest, one for people of 160-175 cm and one for people of 175-200 cm.

The quest body is made with hand lay up of glass and carbon fibre with epoxy resin in a negative mould. The polyester coating is sprayed in the mould.

The target buyers are ourselves. We wanted a fast bike, comfortable suspension, luggage room, low maintenance, gearing for hills for holiday trips, singe side wheel mount for easy tyre change etc.

It appeared that the way we worked out these demands is appealing to other cyclists.

Advise is to pedal yourself and use your own designs. Only than you know if it works or not for certain purposes. You can find a lot of futuristic mobility designs but we make something we can use now and make it with the technology that is available and affordable for the numbers that we make.

Greetings, Ymte
3.52 Shimano

Shimano produce many types of gearing, breaks and other parts for all types of bicycles that could be used with in this project. After contacting them by email and talking with them over Facebook this result was achieved:

Hi there, I am a university student doing my major project in my last year and I am looking at designing a Velomobile using CAD software.

I am looking at including an existing power assist mechanism in my design and was wondering if you are interested in helping me and agreeing for me to use your products in collaboration with my own design.

I would obviously make clear that your product was not my own work.

It would help immensely if you are willing to supply basic CAD files so I could import them in to my design when I get to that stage and any other information and help you have to offer would mean a lot to me!

Thank you very much for your time and I hope to hear from you soon,
Jack Robinson
MMU
3.53 Rollin Nothwehr

Hi Rollin, I am a final year university student at Manchester Metropolitan doing my major project that is based around Velomobiles and I understand that you are a recumbent enthusiast yourself.

I was wondering if you would be kind enough to speak from experience and inform me on a few areas that I am unsure of:

- When designing a recumbent what type of steering and suspension do you prefer?
- What materials do you use for the frame/ fairing (if you use fairing?)
- What common problems do you face during the design stage?

Any other advice that you think would help me during the design stage of my project would be fantastic and greatly appreciated!

Thank you for your time and sorry to bother,

Jack Robinson,
Student
Manchester Metropolitan University

Recumbents and Velomobiles

Hi Jack, I’m happy to give you my opinion on these questions, there are certainly others who might not agree with me. First, all my experience is with long wheelbase bikes.

On steering and suspension - I like the above sort steering, like an Easy Racer, that feels more secure and much easier to start and stop. I’ve ridden the underseat steering and found it to be cumbersome.

I also cheated on the steering angle a bit to make the handle bars move less from side to side called tiller steering. This means a slightly more angled head tube than a typical bike.

Suspension - I built a full carbon frame long wheelbase bike that had really nice soft passive suspension. It flexed just enough to make a very smooth ride. Unfortunately, it eventually broke. Turns out carbon will degrade over time when it is flexed. Now I use a steel rear suspension and a lightweight air shock. I am working on a design for a very lightweight front suspension fork. It is not absolutely necessary but I like to have a full suspension bike next.

I like a frame of a combination of steel and carbon. Both have their unique qualities: steel is ductile, easy to fabricate, easier to attach components that are almost all made to attach to some steel part, like derailleurs brakes and bottom brackets. Carbon can be additional structure and can be formed for aesthetics. With a combined structure of both materials there is a weight saving using less steel, and not a total reliance on the composite. I have not made a fairing yet.

The complexity of building a bike with suspension is greatly helped by a mockup. A full scale storable mockup goes a long way. The chain path, moving rear suspension assembly, derailleurs etc. all need proper clearance in all gears and flex modes. A CAD model is helpful in designing but does not answer all the questions.

I would suggest to go ride as many Bents as you can find to get a real feel for how the different configurations. Long, short, over/under steering feel. Also the 3 wheels are interesting and quite another design challenge. Another interesting bike is an M-5, again, quite different to ride but very fast once you get it going. I hope some of this helps. Feel free to send some pics if you build one. good luck Rollin

Jack Robinson... Thank you and I will! Regards

Rollin Nothwehr... No bother. I will get back to you shortly. Say hello to mike burns for me. Sent from my iPhone

Jack Robinson... Hi Rollin, I am a final year university student at Manchester Metropolitan doing my major pr...
Graydog a user of the BHPF showed interest and requested for a personal message over the forum. After emailing asking for basic information on the suspension and steering set up of his velomobile I also added that we lived within 30-40 miles of each other and that if possible, I could come and see it in person and even possibly test his velomobile out.

Fortunately he responded positively to this and we are due to meet up to allow for further research to be conducted.
4.0 Critical Analysis of Findings and Conclusions

4.1 What has been established from my findings and research

4.11 Finding a suitable HPV

- After researching the history of human powered vehicles it is apparent that the most effective and efficient mode of transport is an electric hybrid that combines the use of human power and an electric motor. Users prefer having protection from weather and collisions; this is why I am going to base my design work around the common velomobile.

4.12 Social and cultural research

- In this section I learnt that velomobiles in the government’s eyes are classed as bicycles and therefore there is a lack of restrictions when it comes to being road legal, the only setback is that the electric motor may not assist after 25km/h.
- Police officers may often pull over a velomobile, simply because they do not fully understand what one is or how it functions (often assuming they have an engine).
- They need no licence plates and have to pay no tax/mot.

4.13 Ergonomics research

- In this section, I looked at different velomobiles and compared them learning the basic size guidelines and geometry that is required to make them ergonomic and comfortable to the user.
- I analysed external safety equipment and learned to understand that just because something is safe, the anthropometrics does not have to be impaired.
- I looked in depth for different suspension set-ups and learned that the best front suspension for a velomobile related HPV is a basic MacPherson Strut, where as the best rear suspension is a coil linking the rear swing arm and the frame.
I learnt that the **positioning of suspension** is key because improper design can result in **excess wheel rub**.

I looked at types of **steering** that should be used and found that most if not all **velomobiles** at the moment use a **tiller** system.

### 4.14 Fitness for purpose research

- In this section, I analysed the **material choice** for the frame and fairing and found out the good and bad qualities for each possible material.
- I explored **brakes** and found that **drum brakes** are most **cost effective** and **low maintenance** whilst also offering more than adequate braking **performance**.
- I looked at **energy consumption** between bicycles and velomobiles and found that velomobiles consume much less energy and achieve higher speeds.
- Reading **user reviews** and looking at **common problems** with velomobiles allowed me to see **areas for improvement** when I am designing in a later stage.

### 4.15 Market research

- Researching **road traffic statistics** and how **road traffic has changed** allowed me to see just how big the percentage of **heavier vehicles** there are out there compared to a bicycle. There is a bigger need than ever for a **safer human powered vehicle**.
- The questionnaire I conducted provided me with valuable user feedback. For analysis refer to section 3.45.

### 4.16 Contacts and advice

**Ymte Sijbrandij**

*The quest body is made with hand lay up of glass and carbon fibre with epoxy resin in a negative mould. The polyester coating is sprayed in the mould.*

*The target buyers are ourselves. We wanted a fast bike, comfortable suspension, luggage room, low maintenance, gearing for hills for holiday trips, single side wheel mount for easy tyre change etc.*

*It appeared that the way we worked out these demands is appealing to other cyclists.*
Ymte taught me the manufacturing method of the Quest and his own preferences when it comes to velomobiles. He also talked about ergonomics and explained that they provide different size velomobiles for different sized users.

**Shimano**

Shimano provided me with little information over email; however I acquired a lot of their **technical documents** that they provided to me. I will be incorporating parts that they make in my design (e.g. brakes).

**Rollin Nothwehr**

**On steering and suspension**: I like the above seat steering, like an Easy Racer, that feels more secure and much easier to start and stop. I've ridden the underseat steering and found it to be cumbersome. I also checked the steering angle a bit to make the handle bars move less from side to side called tiller steering. This means a slightly more angled head tube than a typical bike.

**Suspension**: I built a full carbon frame long wheelbase bike that had really nice soft passive suspension. It flexed just enough to make a very smooth ride. Unfortunately, it eventually broke. Turns out carbon will degrade over time when it is flexed. Now I use a steel rear suspension and a lightweight air shock. I am working on a design for a very lightweight front suspension fork. It is not absolutely necessary but I'd like to have a full suspension bike next.

I like a frame of a combination of steel and carbon. Both have their unique qualities- steel is ductile, easy to fabricate, easier to attach components that are almost all made to attach to some steel part, like derailleurs brakes and bottom brackets. Carbon can be additional structure and can be formed for aesthetics. With a combined structure of both materials there is a weight savings using less steel, and not a total reliance on the composite. I have not made a fairing yet.

The complexity of building a bike with suspension is greatly helped by a mockup. A full scale sitable mockup goes a long way. The link path, moving rear suspension assembly, derailleurs etc all need proper clearance in all gears and flex modes. A CAD model is helpful in designing but does not answer all the questions.

I would suggest to go ride as many bikes as you can find to get a real feel for how the different configurations, Long, Short, over/understeer feel. Also the 3 wheelers are interesting and quite another design challenge. Another interesting bike is an M-5. Again, quite different to ride but very fast once you get it going. I hope some of this helps. Feel free to send some pics if you build one. Good luck- Rollin

Rollin was the most informative of anyone that I have been in contact with. He told me his preferences for the core components: **steering, suspension and frame**.

He also told me that from his experience building recumbent bicycles I should make a full **1:1 scale “mock up”** to allow for **successful ergonomic design**.

**Dr Graham Sparey-Taylor – British Human Powered Forums**

I have learned only a portion of the potential that Graham has to offer due to a pending meeting that will lead to me physically examining a velomobile close up and learning much more about them.
5.0 Conclusions

5.1 Assessments of the research and findings
To conclude my research I feel that I have learnt a considerable amount about recumbent bicycles, velomobiles and all other types of HPVs. I will be able to transfer this knowledge to designing a well thought out and comfortable vehicle whilst also keeping in mind that the project is heavily based on aesthetics.

5.2 Recommendations against the original aims and objectives

5.21 Looking Back at Preliminary Aims and Objectives

Design Aims
The overall aim of this project is to develop a form of human powered transportation that could also incorporate the use of stored (human produced) kinetic power. It is essential that the product is safe, stable and is as environmentally conscious as possible.

It is important to protect the user from the weather as not a lot of human powered transportation offers this. Many people who commute on bicycles arrive at their destination in wet uncomfortable clothing; this can put people off and is a major issue especially in England.

Research Aim
Researching human powered vehicles will allow full understanding of the users needs when it comes to ergonomics, safety and design. The design of the product will be aesthetically pleasing and be based off current and futuristic existing designs.

The project aims to use the most environmentally friendly materials and manufacturing processes that are cost effective. It is important that the materials that are researched are recyclable, reusable and sustainable.
**Objectives**

**Objectives: How will I achieve my aims.**

- Research kinetic energy and how it can be stored and reused with little or no environmental harm.
- When at the design stage, consider how the user could be made comfortable (e.g., a shield to block the rain).
- To improve safety, redesign mechanical aspects (e.g., traction of the tyres, more than 2 wheels).
- Research extensively into concept and current designs to inspire and aesthetically improve my designs.
- Research manufacturing processes and materials by reading books, emailing companies and reports.
- Ensure that any batteries that are used to be kinetically charged and the materials that are used are "green" and environmentally friendly as possible.

**5.22 Analysis of preliminary aims and objectives.**

I feel that I am on track with my aims and have covered every aspect apart from the materials that I have researched; carbon fibre is not yet fully recyclable and therefore not completely sustainable, however there are projects out there that aim to find a use for recycled carbon fibre and hopefully in the near future there will be such recycling facilities country-wide.

**Objective analysis:**

- I have researched kinetic energy and found that stored electrical energy (such as the BionX motor) and regenerative braking is much more effective whilst having a huge range around 100km. This is due to the assist cutting out above 25km/h.
- I have researched into all types of velomobiles and found that the most common one is the “head out” style. However, I will look to design a safe vehicle that covers the head completely but still allows for adequate vision.
- I am going to design the vehicle in a tadpole formation using 2 wheels at the front.
- I have researched all types of current concept cars for use in the design stage and have created a power point for presentation to myself and supervisor use.
• I found that the best method of researching materials was to analyse existing recumbent and velomobile designs. I also had a few responses off contacts telling me what materials they prefer.

• The motor assist that I will be using is very “green” and requires a very minimal electric charge.

5.3 Design Brief
The overall goal of this project is to develop a new and exciting form of human powered transportation that is based on velomobiles. The use of stored electricity is essential to assist the user when traveling uphill.

The product must protect the user from bigger vehicles that also share the roads and offer comfort and suspension that is safe and stable even at high speeds.

It is important to include weather protection as many people who commute on inexpensive bicycles arrive at their destination in wet uncomfortable clothing; this can put people off and is a major issue especially in England.

The design of the vehicle must be innovative and stylish, based of concept cars that offer very attractive shapes and forms.
5.4 Product Design Specification

My product must have a full fairing to protect it from weather and other elements. The fairing must be stylish and inspired by concept car designs.

My product must be made from tough and impact resistant materials (carbon fibre, glass fibre and epoxy resin etc.).

My product must be designed around the "tadpole" shape (2 wheels front/1 rear wheel).

My design must include above seat tiller steering, full rear and front suspension and a recumbent steel/aluminium frame.

My design must feature sufficient luggage room for necessities such as a briefcase/backpack etc.

My product must feature 70mm or 90mm frontal drum brakes. A rear parking brake is optional.

My product must have enough ventilation to allow air to pass through and cool the user.

My design must include safety equipment such as indicators and rear and front lights.

My design must incorporate the BionX motor on the rear wheel.
The fairing must be designed to be produced in a negative or (inverse) mould so should have a clear split-line.

My product should feature an adjustable seat.

My design must be able to fit standardised products in such as brakes, gearings, bottom brackets etc.

My product must appeal to the dominant user age group 40-60 years old.

My product must not cost in excess of £3000 (retail price).

I must design an easy way to enter/exit the vehicle.

My product must have sufficient ground clearance.

My product must be capable of reversing (two feet holes below pedals).
5.5 Product Choice and Assessment Criteria

At the initial stages of this project I had no idea what a velomobile or even a recumbent bicycle was due to geographical reasons, I live in an area where these are extremely rare.

I set out initially to re-design the common bicycle to offer more protection and stability to the rider; however I soon realized that this had already been done in the form of a velomobile.

I shall use existing designs and improve on them both aesthetically and ergonomically to comply with the results and feedback I have gained throughout the research stage of this project.
7.0 Bibliography

7.1 Image links

Fig 1 - http://www.bicycleman.com/recumbents/rans/images/rans_force5_LE-lg.jpg
Fig 2 - http://www.beautifullife.info/automotive-design/new-concept-car-from-morgan/
Fig 3 - http://bicycling.about.com/od/thebikelifess/History.htm
Fig 4 - http://bicycling.about.com/od/thebikelifess/History_3.htm
Fig 5 - http://tweedrun.com/blog/wp-content/uploads/2011/02/PennyFarthing.jpg
Fig 6 - http://bicycling.about.com/od/thebikelifess/History_5.htm
Fig 7 - http://www.designbuzz.com/hybrid-human-powered-vehicles-transform-future-transport/
Fig 8 - http://www.designbuzz.com/hybrid-human-powered-vehicles-transform-future-transport/
Fig 9 - http://www.designbuzz.com/ergonomics-meets-comfort-in-zurlinden-s-recumbent-bicycle/
Fig 10 - http://www.academia.edu/267207/Energy_and_the_Bicycle_-_Human_Powered_Vehicles_in_Perspective
Fig 11 - http://fc03.deviantart.net/fs40/i/2009/039/3/f/amazing_waterRfall_by_leEarch.jpg
Fig 12 - http://www.bionxinternational.com/bionx-international-north-america/products/bike-retrofit-systems/motors/
Fig 13 - http://www.bionxinternational.com/bionx-international-north-america/products/bionx-e-bike-systems/
Fig 14 - http://www.waw-bionx.blogspot.co.uk/
Fig 15 - http://www.waw-bionx.blogspot.co.uk/
Fig 16 - http://www.velomobiles.net/buying/goone3.jpg
Fig 17 - http://en.velomobiel.nl/quest/quest/racing/Wielophanging.png
Fig 18 - http://www.dailymail.co.uk/sciencetech/article-1322484/Airbag-cyclists-Inflatable-collar-protects-riders-refuse-wear-helmet.html
Fig 19 - http://www.dailymail.co.uk/sciencetech/article-1322484/Airbag-cyclists-Inflatable-collar-protects-riders-refuse-wear-helmet.html
Fig 21 - http://en.velomobiel.nl/quest/quest/racing/Wielophanging.php
Fig 22 - http://en.velomobiel.nl/quest/quest/racing/Wielophanging.php
Fig 23 - http://static.ddmcdn.com/gif/car-suspension-11.gif
Fig 24 - http://farm4.static.flickr.com/3015/3008790838_b23e643eeb.jpg /
http://www.recumbents.com/wisil/wiancki/velomobile/default.htm /
http://www.flickr.com/photos/wmbates/sets/72157622958723469/
Fig 25 - http://www.recumbents.com/wisil/wiancki/velomobile/default.htm
Fig 26 - http://www.recumbents.com/wisil/wiancki/velomobile/web/SwingArmDetailB.jpg
Fig 27 - BMX
Fig 28 - http://i183.photobucket.com/albums/x170/Bluewalrus/IMG_0691.jpg
Fig 29 - http://www.bentrideronline.com/messageboard/showthread.php?t=57296
Fig 30 - http://farm8.staticflickr.com/7084/7406131236_524f61ab0a.jpg
Fig 32 - http://www.lowtechmagazine.com/2010/09/the-velomobile-high-tech-bike-or-low-tech-car.html
Fig 33 - https://www.gov.uk/government/organisations/department-for-transport/about/statistics
Fig 34 - https://www.gov.uk/government/organisations/department-for-transport/about/statistics

Pds 2 http://upload.wikimedia.org/wikipedia/commons/thumb/4/44/Kohlenstofffasermatte.jpg/220px-Kohlenstofffasermatte.jpg
Pds 4 http://2.bp.blogspot.com/_mKi9xtyGV-8/T54W51OO_DI/AAAAAAAAADFO/jjXOWqzEoNs/s1600/ trike+frame.JPG
Pds 5 http://www.recumbent-gallery.eu/wp-content/uploads/duo-quest-velomobile-6-1024x768.jpg
Pds 6 http://www.sturmey-archerheritage.com/images/photos/pic-137.jpg
Pds 7 http://bicycledesign.net/wp-content/uploads/2012/05/Petal-Velomobile-Eric-Birnhauser-3.jpg
Pds 8 http://i43.tinypic.com/s6ppix.jpg
Pds 9 http://www.hpvelotechnik.com/images/produkte/spirit/spirit_bionx_motor.jpg
Pds 12 http://www.sicklines.com/news-images/Shimano_saint_4pot_brake_s.jpg
Pds 13 http://i.telegraph.co.uk/multimedia/archive/01829/middle-aged-man_1829805c.jpg
Pds 15 http://bicycledesign.net/wp-content/uploads/2012/10/VeloTilt-open-498x280.jpg
Pds 16 http://traxxas.com/sites/default/files/3903emaxx_ground Clearance.jpg
Pds 17 http://4.bp.blogspot.com/-5S6LDSP6Rpg/UCH-RDUkh5HI/AAAAAAAASlV/wkQrnxhga/1s1600/Milan+GT+interior3.JPG
8.0 Appendices

8.1 Literature survey

Books
The voice of the engineering profession September 2012 – Page 24-27 – Gained concept inspiration from the article about car company Morgan, and their new innovative designs

Government Reports
http://www.dft.gov.uk/statistics
Allowed me to see statistics that relate to transportation.

http://www.bis.gov.uk/files/file34992.pdf

Educational Reports
http://www.oit.edu/faculty/hughcurrin/velo/Velo-RearSusp_09-10.pdf
Single handily explained what the best type of rear swing arm and suspension set up is.

Online newspaper articles
Provided good information about how safety doesn’t have to look bad and inspired me to think how it can use this view in this project.
Online publications


Publication by Frederik Van De Walle that heavily looks into the feasibility of the velomobile being our next form of widely used transportation.


Provides sizes and information for three and four wheel Velomobiles.

Websites

http://www.cuer.co.uk/wiki/images/0/00/Kyle2004-aerodynamicsofhpvs.pdf

This report on aerodynamics of human powered vehicles has enlightened me on the most used and effective riding positions, aerodynamic shapes and mechanical setups.

http://inventors.about.com/od/bstartinventions/a/History-Of-The-Bicycle.htm

Provided me with useful information about general history of bicycles.

http://bicycling.about.com/od/thebikelife/ss/History.htm

Excellent information regarding the history of bicycles. Gave specific dates to when certain things was invented and helped me understand how the bicycle has been redesigned.

http://www.academia.edu/267207/Energy_and_the_Bicycle_-Human_Powered_Vehicles_in_Perspective

Taught me very in depth about rider positions, the history of human powered racing and transport and the first I read about velomobiles.


Inspiring existing designs and made me realise that it is feasible to use kinetic motors in my design to improve the users experience and improve the efficiency of the vehicle.

Explained the term “velomobile” and the reasons why people choose to use one.

http://www.velomobiles.net/buying/buying.html#goone

Specifications of existing velomobiles that can be used as references when it comes to designing my HPV.

http://en.velomobiel.nl/quest/wielophanging.php

Explained wheel wear and how important correct suspension setups are.


An interview with Ymte Sijbrandij (co-inventor of the quest) that informs the reader of many of his professional views on velomobiles. Including how you shouldn’t use disc brakes.

http://www.recumbents.com/wisil/wianecki/velomobile/default.htm

Supplied suspension diagrams.


This website produces and sells electric motor assists for velomobiles.

http://www.waw-bionx.blogspot.co.uk/

A blog that describes in detail how they used a BionX electric assist in co-operation with a Waw velomobile.

http://www.hembrow.eu/personal/sinnermango2.html

Extremely useful informed author writes about all sorts of aspects of working producing velomobile (Mango) and experiences driving them and optimal brake/drivetrain setups.
http://www.linkedin.com

Massive exchange of ideas from professionals

http://www.linkedin.com/groups/HPV-Recumbents-937617?home=&gid=937617&trk=anet_ug_hm

Group on LinkedIn specifically for HPV and recumbent bicycles and tricycles. Helped me understand sprocket and gear ratios.

Videos

http://www.youtube.com/watch?v=a6E1OrwaLPo

Shows a Quest Velomobile sliding sideways due to the rear suspension. A problem that can be solved by redesigning the rear shock.

http://grabcad.com/library/allight-kv4-velomobile-rear-suspension-arm-assembly

Very interesting and impressive assembly video of an aluminium velomobile showing how everything fits together.

http://velorydr.blogspot.co.uk/2012/03/rise-shock-testing-goes-on.html

Video to show the difference between a new “Rise” rear shock absorber and the old type. You can clearly see the difference between them and should be considered in the design stage.

http://www.youtube.com/watch?feature=player_embedded&v=tr_miZZxldQ

Introduced the velomobile “rotovelo “and explained the design functions and problems that they faced and overcame when designing there velomobile.

http://www.youtube.com/watch?v=fXIau2b_RHw&feature=related
Shows a user’s 17 minute commute to work in a Mango velomobile. He captions as he goes along outlining the design problems of the Mango and problems he faces whilst commuting. He reaches speeds of 60-70kph towards the end when he is going downhill!

http://www.youtube.com/watch?v=B2nnuu-Ecy0

Helps to better understand how velomobile suspension works and shows how a U turn procedure is done in a velomobile (no reverse gear).

http://www.youtube.com/watch?feature=player_embedded&v=AAqIBhfBbPc#

Shows how Velomobiles handle on sheet ice (perhaps invention of velomobile snow tyres is needed.

**Tutor and supervisor contact:**

19/11/12 Email – Emailed Mike to ask for extra recumbent bicycle related contacts.

19/11/12 Email – Emailed Jason informing him of worries that there was too much to cover and I wasn’t sure what my conclusion should consist of.

20/11/12 Meeting – Spoke to Dave about problems that were bothering me at the time.

20/11/12 Email – Organised to meet up with Jason to talk about report and the conclusions that I have to make.

22/11/12 Tutor Meeting - Jason, talked about the next stage of my project and various problems I had with the report.

25/11/12 Email – Requested that Jason glance over my document for content to see if I was missing anything.

26/11/12 Email – Informed Jason that I have made a contact with someone in Wales who I intend to professionally meet up with.
Human Powered individual transport systems

Preliminary Feasibility Report

Project 3a (64ET6918_1213_9)

By Jack Robinson

10298859
Contents

1.0 Introduction

1.1 Introduction
1.2 What are human powered vehicles?
1.3 Inspiration
1.4 The interest behind the project
1.4 History and future of human powered transportation

2.0 Statistics and Information

2.1 Statistics to show all road traffic
2.2 Statistics to show how road traffic has changed (1970-2010)

3.0 Aims and Objectives

3.1 Project Aims
3.2 Research Aims
3.3 Objectives

4.0 Development Plan

4.1 Gantt chart to show my development plan

5.0 Literature Survey
1.0 Introduction

1.1 Introduction
This report aims to inform the reader about different forms of individual human powered transport. The key areas that will be assessed include:

- The history of human powered transport and the huge innovations that have changed the way we think about transport.
- The decline of renewable resources, in addition to the progression of environmentally powered and sustainable ways of commuting.
- The aims and objectives that this project hopes to achieve through its entirety.
- A time plan for the early portion of the project outlining key deadlines and objectives that needs to be achieved.
- The huge range of existing concept and futuristic designs, which range from simplistic bicycles to complex and beautiful sports cars plus how the shaping of them will influence this project.
- A breakdown of Britain’s current selected modes of transport and how they have changed within the last few decades.

1.2 What are human powered vehicles?
This project named “human powered individual transport systems” will look at the many ways that humans commute using their own energy and how they can be improved.

The areas in which existing designs may have room for improvement include:

- Radical aesthetic changes to give a more modern look.
- Different mechanical setups.
- A versatile cover system that will protect the user from collisions and different weather conditions.
- Greater stability when riding compared to the typical bicycle.

Although the project will focus on human powered transportation, it is important that the aesthetics are inspired from a broader range of designs that will include concept and futuristic cars, bicycles and motorbikes.

Figure 35: A concept car designed by the car company Morgan.
1.3 Inspiration
Experienced gained from years of riding bicycles and examining other types of human powered transportation has brought up many issues that could easily be resolved by design. For example in bad weather conditions the user can fall injuring themselves. Although injury is a key issue there is also discomfort in conditions like rain, simply giving the bicycle an impact absorbing transparent cover would improve the aesthetics as well as solve these two issues.

The inspiration and the visual fuel for this project will come from many smooth, elegant and simplistic current concept car, motorbike and bicycle designs.

1.4 The interest behind the project
Anyone who has built, maintained and has ridden a bicycle will tell you that the simple and very efficient mechanics are very adaptable and fun to experiment and work with. Because of this, there are already very interesting concept designs being generated.

The interest that comes from bicycles and other forms of human powered transport is that they have the ability to transfer minimal energy put in from the user into the bicycle that using that energy can propel someone much faster than any human can run.

1.5 History and Future of Human Powered Transportation

The Creation

Human powered transportation has been around for many centuries however the first resemblance of a modern day bicycle was constructed around 1790 by a Frenchman named Comte Mede de Silvrac. Called “a celerifere”, it was much more basic than a bicycle from today. With no steering or pedals, it relied on the human pushing off the ground to roll forwards. It was tailored for very smooth and perfectly groomed pathways to roam down that only the most privileged citizens of the time had access to.

The first major innovation was in 1816, German Baron Karl von Drais designed a similar model only this time including a steering mechanism attached to the front wheel. This allowed for the user to be able to dictate the direction that the bicycle traveled in. He called it a Draisienne, after himself, though many people later dubbed it a hobby horse.
The Invention of Pedals
Historians widely believe that the invention of the pedal bicycle, made reality by Kirkpatrick Macmillan, a Scottish Blacksmith. After analyzing the current model where the user would push off the ground with their feet he realized there was improvement that could be made and set to work designing his bicycle. Around 1939 he introduced his model that not only had the ability to steer but also had a set of simplistic pedals fixed to the rear wheel that greatly improved the efficiency in which humans could get more of a power output.

The First Recognizable Modern Bicycle
Most believe father and son Pierre and Ernest Michaux to be the true inventors of the modern bicycle. There invention the Vélocipède was produced in 1867 and was propelled and steered from the front wheel by a set of cranks and pedals.

In 1866, his design was patented in the United States when one of the Michaux’s employees named Pierre Lallement went over and filed for one. Although the Vélocipède was revolutionary it was named as the “boneshaker” because of the extremely rough ride the user experienced, this was due to the lack of suspension and the stiff iron frame and wooden wheels wrapped in an iron rim.

The Penny-Farthing
Eventually by 1870, bicycles where being constructed completely out of metal with a much larger front wheel known as a penny-farthing or a high wheel bicycle. The reason behind this was that the larger the wheel the faster the bicycle would move.

The rider is constantly at risk however; hitting even a tiny stone could launch the user forwards often making them land on their head. This led to the origin of the term “breakneck speed”.
The Beginning of Today's Bicycles
In 1855, designers began to recognise the limitations of the high wheel bicycles and set to work designing the safety bicycle. The safety bicycle would be a huge step forward in human powered transport. Most importantly it allowed people of all ages and sizes too comfortably and safely commute. This of course expanded the buyer market considerably.

In 1885, John Kemp Starly designed a bicycle that has two similar sized wheels. Together with a sprocket and chain, the basic diamond shaped frame and inflated rubber tyres cycling became enjoyable and safe. This later led to a golden age of cycling and the birth of bicycle racing, with many people being able to afford riding them for both pleasure and practical means.

The Future of Human Powered Transport?
Looking at the radical changes that have happened in the history of human powered transport it is hard to believe that such little has changed in the last century. With today's modern and affordable material choices and the shapes that we can achieve via rapid prototyping who knows what kind of advancements we can make. The picture on the left is a hybrid that combines human energy and motor that charges its 300watts with kinetic energy to then later power it up to 50kmh!

There are already advancements in the area that this project may continue in, these vehicles are called velomobiles and are derived from recumbent bicycles, they have a smooth shell like exterior and therefore have major aerodynamic benefit compared to a bicycle. They offer weather and collision protection, but even with all these advantages there are very few manufacturers of velomobiles and therefore a gap in the market.

Velomobiles are capable of integrating roll protection and user harnesses that greatly improves safety. Headlights and turn signals (indicators) can be equipped on these vehicles that would make them a lot more visible on the roads especially at night. This is important because of the numerous amounts of cars on the road and the hazard they present to the rider.
Improving Safety

*Just because safety is being improved doesn’t mean that the aesthetics and the product have to look any worse.*

A good safe design must also look the part; this is a belief that is going to be of use in this project. A great example of this is the bicycle neck airbag, an airbag that blends in with your clothes for people who do not want to wear a helmet.

Taking only 0.1 seconds to inflate, when a bicyclist is unfortunate enough to be involved in a collision the sensors inside of it will detect a sudden jolt and deploy the hood shaped airbag that will surround the user’s whole head protecting it from injury.

The colour of the collar can be adapted to suit whatever outfit the cyclist wears. Made from a durable nylon fabric, it is capable of withstanding the heavy conditions that surround the bicycle user in a crash.

“Both myself and my colleagues are very keen cyclists, but in Sweden a law was brought in that all people must wear helmets.

A lot of people don’t like a bicycle helmet because of the way it looks and what it does to your hairstyle once you have taken it off.

So despite the law many people carried on not wanting to wear cycle helmets, and this is the same not just in Sweden but in places like the UK too.” – Anna Haupt, designer
2.0 Statistics and Information

2.1 Statistics to show all road traffic

Above is an insight to just how many people use pedal cycles compared to motorised vehicles. It is clear to see that with only 4.9 bicycles per kilometre compared to 387 cars, something is putting people off cycling.

This shocking information tells us that in order to change these figures and get people on bicycles we must look at what could be causing people to drive instead of cycle.

**The danger of cycling on the road along with many bigger and heavier vehicles**

People are put off cycling because the danger of being hit by a much larger vehicle. There is less protection and there could be a bigger chance of fatality when using open vehicles such as a bicycle. This could be resolved by introducing an exterior, or an outer shell to the vehicle and a roll cage to protect the user.

**The effort that someone has to put in to power a bicycle compared to driving a car**

There is an obvious advantage when it comes to driving a car: that it requires very little effort. The concept of riding a bicycle to work/school every day may become more appealing if there was a motor that would activate when going uphill or when fully charged.
Wet and windy weather conditions

The weather is a huge condition that will influence if someone takes the bicycle or the car when travelling. With a simple cover over the bicycle, the user will feel much more like pedalling to where ever they are going instead of having to pay for petrol and damaging the environment.

2.2 Statistics to show how road traffic has changed (1970-2010)

| Year | Buses & coaches | Cars, vans & trucks | Motor cycles | Pedal cycles | All road | Rail \(^1\) | All modes | \(^2\) |
|------|-----------------|---------------------|--------------|--------------|----------|------------|-----------|
| 1970 | 60              | 791                 | 4            | 4            | 365      | 36         | 2        |
| 1971 | 60              | 791                 | 4            | 4            | 361      | 35         | 2        |
| 1972 | 60              | 791                 | 4            | 4            | 355      | 34         | 2        |
| 1973 | 60              | 791                 | 4            | 4            | 343      | 34         | 2        |
| 1974 | 60              | 791                 | 4            | 4            | 344      | 34         | 2        |
| 1975 | 60              | 791                 | 4            | 4            | 344      | 34         | 2        |
| 1976 | 58              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1977 | 58              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1978 | 56              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1979 | 56              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1980 | 52              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1981 | 48              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1982 | 48              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1983 | 48              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1984 | 48              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1985 | 49              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1986 | 47              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1987 | 47              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1988 | 47              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1989 | 45              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1990 | 44              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1991 | 43              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1992 | 43              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1993 | 43              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1994 | 43              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1995 | 43              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1996 | 43              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1997 | 44              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1998 | 45              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 1999 | 46              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 2000 | 47              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 2001 | 47              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 2002 | 47              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 2003 | 47              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 2004 | 47              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 2005 | 47              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 2006 | 47              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 2007 | 47              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 2008 | 47              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 2009 | 45              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 2010 | 45              | 791                 | 4            | 4            | 341      | 34         | 2        |
| 2011 | 45              | 791                 | 4            | 4            | 341      | 34         | 2        |

This graph is both interesting and useful to see just how fast and intense the rise of motor vehicle was, consequently how it caused the decline of human powered vehicles.

There is a shockingly low number of pedal cycles on the road and with everyone becoming more environmentally aware and the price of petrol rising, it is a figure that can only go up.
3.0 Aims and Objectives

**Design Aims**
The overall aim of this project is to develop a form of human powered transportation that could also incorporate the use of stored (human produced) kinetic power. It is essential that the product is safe, stable and is as environmentally conscious as possible.

It is important to protect the user from the weather as not a lot of human powered transportation offers this. Many people who commute on bicycles arrive at their destination in wet uncomfortable clothing; this can put people off and is a major issue especially in England.

**Research Aim**
Researching human powered vehicles will allow full understanding of the users needs when it comes to ergonomics, safety and design. The design of the product will be aesthetically pleasing and be based off current and futuristic existing designs.

The project aims to use the most environmentally friendly materials and manufacturing processes that are cost effective. It is important that the materials that are researched are recyclable, reusable and sustainable.

**Objectives**

**Objectives: How will I achieve my aims.**

- Research kinetic energy and how it can be stored and reused with little or no environmental harm.
- When at the design stage, consider how the user could be made comfortable (e.g. a shield to block the rain).
- To improve safety, redesign mechanical aspects (e.g. traction of the tyres, more than 2 wheels).
- Research extensively into concept and current designs to inspire and aesthetically improve my designs.
- Research manufacturing processes and materials by reading books, emailing companies and reports.
- Ensure that any batteries that are used to be kinetically charged and the materials that are used are "green" and environmentally friendly as possible.
### 4.0 Plan (Gantt chart) up to 29th Nov

![Gantt Chart Image]

<table>
<thead>
<tr>
<th>Month</th>
<th>Task Description</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>Initiation</td>
<td>1.1.2024</td>
<td>5.1.2024</td>
</tr>
<tr>
<td>Feb</td>
<td>Research Literature</td>
<td>6.1.2024</td>
<td>10.2.2024</td>
</tr>
<tr>
<td>Mar</td>
<td>Collaboration Model Design</td>
<td>11.2.2024</td>
<td>15.3.2024</td>
</tr>
<tr>
<td>Apr</td>
<td>Concept Design</td>
<td>16.3.2024</td>
<td>20.4.2024</td>
</tr>
<tr>
<td>May</td>
<td>Detailed Design</td>
<td>21.4.2024</td>
<td>25.5.2024</td>
</tr>
<tr>
<td>Jun</td>
<td>Prototype Build</td>
<td>26.5.2024</td>
<td>30.6.2024</td>
</tr>
<tr>
<td>Jul</td>
<td>Testing Phase</td>
<td>1.7.2024</td>
<td>5.8.2024</td>
</tr>
<tr>
<td>Aug</td>
<td>Market Analysis</td>
<td>6.8.2024</td>
<td>10.9.2024</td>
</tr>
<tr>
<td>Sep</td>
<td>Product Launch</td>
<td>11.9.2024</td>
<td>15.10.2024</td>
</tr>
<tr>
<td>Oct</td>
<td>Sales Training</td>
<td>16.10.2024</td>
<td>20.11.2024</td>
</tr>
</tbody>
</table>

---

**Objectives**

1. **MMU 4.0 Plan (Gantt chart) up to 29th Nov**

**Jack Robinson**
5.0 Literature Survey

Books
The voice of the engineering profession September 2012 – Page 24-27 – Gained concept inspiration from the article about car company Morgan, and their new innovative designs.

Government Reports
http://www.dft.gov.uk/statistics

Allowed me to see statistics that relate to transportation.

Online newspaper articles

Provided good information about how safety doesn’t have to look bad and inspired me to think how it can use this view in this project.

Websites
http://www.cuer.co.uk/wiki/images/0/00/Kyle2004-aerodynamicsofhpvs.pdf

This report on aerodynamics of human powered vehicles has enlightened me on the most used and effective riding positions, aerodynamic shapes and mechanical setups.

http://inventors.about.com/od/bstartinventions/a/History-Of-The-Bicycle.htm

Provided me with useful information about general history of bicycles.

http://bicycling.about.com/od/thebikelife/ss/History.htm

Excellent information regarding the history of bicycles. Gave specific dates to when certain things was invented and helped me understand how the bicycle has been redesigned.

http://www.academia.edu/267207/Energy_and_the_Bicycle_-_-Human_Powered_Vehicles_in_Perspective

Taught me very in depth about rider positions, the history of human powered racing and transport and the first I read about velomobiles.


Inspiring existing designs and made me realise that it is feasible to use kinetic motors in my design to improve the users experience and improve the efficiency of the vehicle.

Helped me fully understand the term “velomobile” and the reasons why people choose to use on