TAILORING EXTERNAL PROTECTION FOR ACTIVE TARMAC CONTACT POINTS IN MOTORCYCLE CIRCUIT RACING

Master Thesis by Nola Houtepen

Integrated Product Design
Delft University of Technology

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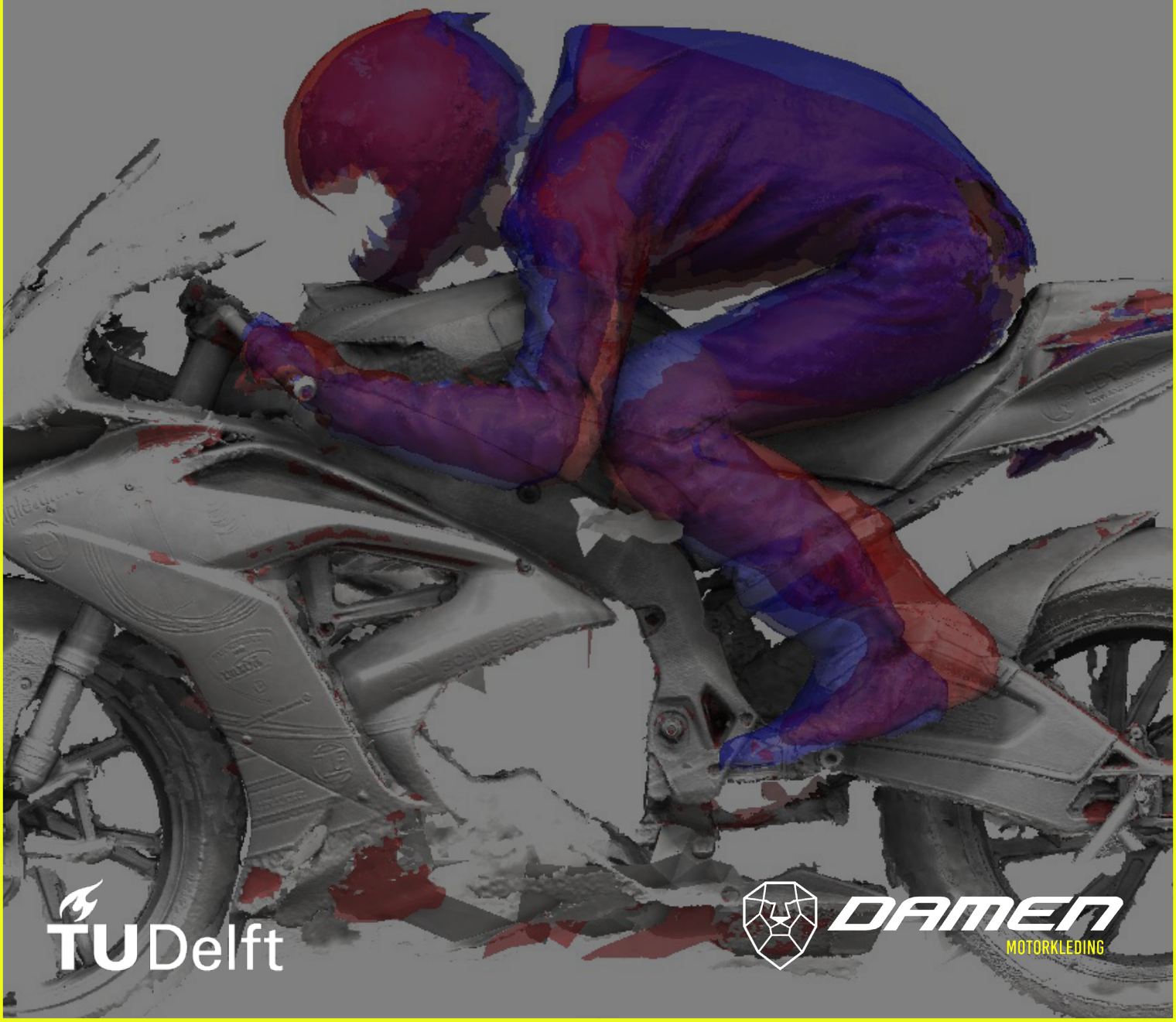

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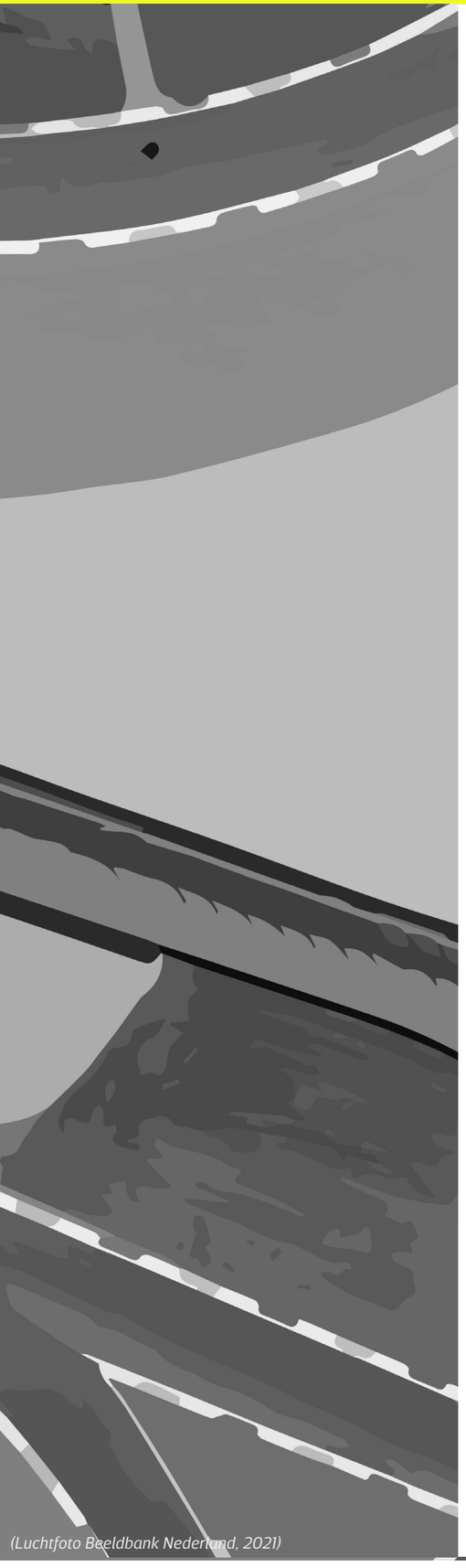

(Luchtfoto Beeldbank Nederland, 2021)

Tailoring external protection for active tarmac contact points in motorcycle circuit racing

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Master thesis

MSc Integrated Product Design
Faculty of Industrial Design Engineering
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Damen Motorkleding
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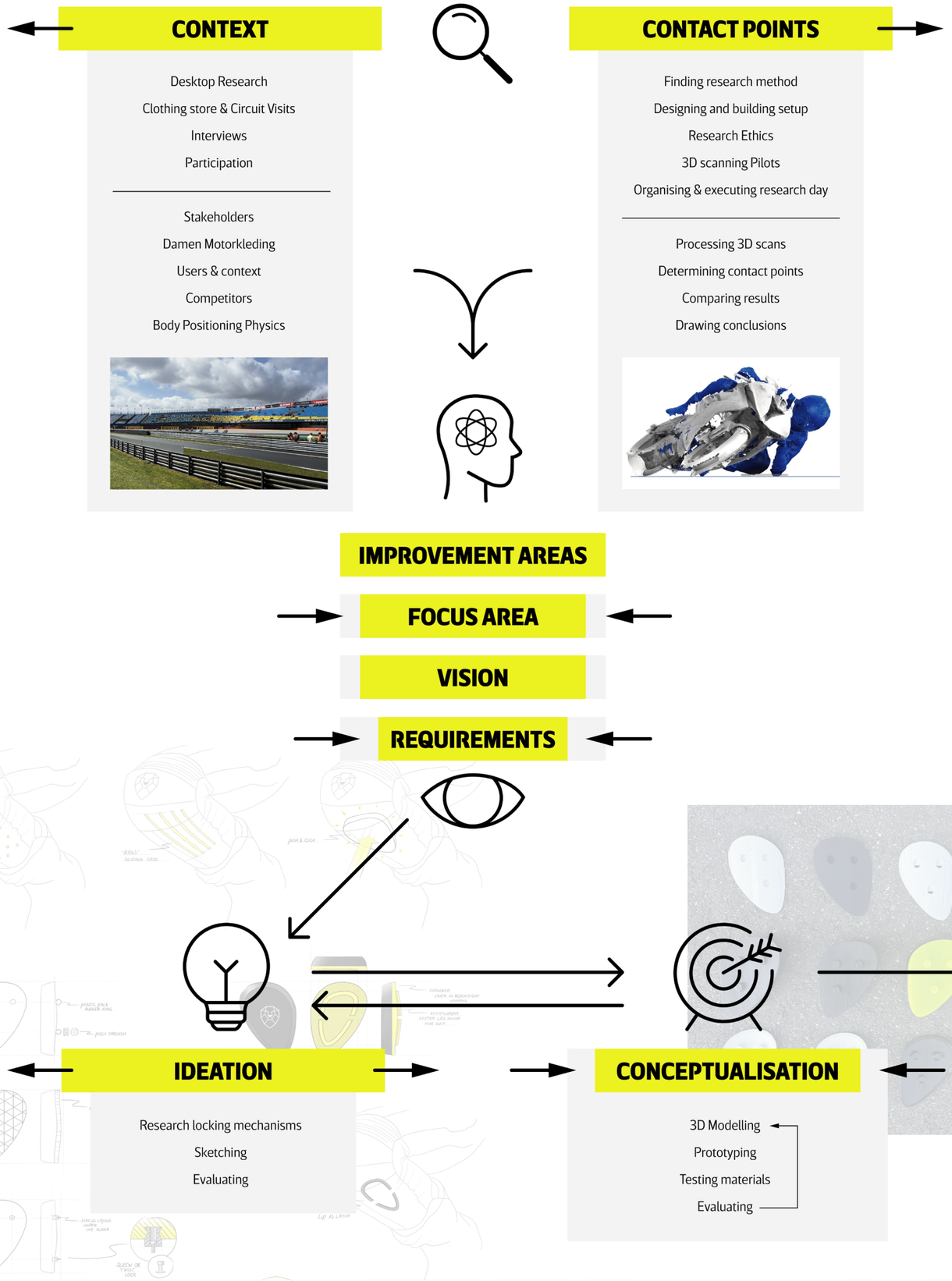
Thank you all, for believing in me and helping me reach this milestone.



EXECUTIVE SUMMARY

The assignment for this project with Damen Motorkleding (EN: Damen Motorwear) was to design a tailor-made solution for external protection in custom leather motorcycle suits (Appendix 1). From the different types of external protection, the project focusses on the protection that is in active contact with the tarmac as the rider takes a corner.

The final design and result of the project were aimed at supporting variety in the user's body and riding technique and improve the lifespan of the leather suit used by professional and amateur motorcycle circuit racers.

To achieve these results, the project was kicked off with an extensive research phase, including both context research on many different aspects, as well as a deep-dive into the differences between active tarmac contact points and the variables that influence them. For accurate results of this contact point research, a collaboration with two professional circuit riders was arranged.

The two research sections led to a broad collection of knowledge about the existing external protection and the different needs of the users and other stakeholders. This knowledge was structured and filtered into four different areas for the improvement of the external protection: Modularity, Longevity, Tailoring and the Attachment system.

It was decided that an alternative attachment system was the most valuable improvement area to focus on in the design phase, as this could eliminate many of the issues accosiated with the current Velcro attachment and proposed high and complementary value to the results of the contact point research.

A vision was defined, which includes clear goals for the integration of a new attachment system with a tailored position:
"I want to create a reliable and user-friendly knee slider attachment system that ensures precise and consistent placement, enhances safety, and integrates seamlessly with motorcycle racing suits, increasing their durability and aesthetic quality."
To achieve these goals, design requirements that correspond with the focus area were gathered from the research insights.

The design phase starts off with the ideation, which was structured by combining several metods from the Delft Design Guide by Van Boeijen, Daalhuizen, & Zijlstra (2020). Sketches were turned into multiple concept ideas which were elaborated on similar levels and compared in an evaluation using criteria. This evaluation resulted in a final sketch before moving on to the conceptualisation stage.

Working out the concept included several rounds of prototypes and an occasional tap back into the ideation content. The conceptualisation was mainly about getting the protector to lock in and out of its place properly and facilitating a comfortable and (aesthetically) seamless integration into the leather suit.

The converging and diverging nature of each phase is indicated in the project overview on this spread.

Requirement- and user evaluations of the final concept design confirm that the project goals have been reached and with that, the assignment has been completed.
Since this project forms the start of promising developments in external protection for motorcycle circuit racing, the project has been concluded with recommendations for further implementation of the work presented in this report.

CONTENTS

GLOSSARY

(Active tarmac) contact point
Points on the knees and elbows of the motorcycle rider which touch and scrape over the ground while the rider is leaning his motorcycle and his body through a corner.

Baselayer
A special garment that is worn as an undergarment in combination with a leather race suit. The baselayer is developed to help regulate body temperature and prevent the suit from sticking to the skin of the rider.

BETAC protector
The company "BETAC" produces different types of protection (standard parts) that can be integrated into the exterior and interior of garments designed by companies like Damen Motorkleding. In this report, the BETAC protector refers to an internal knee protector, which sticks to the inside of the suit using Velcro.

Body positioning
Posture of the rider on the bike:
1. As a result of anthropometry and/or bodily range of motion.
2. As a result of technique and/or personal riding style.

Kerbs
Known as the red and white colour blocked border in the corners of a circuit. Often made up out of individual blocks called "kerbstones" (US: "Curbstones"), which are angled to create a ribbed surface. Different shape variations are used in practice.

External protection
Elements on the outside of the leather suit with a purpose to protect the body of the rider. Usually consisting of different types of sliders.

Internal protection
Protectors implemented on the inside of the suit (between the lining of the suit and the leather layer(s)), which absorb impact during a crash to protect the rider's body.

Kneedown
When a rider scrapes his knee over the tarmac during a corner.

Lean angle
The amount that a motorcycle leans over in a corner, starting at 0 degrees with the bike standing vertical and increasing as the motorcycle tilts towards to tarmac.

Leathers
Frequently used nickname for a leather motorcycle race suit.

Non-incidental road rash
The name of a type of injury a rider suffers when purposefullly scraping their body over the tarmac in a corner without proper protection.

Pit lane
"A lane adjacent (usually on the inner curve) to a racetrack where the competing teams' garages are situated (Wiktionary, 2023)."

Pucks
Active knee or elbow sliders.

Riding technique
Determines when and what body positioning the rider adopts during a race.

Sliders
There are two main types of sliders, which provide low friction when the rider is in contact with the tarmac:
1. Crash sliders: External protection element on the outside of the leather suit that helps spread forces over a wider area upon impact from a crash and helps a rider slide across the tarmac instead of tumble, to minimise the chance of serious injuries. Made from TPU or Metal with low friction.
2. Active sliders: External protection element on the outside of the leather suit that protects the knees and elbows of the rider from abrasion as the rider scrapes them over the tarmac (for gauging their lean angle during cornering). Usually in the form of thick replaceable TPU pucks which wear down on the tarmac. The standalone term "sliders" mostly refers to this active type of slider.

Sliders are mostly used at the knees, elbows and shoulders of a leather suit, as well as on the toes of a racing boot.

Starting Grid
The line-up in which riders start a race. The order of the line-up is determined by previous performance. The exact spots are marked on the circuit in a carefully measured grid-like formation.

Tread
The part of the tire that can come into contact with the asphalt. The tread stops suddenly and merges into the sidewall of the tire at an angle.

CONTEXT

1. INTRODUCTION

In professional motorcycle circuit racing, riders manage to defy the laws of physics with the help of nothing more than their own body (Martin, 2022). Few talented riders have developed this astonishing skill after many years of development in competitive motorcycle racing. Nowadays, riders hang off the side of their bike, often touching the tarmac with their knees and elbows. However, this has not always been the case.

In the early days of motorcycle racing, riders remained in the middle of the seat when taking corners. At the time, the challenge was to get through the corner without losing tire grip (Figure 1.1A). When tires were further developed and grip started to increase in the 60's, the toes were the first to touch the ground when leaning into a corner, logically making them the first reference point for the bike's lean angle (Figure 1.1B). It was not until the late 70's when Kenny Roberts re-introduced a style inspired by Jarno Saarinen, that knees actually started to touch the tarmac. This style was copied by many other riders, who also started moving their body towards the inside of the curve and dragging their knees (Bx_Ayesa, 2023). This technique not only shifts the combined centre of gravity to the inside of the curve, allowing the bike to stay more upright at the same speed. Riders also learned to use their knee as a third contact point with the tarmac, gauging their lean angle more precisely (Figure 1.1C) and supporting the bike when traction is lost (Wood, 2021).

With the ultimate goal of getting though the corner as fast as possible, riders keep pushing the limits of the bike, the tires and corresponding physics. With the tremendous amount of control in tire grip acquired today, well known riders take corners with so much lean, that their elbow forms a new contact point (Bx_Ayesa, 2023). As the example of this new riding style, Marc Márquez (Figure 1.1D) has even obtained the ability to detect and control front tire sliding, defying physics by taking corners at speeds beyond the grip of the tire (Sagawa, 2019). For a more in-depth explanation of the physics behind this competition technique, see Chapter 8.

Often taken for granted is the development of the leather suit as a result of the evolution in body positioning/riding technique. When the first riders started dragging knees, they added padding, duct tape and even old helmet visors to their leather suit, in an attempt to protect their knees from abrasion. Clothing brands realised the need for a permanent solution, as the riding style quickly became popular. Knee 'sliders' or 'pucks' were invented to help the knees of riders glide across the tarmac smoothly, while their thickness protects the leather and body from abrasion. The knee slider we know today first appeared in the 1990's and has not changed much since (DemoneRosso, 2021a). A similar process brought the elbow slider to the market. At first, primitive solutions were used

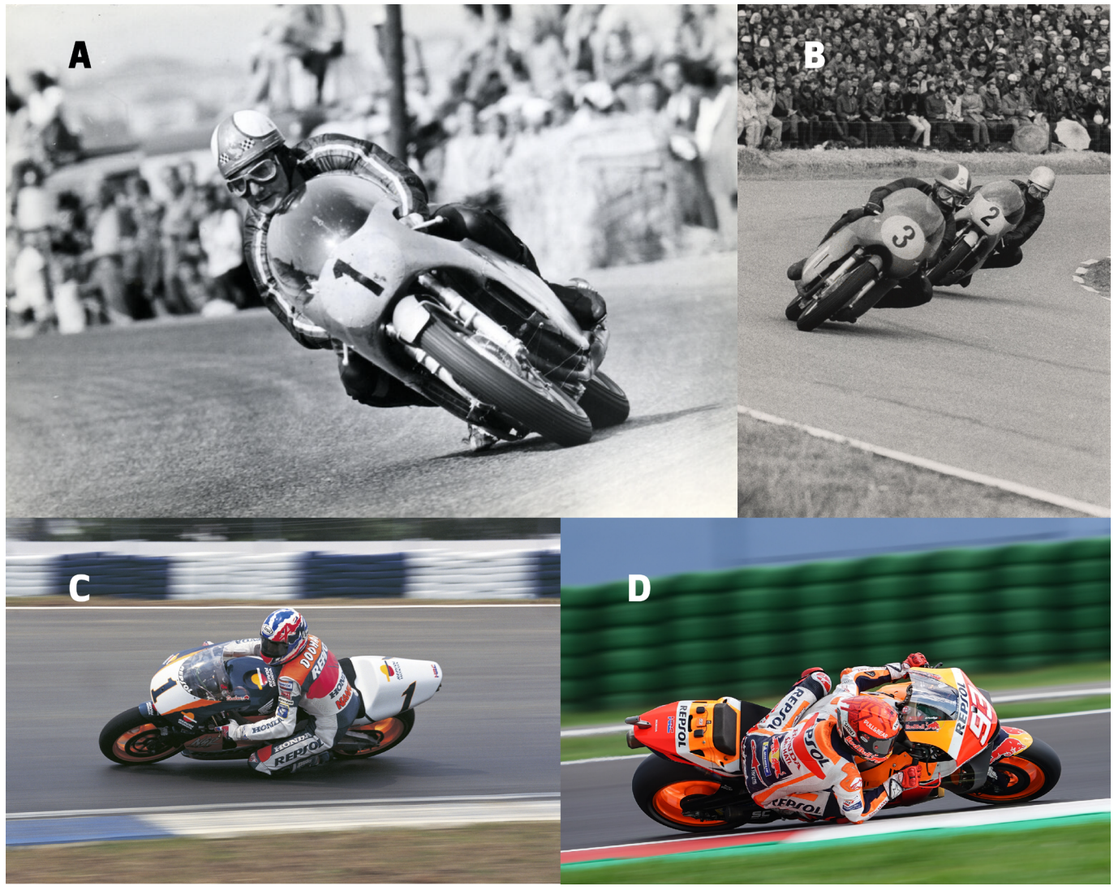


Figure 1.1: Visual changes in lean angles and riding styles as a result of tire developments (Bx_Ayesa, 2023).

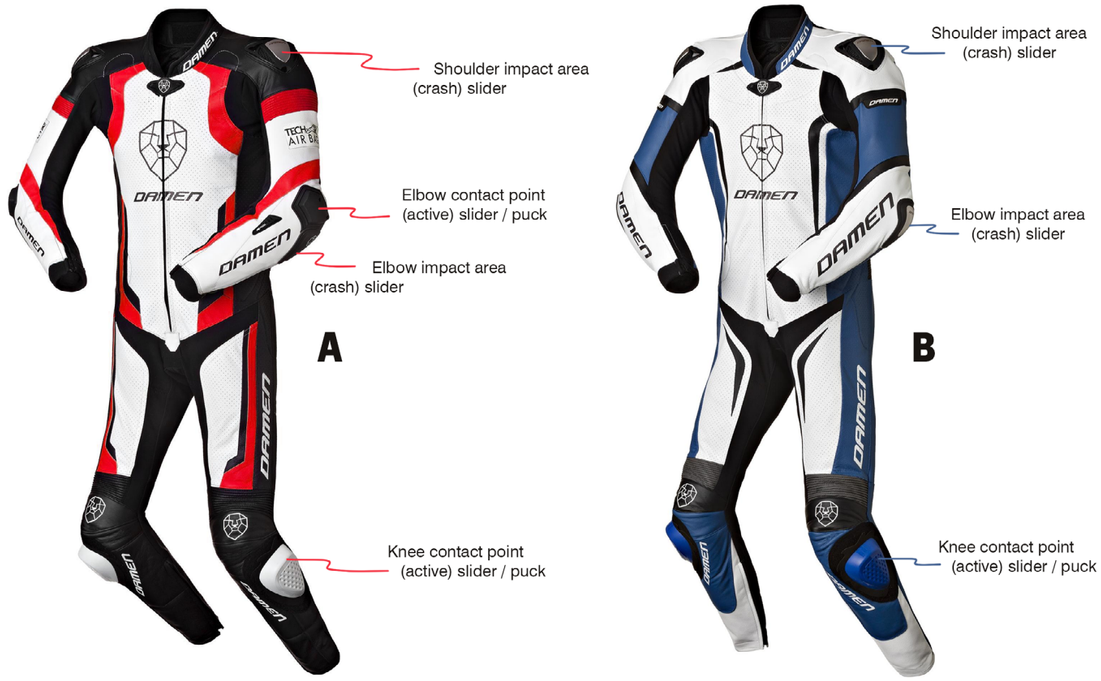


Figure 1.2: One-piece leather race suit by Damen, also known as 'leathers' (Damen Motorkleding, n.d.-d, -f).

by the few professionals who dragged their elbows. Today, clothing manufacturers have integrated sliders similar to those existing for the knees (DemoneRosso 2021b).

Damen Motorkleding (EN: Damen Motorwear), a Dutch company specialised in producing all sorts of motorcycle clothing, has been providing famous riders with leather racing suits since 1964. The company has a lot of expertise in tailor made motorcycle clothing. When Damen started their business, race suits were almost fully made of leather. Over the years, their suits have evolved with protective and aerodynamic inserts, hydro bags, crash airbags and not to forget – sliders. However, these new features, including the sliders, are not a part of the tailored work. They are standard parts implemented in pre-determined locations. For professional riders, the comfort of a suit that matches their body and personal riding style is very important. A suit made to fit the rider's needs can be essential to help them perform.

The aim of this research is therefore to examine whether or not a tailored solution for active tarmac contact points can be considered necessary or beneficial, by exploring the relations between active tarmac contact points, rider anthropometry and riding technique. In addition, the research aims to examine (differences in) rider needs for knee and elbow pucks. The goal is to use the findings in designing a new slider concept.

For a good understanding of this project, it is important to note the difference between two types of sliders that are integrated in the suit and discussed in this report (see Figure 1.2):

1. Sliders used for active contact points, which are the thick pucks that wear down during the ride itself, as the rider uses their knee or elbow to gauge their lean angle. These are the thick, replaceable sliders close to elbow and knee that may be referred to as 'active sliders' or 'pucks' for clarity.
2. Crash sliders were inspired by the active sliders after developers realised the potential of sliding for impact protection. They are integrated on the impact zones of joints including the top of the knee, elbow and shoulder and have the purpose of spreading impact force over a bigger area and prevents the joints of the rider from catching grip when falling off their motorcycle, lowering the risk for serious injuries like hyper-rotations (DemoneRosso, 2021a).

   Active sliders and crash sliders can be integrated as shown in Figure 1.2A. Alternatively, the elbow can include only the crash slider (Figure 1.2B), as active elbow sliders are only required with advanced riding technique.

Although the this project dives into the external protection, it is important to note that there are also internal protectors inserted into the garments. These protectors are designed to absorb impact in the event of a crash and thus do not have a main function during the ride itself.

This project report includes many research areas which can be divided into sections as structured in Figure 1.3. This research forms the base of the project and gives direction towards the goal of designing a new active slider concept. After the research sections of the report, this project and report will thus be concluded with a design concept and recommendations for further developments.

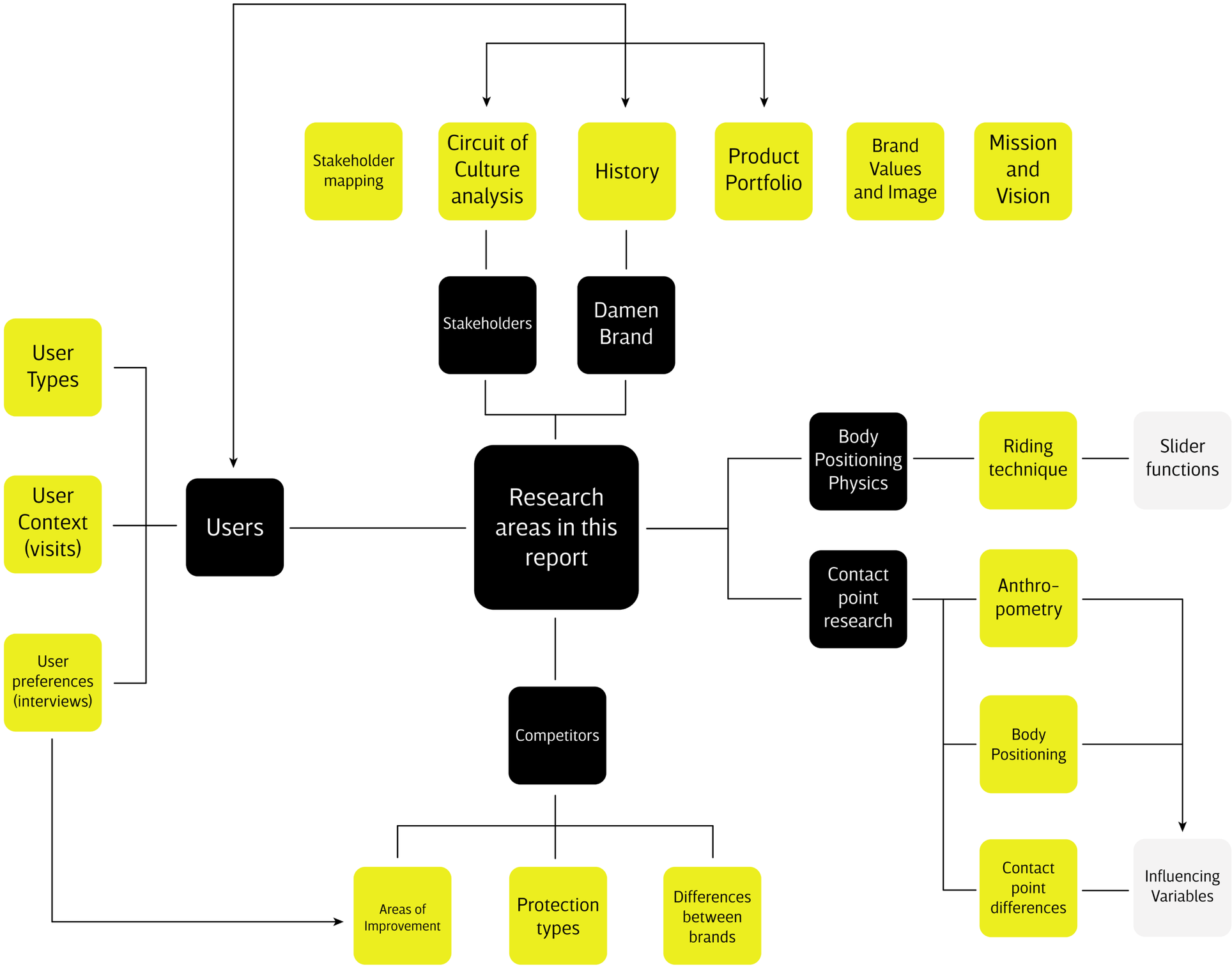


Figure 1.3: Overview of research areas that are included in the report.

2. STAKEHOLDERS

2.1 Cultural influences on race suit design

Besides the technique/body positioning used by professional track riders, there are many other influences that determine how leather gear changes. New features in leather suits are not only a result of evolving riding technique, but also that of racing culture. The circuit of culture model as explained by Van Boeijen and Zijlstra (2020) shows just how much all of the cultural processes that are involved are interrelated (see Figure 2.1.1):

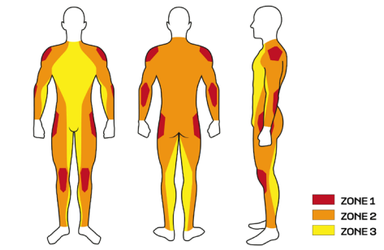
Production
First and foremost, leather race suits were developed according to the needs of competitive circuit racing professionals. Riders started wearing leather clothing for protection, as the first alternative to regular clothing. In the 1950's, a competitive rider called Geoff Duke started working together with a local tailor to create the first one piece suit. His idea behind the one piece suit was to obtain better aerodynamics (Mike on Bikes, 2020). Nowadays, the leather suit is still created mainly for circuit racing. Its number one socio-cultural meaning of *protection* and *aerodynamic* purposes thus remains. Still, additional socio-cultural meanings have been added to the leather suit overtime.

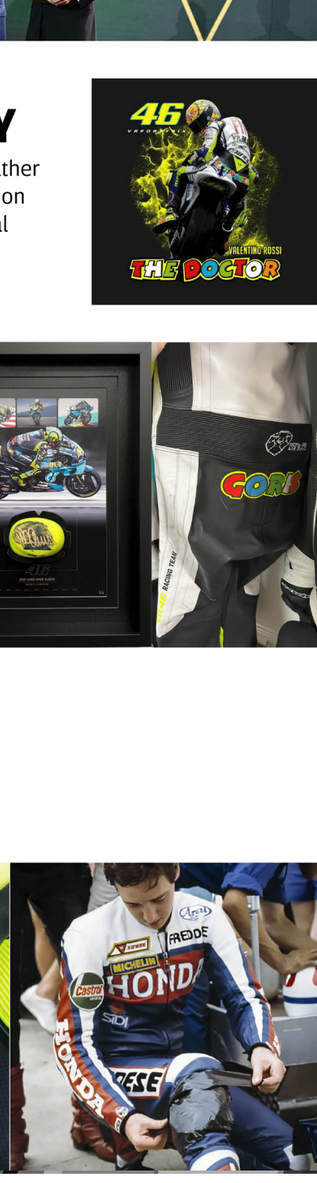
Consumption
With increased use and development of the leather one-piece in racing, wearing such a suit distinguished racers from casual riders and showed the riders' *commitment* to the sport, creating a sense of *community*. Later, it has become a widely adopted form of protection for amateur and everyday riders, who wear the same suits as a symbol for their commitment to the riding lifestyle and their membership in the motorcycling community.
Though the leather suits are still highly associated with racing on circuits today, they are also widely used on the road by motorcyclists who ride sports bikes and naked bikes (see Figure 2.1.2). Now that textile alternatives have been developed for protection and weather-proofing thoroughly, one might question the use of impractical leather suits on the road. This can be explained by the community and identity that is still associated with the leather suit.
However, there is a visible difference in the use of leather suits between the context of competition and amateur use.

Identity
The suits of professional motorcycle racers are made to size and have obtained additional socio-cultural meaning through the inclusion of many logos of their racing team and other sponsors in the suit design. The colours and design of the suits are chosen carefully to fit the riders' team, main sponsors and for *personal branding*. Besides sponsor logo's, professionals also wear their name or nickname on their lower back and sometimes their racing (competition) number is added to the leathers. This way, the suit has become a canvas for expressing the achievements, status and skill of the rider.
Since in competition, crashing is inevitable (see Chapter 8.3), professional riders go through multiple suits in one season and often have spares at hand. Spares sometimes include a suit with different colours and designs, which is used specifically at their home circuit, to express their identity and appreciation towards their country and their supporters. These suits are often used together with special matching livery on the bike's fairings, see Figure 2.1.3.
Non-professional riders mostly use one suit for multiple years. In both use cases though, damages require quick repair to continue riding.

Standard-sized suits that are stocked in stores and mostly sold to amateurs

Figure 2.1.1: Overview of interrelated factors that influence the design and use of the leather suit (Amazon Inc., 2015) (Autographed Collectables, 2024) (Biker Outfit, n.d.) (Buis, 2024a) (Classic Bike Hub Uk, 2023) (Dainese, n.d.-a) (Damen Motorkleding, n.d.-f) (DemoneRosso, 2021a) (DemoneRosso, 2023a) (Hebbrecht, 2022) (Leopard Racing, 2023) (Motardes, 2015) (motogp.com, 2022a) (Nedgame, 2024) (Siahaan,2023) (Swarts, 2021).





REPRESENTATION
The influence of media on the meaning of the leather suit.

REGULATION
Meaning of the leather suit formed through social regulation.

IDENTITY
Meaning of the leather suit as an expression of people's cultural identity.

CONSUMPTION
Meaning of the leather suit through the manner in which people use it in their daily practices.

PRODUCTION
Meaning of the leather suit in its creation.

Figure 2.1.2: Sports bike (left) vs Naked bike (right) (cycle-ergo, 2024).

exclude all of these logo's, names and racing numbers and there are both one-piece and two-piece options available with lower levels of protection, to keep the suits more affordable to the public. For example, these options may exclude elbow sliders, airbags and crash sliders. When it comes to sliders, knee pucks are used in larger numbers both by professionals and amateurs. Elbow pucks require more advanced riding technique and are therefore not used by many amateurs, hence their exclusion in some suits on the market. Still, many amateurs like to wear a suit with full external protection and graphic designs, as the sliders, names and sponsorship logos on the suits have obtained a meaning of commitment, status and *professionalism.*
Besides standard suits, custom options similar to those of the professionals' suits are also available to the public. Semi-professional circuit riders often choose for a tailor-made suit like a Damen suit. Customers often add colours, logos, names or numbers that match those of MotoGP legends (See Chapter 4.1), or create their own personal branding to imitate professional suit aesthetics and express their own identity.

Figure 2.1.4: Influence of motorcycle gear on main-stream fashion (Dior, 2022) (Rachepoot & Bauer-Griffin, 2022).

In mainstream fashion, the leather gear and logo-filled designs seen in motorcycle gear have been adopted into jackets and other suitable garments (Figure 2.1.4) as an expression of toughness (Satenstein, 2022) (Street, 2022).

Alternatively, there are of course many other styles of motorcycle clothing, each with their own type of rider identity attached to it.

Regulation
Most of the influence on the leather suits in terms of regulations comes from norms introduced by governments, circuit owners, competition organisations and standardisation organisations. An example is the European norm for protective motorcycle garments. This norm requires the clothing to comply with a carefully determined set of rules and tests about safety concerns like impact zones, fabric and textile requirements and pattern design (e.g. double layers of leather in critical areas) for abrasion resistance (European Committee for Standardization, 2020a, -b) (Confidential Appendix 1). These norms are often adopted and elaborated by organisations for circuit racing like the Fédération Internationale de Motocyclisme (2024b), who states that in the WSBK (World Superbikes) championship of 2024, "Riders must wear a complete leather suit with additional leather padding or other protection on the principal contact points, knees, elbows, shoulders, hips that conform to EN1621-1:2012." (Leather substitutes are allowed under additional requirements, see Appendix 2). Riders may thus be obligated to wear leather suits, integrated airbag systems and other forms of protection to access a circuit or participate in a racing event or competition.
On the other hand, there are also prohibitions. Metal knee pucks are prohibited on circuits as the rain of sparks they leave behind can be a danger hazard. In other words, "The use of sliders (specific parts of the riders safety equipment, either permanently fixed or removable, intended to make regular contact with the track surface to assist the rider while cornering), is permitted on the knees, elbows or any other parts of the race suit, where it is deemed necessary. They must not be manufactured from or contain any material that when in contact with the track surface may cause visual or other disturbance to other riders (Fédération Internationale de Motocyclisme, 2024a, -b)." For the design of a new slider system, this requirement should thus be taken into account. In addition, the slider system should not interfere with the European regulations concerning internal protection/impact zones and abrasion resistance.

Representation
Leather race suits of various brands are worn by professional riders. The MotoGP (Moto Grand Prix) world championship for example, is the worlds' most known professional motorcycle circuit racing

Figure 2.1.3: Regular livery and suit (left) vs home race livery and suit (right) (van Straalen, 2024a, -b).

competition and is considered the highest class (see Chapter 4.1). Not only can the riders in this competition be spectated from tribunes during races at tracks worldwide. Their performance is also being broadcasted on TV (Dorna, n.d.), in news, documentaries, movies, magazines, various social media and their suit even appears in video games. Thus, it is not surprising that these riders are one of the biggest *advertisements* for the clothing brands. In this case, a crash does not necessarily mean bad advertisement: they are a perfect opportunity to prove the protective performance of the suit to the public, who are often amazed at how little injuries result from high-speed crashes in the MotoGP, thanks to the protection of the race suit.

By having the professionals test new features and provide feedback, suit brands can implement the best protection, support and the most comfort. Consequently, the production of the clothing shows the *development* of riding technique and *evolution* of technology in riding gear over the years, giving it new meaning in terms of *high-tech safety*. For example, when functional sliders were developed to support riders in dragging their knees, suit manufacturers realised that sliding could also be used as a crash protection. This resulted in the implementation of a second slider type, that prevents the user from tumbling during a crash (DemoneRosso, 2021a).

Not only do riders represent suit brands. With most brands supporting and providing multiple well-known riders with their suits, the brand assembles their 'team'. Their goal is to gather the best riders to wear their brand through a sponsorship. As a result, the biggest garment manufacturers and the best riders are easily associated with one another, meaning that the suit brand can also influence the reputation of the rider, or motivate them to wear a specific brand and be a part of its team.

Popular professionals dispose of some outfit parts by signing them and throwing them in the public, or giving them away to their fans. Some items are even sold in auctions. Gloves, but especially also the knee sliders are a popular example of these rituals. Although this makes the products more sustainable, only few items are given a second life with fans and collectors.

In conclusion, these interrelated processes should be taken into account when designing the new change for leather gear. Not only does a new concept need to fit in the existing culture, it can also influence how motorcycle racing culture changes in the future.
Ideally, a new slider system supports the correct use of body positioning and riding technique, providing a better understanding of safe use to novel circuit riders who often prioritize wearing out the sliders to obtain a more professional status. A new design could help enhance and expand cultural meaning by using technological innovation to develop a more sustainable use of the sliders, enhanced safety and new ways of personal expression, whilst

2.2 Stakeholder overview

As illustrated by the circuit of culture, many people are involved in the products' (and cultures') evolution, but they do not all contribute to change in the same manner. Therefore, during the design project, they should be treated and considered in a way that suits their role. Figure 2.2.1 visualises how stakeholders can be distinguished through the amount of interest they have in the project and the amount of power they have over the design and implementation of a new concept for external protection. This method of organising stakeholders was inspired by the power-interest grid as presented by Ackermann and Eden (2011). The stakeholders that should be managed closest are in the upper right corner. They possess the highest amount of power and interest.

Prioritised stakeholders with much power or important interest are marked yellow in Figure 2.2.1. These stakeholders have important influences on the project, which must be considered in the process of this research and design project:

Damen
The number one stakeholder for this research and design is of course Damen. With changing times comes new technology. Though Damen has decades of experience in their traditional ways of creating suits, it is time to explore new methods for product improvement. Since Damen is a small business, USP's (Unique Selling Points) are of high importance to draw attention of their customers. New design for the external protection in Damen suits could be a nice eye-catcher that makes their tailored work complete and unique.

#TEAMDAMEN
Damen provides many professional and semi-professional motorcyclists with leather suits (Damen Motorkleding, n.d.-c). They are all part of #TEAMDAMEN, though some of them, like sponsored riders, become featured representatives. They are the ones that are able to give the most in-depth feedback and can help improve the product. This is mutually beneficial for Damen and their riders, as a good product should fulfil all the needs of the professional rider, giving them the most comfort to help them win.

Suppliers and manufacturers (including Damen workshop)
Traditionally, Damen produced all of their products in their workshop in-house. Nowadays, they work together with suppliers and manufacturers, combining protective elements including the external protection into their leathers. The limits of manufacturing should be considered. Costs and batch sizes are an important factor as Damen works on a small scale and they need to be able to produce and integrate the design solution in their suits, as well as execute repairs.

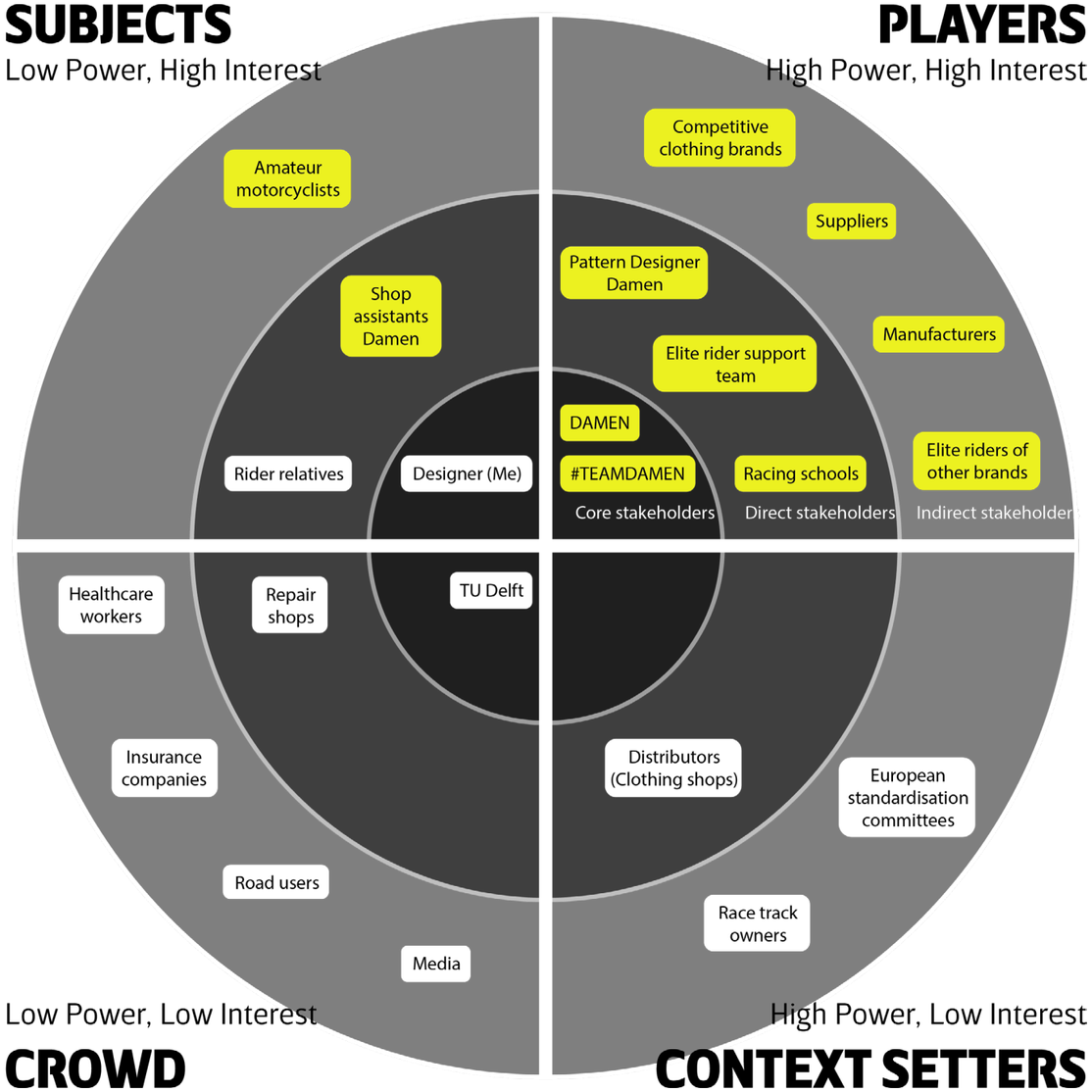


Figure 2.2.1: Overview of stakeholders in this research and design project.

Pattern designer Damen
The pattern designer at Damen should be involved in design stages and informed during research phases of the project. Since the goal is to design new external protection for the leather suit, adjustments to the sewing pattern may be needed in order to integrate the design solution. Another reason for the importance of this stakeholder is to acquire an understanding of the current methods for integrating external protection in the suit.

Shop assistants Damen
As Damen suits are tailored, shop assistants may need to adapt to the design solution during measuring appointments.

Semi-professional and amateur motorcyclists
The suits developed for professionals are also worn by semi-professionals and amateurs, meaning they will pay for and take over design solutions developed for professionals. By keeping amateur riders informed about the project, it is possible to gain an understanding of their demand and, for example, if the new system for external protection should become optional or standard in a new suit design.

By keeping these important stakeholders involved and informed, a feasible and viable concept can be developed as a new evolution of existing external protection.

Takeaways | Chapter 2 – stakeholders

2.1 Originally and currently, the leather one-piece suit is invented with the socio-cultural meaning to protect and improve aerodynamics for motorcycle racing.

2.2 Over time, race suits have obtained new socio cultural meanings including commitment, community, personal branding, professionalism, toughness, advertisement, development/evolution and high-tech safety. The interrelated processes of culture can transform slider use in the future and should be taken into account in the design of a new slider system.

2.3 Professional circuit riders are the trendsetters of riding technique/body positioning. New features in leather suits are developed to fit needs of the professionals and are adopted by amateurs.

2.4 Leather suits require quick repairs for any user.

2.5 Race suits should comply to the regulations of the European Norm and the regulations of the FIM.

2.6 Production costs and batch sizes are an important factor in the viability and feasibility of the product, as Damen currently works on a small scale.

2.7 Workshop employees and shop assistants need to be able to implement the slider system into the production process of a tailored suit. This may require new assembly methods and additional steps during measuring appointments.

2.8 Depending on the costs and required skill for the use of the slider system, it may be beneficial to allow it to be an optional feature to the suit.

Requirements

2.1 The slider system must adhere to the socio-cultural meanings of protection and aerodynamics.

2.2 The new slider system must be more sustainable than its current counterpart.

2.3 Professional circuit riders must participate in the projects' research for the most valuable in-depth insights of slider use and rider needs.

2.4 a The new slider system must be more durable than the current system.

2.4 b The new slider system must allow quick repair to the suit and system when either one is damaged.

2.5 a Sliders must comply to the regulations of the FIM (Appendix 2).

2.5 b The new slider system must not interfere with the European regulations concerning internal protection, impact zones and abrasion resistance (Confidential Appendix 1).

2.6 a Batch sizes must not exceed 200.

2.6 b Production costs must not exceed €30,-.

2.7 Workshop employees and shop assistants must be able to implement the new slider system into the suits' tailoring and assembly.

Wishes

2.2 a The slider system should support the correct use of body positioning and riding technique.

2.2 b The slider system should provide new users with a better understanding of safe slider use.

2.2 d The new slider system should enhance safety.

2.2 e The new slider system should allow personal expression whilst staying close to traditional aesthetics of the leather suit.

2.8 The slider system should be an optional feature to the tailor-made suit, without too many alterations to the design of the sewing pattern.

3. DAMEN MOTORKLEDING

With the involvement of Damen in the career of professional circuit racers, they have the power to bring new development to the leather suits they create. A brand analysis gives an idea of where the company stands as a brand and in the world of motorcycle racing. This information will help to design a rich addition to the product they currently offer and to position the new concept development in the market.

This year, Damen celebrated their history of 6 decades. Over the years they have stayed true to their nature as a small family business with a relatively well-known name. Their power has always been to stay customer-focussed by working according to tradition, on a small scale. Chapter insights were collected from interviews and desktop research (see Confidential Appendix 2+3 and Appendix 3).

3.1 Brand name

Throughout all these 60 years, the Damen shop, workshop and office have remained in the same location and building which was opened by Ad Damen in 1964 (Hulshof, 2018). Even though the company has stayed close to tradition over the years, some change has been inevitable. For example, the name has changed from several variations of Damen (e.g. Damen Leathers, Damen motorfashion) to Top Skin and back. Today, the brand is known as Damen Motorwear (Dutch: Damen Motorkleding). Because of identity concerns (Chapter 2.1) of customers in the male dominated world of motorcycling, sometimes the name "Top Skin" is still requested to be used on the leather suits alternatively to "Damen", which may be associated with the word "women" in Dutch and mostly German language. For this reason, the new logo comes in handy. This visual brand representation ensures that brand recognition can remain more uniform across different suit designs, even when the company name itself is not on the suit.
The current logo refers to an old logo of a lion, which was used together with the company name. This modern visual of a lion is also shaped like a shield, resembling the protective functionality of the brand's clothing.
Another important change is that of workshop use. Where every piece of clothing used to be created in-house, the workshop has endured a significant size reduction, as today it is nearly impossible to find skilled employees willing to create and repair the clothing in the workshop. Only few prioritized products like those of sponsored world-class riders are still created in-house, and a large section of the workshop space in the building (Fig 3.1.1) has been transformed into additional shopping area.

3.2 Product portfolio

Damen is not only specialised in tailor-made leather clothing. They also have great amounts of experience in textiles. Their product portfolio can be split into three main categories, as was already the case in the 70's. Back in the day, they offered "Racing Sport", "Tour & Travel" and "Classic" motorcycle clothing (see Figure 3.2.1). The categories of Tour & Travel and Classic can now be seen as merged under the name "Tour", whereas, thanks to many years of experience, a new category called "Pro" appears as third (see Figure 3.2.1):

Race (Racing Sport)
The race category consists solely of full leather suits containing all the circuit protection (e.g. sliders, airbags etc.). The suits Damen offers are either made into a one-piece, or split into a jacket and pants by means of a zipper. The race category is developed for professional track racing and mainly targets competitive professionals and semi-professionals, but is also widely used by amateur circuit riders and on naked- and sports bike riders on the public road (see users Chapter 4).

Tour (Tour & Travel + Classic)
The tour clothing line uses both leather and textiles and targets riders who are often looking for practical all-weather protection. The target group of this category can include for example those who are commuting by motorcycle, recreational riders and adventurous travellers.

Pro
A special category is set up for those who ride for their profession. Thanks to their extensive experience, Damen provides many Dutch and Belgian police officers, instructors of Riding and Traffic schools, Traffic controllers, Medics and Other services with a perfectly fitting, comfortable and complete package of daily protection.

Tailoring options are available in all three categories, ranging from size adjustments and colours to logo's and leather perforations. Still, Damen can advertise their name and tailoring best via their leather racing gear. Providing ever-developing athletes with suitable clothing can be quite a challenge. Therefore, this category opens great opportunity for solving challenging imperfections with new solutions.

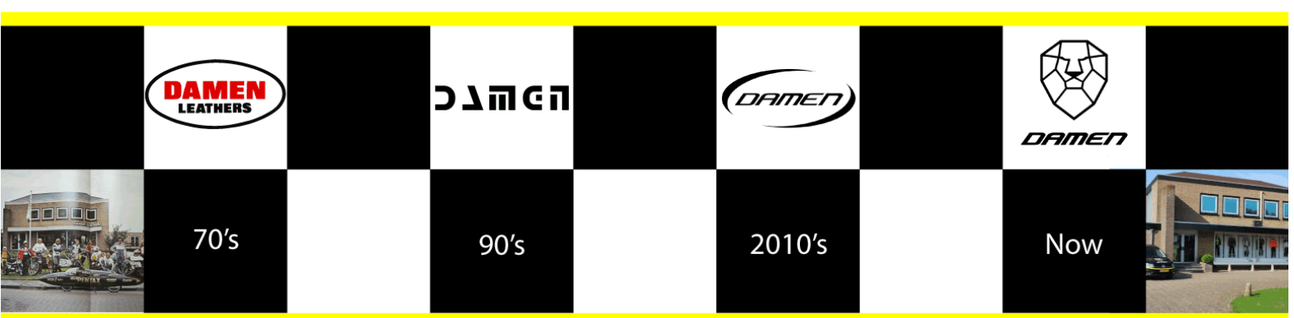


Figure 3.1.1: Timeline of logo changes (Note: does not include all years and logo's, but the ones that are still seen most on products worn today.) (Bleijs, 2016) (Damen Motorkleding, n.d.-a) (Golda61 & 2dehands.be, 2024).

Figure 3.2.1: The three main categories that define Damen's product portfolio (Damen Motorkleding, n.d.-e) (Golda61 & 2dehands.be, 2024) (Magdam2784 & allegro, 2018).

3.3 Damen Mission & Vision

When riding a motorcycle, whether for daily work, travelling, commuting, or for sports, comfort is one of the most important factors in making the ride enjoyable. A good fit is crucial to ensure safety, as ill-positioned protection does not do the job it was designed for. Yet still, for many people, it is impossible to fit into the limited options of standard sizing, let alone get their hands on an extremely expensive custom suit by big clothing brands.

Mission
As can be concluded from the product portfolio as well, Damen has a clear and consistent mission with their work: The company knows that *"Everyone is unique (Damen Motorkleding, n.d.-e),"* and bodies change when years go by. That is why their mission is to provide custom modifications for any need. Whether it is gloves with four fingers or asymmetrical suits, Damen pays attention to every customer to help them find the perfect fit.
They want to make riding enjoyable for any (type of) motorcyclist, by creating gear that fits their needs. This includes a focus on providing comfort, safety and confidence via a perfectly tailored fit, at a reasonable price.

Vision for the future
Logically, the main source for the success of Damen has been their tailoring, which they have always been able to do because they chose to operate on a small scale. The international range of the company mainly includes neighbouring countries Belgium and Germany, although occasionally expanded to countries further away via mouth-to-mouth or visits to the paddock shop at the Dutch race track for competition, TT circuit in Assen. For many customers, the service of Damen requires a long journey.
However, the company's dream is to make tailoring more accessible to everyone, thus on a bigger scale. To achieve this, Damen would like to bring tailoring to dealers across the country. By working together with third parties / dealers, tailoring should become more accessible to everyone. With this, Damen would also like to optimize their order processing and production line, to reduce the delivery time for their tailored products and allow bigger production numbers.

3.4 Brand Values & Brand Image

To remain loyal to a brand mission and to be able to achieve new goals with regards to the future vision, it is important for Damen to be aware of their brand values and to keep track of their Brand image as seen from the eyes of their customers.

Brand Values
Besides the new shield-shaped logo, Damen has known many slogans to express what they value, ranging from *"Functional motorcycle equipment"* and *"The power of tradition"* to the slogans shown in Figure 3.4.1.

Figure 3.4.1: Slogans used by Damen over the years (Bleijs, 2016), (Groowup Digital Agency, n.d.).

Speed, passion, safety and tailoring are at the core, making it safe to say these are highly important to the brand. However, these 'values'

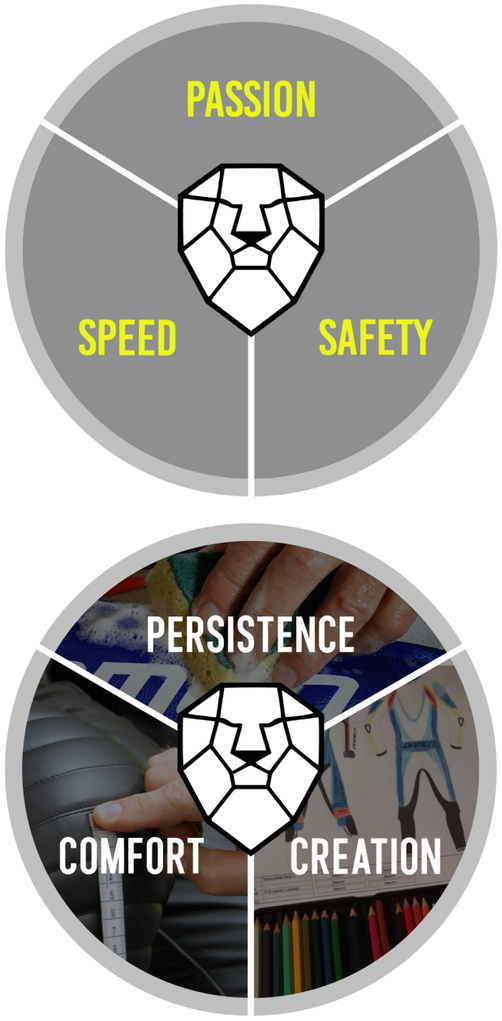


Figure 3.4.2: Core values as expressed through recent slogans (top) and as derived from pursuits (bottom) (Damen Motorkleding, 2020a, n.d.-d).

are quite superficial and obvious, so to get a better understanding of the core of the company, a further analysis was executed.

Further analysis (see Appendix 3) shows the values of: *Creation, Comfort* and *Persistence.*

(Co-)Creation
The team at Damen loves to create unique leather pieces for their customers, which ties in with their traditional methods of working. Creating handmade items and prototypes and executing repairs remains a passion even when faced with the challenges of current import, replace and dispose cultures. The Damen team puts in the effort to take every request seriously and with the exception of few structural, logo and brand rules, they keep a very flexible attitude while designing suits. Often, many iterations of suit designs are made to ensure that every detail is in accordance with the customers' vision. Before sending out the final product or calling the customers to pick up their gear, the Damen team ensures that visible custom elements are exactly as requested.

Comfort
Another highly important value at Damen is that of comfort. Not only within the team, but especially in the clothing they produce. Whether it is race, tour, or pro clothing, providing riders with comfort is at the top of the priority list. In terms of comfort, Damen focuses on many different types including practicality and weather-proofing, but most importantly; freedom of movement and a perfect fit. Customers are always welcome to come back for (size) adjustments, just after purchasing or years later, when their new body measurements ask for a garment update.

Persistence
Even though "the power of tradition" is a slogan that is no longer used, it is still represented in the comprehensive amount of experience the Damen team has gathered by staying persistent with their brand and its mission. To this day, they keep supporting their customers as much as possible. This also includes providing them with maintenance products like leather soaps and greases and instructions on how to maintain their suit and keep the leather flexible, ensuring a long lifetime. Damen goes the extra mile when it comes to maintaining their customers' suits. They offer in-house repairs to ensure a safe re-use of the suit after a crash and they organise dedicated days for free Damen suit cleaning maintenance.

In conclusion, Damen values to provide safety, comfort and quality from start to end, creating unique pieces together with their customers and maintaining the lives of their suits.

Brand Image
To see if Damen is on track with their mission, a brand image analysis was done. Many opinions were collected through reviews, forum posts and mouth-to mouth conversations. These were clustered on re-occurring themes, to find out what customers like and dislike about the company and its products (see Appendix 3).

Looking at the overall image, Damen is known as a quality brand that has great personal attention for their customers. Almost every customer opinion found online is positive and finding overall negative experiences of customers is a serious challenge. An overview of the strengths and weaknesses of Damen's brand image can be found in Figure 3.4.3.

Damen products are experienced to be of high quality and to last for a long time (10+ years) when used frequently and taken care of as advised by the brand. Thanks to the tailored products, no-one feels left out in terms of sizing and customers are pleasantly surprised by the perfect fit Damen products offer, along with highly flexible leather and a lot more freedom of movement than they are used to when wearing clothing of other brands. Besides, Damen offers more personalisation options than other brands, which allows customers to create a one-of-a-kind riding outfit. At a reasonable price, the result of these USP's (Unique Selling Points) is a good experience of value for money.
Besides good products, the company gets many compliments for their vast amount of knowledge and experience in their field, which they combine very well with a personal customer relationship. Visiting the store is always possible, yet Damen works a lot with appointments in busy times, ensuring that every customer obtains the time and attention they need. This approach is clearly a success, as seen from many of the enthusiastic comments about the brand's service and transparent attitude. As remarked by customers, Damen is easier to contact than bigger brands, both before and after purchasing. Motorcycle gear is expensive, so this easy contact adds important value. This way, the customers can always bring their clothing back in for repairs, re-fitting or other issues, allowing them to get the most out of the products. The result of this USP is that the Damen brand image includes a big collection of loyal customers, who have been using Damen gear for decades on end.

The downside to these USP's is that quality and personal attention takes time. Most complaints found in customer experiences have to do with long production times of tailored clothing. A leather suit takes 10-12 weeks to produce, yet the circuit racing season only lasts a few months for most recreational- and especially Dutch good-weather riders.
Though repairs are often a lot faster, the downside experienced by customers is that repairs are quite expensive in comparison to the initial product price.

To maintain this positive brand image, Damen can elaborate on their USP's by continuing to develop unique and personal options for suit tailoring. On the other hand, they can work on improving their production line efficiency, to shorten the production time of their tailored products and make the tailored products more accessible, as Damen envisions (see Confidential Appendix 3).

Damen brand image	
Product quality & Fit	10-12 weeks production time is a long wait
Customer loyalty	Repairs are expensive
Knowledge & experience	
Service, custormer oriented, personal, transparent	
Value for money	
Easy contact compared to big brands	
One of a kind clothing, more personalisation options than other brands	

Figure 3.4.3: Overview of strengths and weaknesses as determined through Damen's brand image.

Takeaways | Chapter 3 – Damen Motorkleding

3.1 Workshop use has reduced significantly due to the scarce amount of skilled workshop employees available. The employees should have enough time to offer quick repairs and express-delivery to professional customers.

3.2 Damen mostly targets professional and semi-professional circuit riders with their "Race" product category, yet the products are also widely used by amateurs on the circuit and public roads.

3.3 Leather race suits are the best advertisement for Damen when they are worn by professionals. Eye-catching innovation can help them stand out in the crowd of many other suit brands and arouse the interest of potential users.

3.4 The mission and vision of Damen are based around the company's tailoring profession, providing comfort, safety and confidence via a perfect fit, at a reasonable price and making tailored suits accessible to more people.

3.5 Damen has an overall good brand image with many appreciation for their vast amount of knowledge and experienced, combined with a personal and attentive customer treatment and relationship. The pitfall of their tailored and traditional methods are the 10 weeks of production time and relatively expensive repairs.

Requirements

3.1 The new slider system must not lead to a growing need for repairs.

3.2 The new system must be suitable for use by professionals, semi-professionals and amateurs.

3.3 The new system must be visually novel and attractive, to catch the interest of potential users.

3.4 a The design must adhere to the mission and vision of Damen.

3.4 b The design must pursue the values of creation, comfort and persistence.

3.5 The new external protection must be implemented in the suit efficiently to prevent high repair costs and long production times.

Wishes

3.5 The new external protection should arouse new life into the brand image of Damen and draw the attention of young riders who are open to trying new innovations.

4. USERS

As becomes clear from the product portfolio, Damen has customers ranging from police to travellers. Since this project focuses on the development of leather race suits, a closer look into the customers of the Race category of Damen gives important insights about the users of leather race suits. This chapter is based on knowledge gathered during user context visits and user interviews (see Appendix 4 and 5).

4.1 Professional users

FIM (Fédération Internationale de Motocyclisme) is a 120 year old organisation founded in Paris and based in Switzerland. "FIM is the supreme and sole international authority empowered to control international motorcycling events organised under its jurisdiction throughout the world (Fédération Internationale de Motocyclisme, n.d.)." The FIM organises more than 150 championships spread over many different motorcycle racing categories including Circuit Racing.

The best known and highest level championships are known under the names of "MotoGP" (Moto Grand Prix) and "WSBK" (World Superbikes). Both of these events have a similar collection of riding classes in circuit racing, with the biggest difference being the performance characteristics of the motorcycle that is used (see Figure 4.1.1).

Figure 4.1.1: Overview of the most popular motorcycle racing championships/classes (Logowik, 2024) (Nguyen, 2017) (Nikon1803, 2020) (VulcanSphere, 2022).

As indicated with their logo in Figure 4.1.1, Damen has sponsored riders in several classes. In each class, multiple types of professionals can be identified:

Persistent professional

Legend

The type with exceptional achievements and extraordinary success, that has been revolutionary for riding style. This often includes winning multiple world championships or setting records. Another characteristic for this group is a long career, in which they show resilience and are recognised by many fans for their skills, contributions and impact on the development of the sport. Examples of legends who are officially honoured in the MotoGP hall of fame are Geoff Duke, Jarno Saarinen, and Kenny Robberts, as mentioned earlier in this report for their contributions. More recent examples include Valentino Rossi and Dani Pedrosa (MotoGP, n.d.-a).

Runner up

Another typical professional rider is the runner-up, who is known for finishing second in the championship, at the end of the racing season. By scoring points consistently in the individual races of the season, they secure second place overall. They often receive recognition for their performance and can be seen as a potential world champion in following seasons.

Rookie

The title rookie is used for riders who are making a debut in a new championship class. Often they are talented, young riders, who take many risks to climb to the top, making them a popular sensation.
Damen gets their talent acquainted with their brand from a young age. The riders need to bring enough capital to the table in order to fund competing in a championship. Riding in a higher class also requires a higher capital, which is why riders and sponsors help each other out. By providing the rider with the products they need to compete and investing some extra (prize) money, the rider can grow in their sport while the sponsor gains good advertisement for their brand. A rider in the top three is the best advertisement, which is why some sponsors are very selective in who they choose to invest in. Damen invests in sponsoring young talent who may become future legends or runner ups. Young riders are working their way up to higher classes, meaning that they are often a rookie every few years and are closely followed by the public and the media.

Besides these three main types, there are many riders who fall somewhere in between.

Champion

For example, a rider who has won one or multiple championships and continues to compete for more world titles in the same class is not a rookie or a runner up, however, they can potentially reach the status of a legend in the future.

A detailed example of what a professional user looks like can be found in Figure 4.1.2.

4.2 Semi-Professional and Amateur

Damen suits are not only used by the professionals. Though they are developed to be safe to wear for competitive purposes, Many semi-professionals and amateurs also use the same levels of protection.

Serious Semi-professional

The semi-professional user can be defined as presented in the persona in Figure 4.2.1. These people usually ride in fully equipped and tailored one-piece suits with airbags, names, logo's and numbers. They often have their own racing team with whom they participate in competitions or endurance races, yet they do not participate in world championships. Their motorcycles are circuit bikes with no headlights, special circuit fairings and livery and other modifications. The semi-professional rides on slicks or wets - special circuit tires without profile (slicks) or with rain profile (wets). They often travel around different countries to ride the big circuits associated with the world championships and for some semi-professionals an occasional elbow down may be part of the skill-package. In other words, these people are very serious about recreative circuit racing and are constantly working on their lap times on different circuits. Some may even turn riding into their job by becoming a trainer.

Ambitious Amateur

The amateur rider often starts out with a road bike and road tires on smaller circuits for their first training sessions, but may quickly move on to participate in training or free training sessions on bigger circuits.

For amateurs (see Figure 4.2.2), often a downgraded version of the competitive suit exists, which can be a combi of jacket and pants instead of a one piece, or include less of the protective elements, such as crash sliders, elbow sliders and airbags. The design of the suit (and the bike fairings) also more often excludes logos, race numbers and names.
However, the amateurs that move from the public road to the circuit are usually very excited to learn the riding technique used by professionals, buying fully equipped suits and trying to get their knees down as early as possible, to feel like they belong in the group of skilled riders. To no surprise, this leads to bad body positioning and user errors around knee sliders quite frequently.
For example, an amateur who is focussed on the cool look of dragging a knee may pushing their knee into the ground rather than gauging their lean angle. In doing so, their knee slider wears out much faster than it is intended to (Bradley, 2016). This can become quite expensive.
Elbow sliders may be worn by amateurs but realistically are not used by this rider type, as the bikes and skills of this user group are often lacking too much to reach this level of cornering.

As mentioned earlier, Damen focuses on the semi-professionals for selling their product, who should thus be considered when developing new products. However, in order to obtain the most valuable input for developments of the race suit, the focus during this research phase needs to be on the professional rider context. These elite riders are the ones that use the suit and its features to their full potential. Therefore, they are the prioritised user for further research.

SERIOUS SEMI-PROFESSIONAL

What my passion for riding entales
I started working at a circuit school to teach beginners while improving my own skills. Later, I managed to assemble a team with whom I could compete in races. I have been hooked at improving my lap times since.

Why I ride in Damen leathers
Damen offers great service for their suits in case of a crash. They offer suits with airbags and are easy to contact when maintenance or repair is required. In combination with the possibility to design your own suit and the perfect fit, they simply offered everything I needed.

How I use my sliders
I have obtained a fair amount of control over my knee and elbow slider use and am well on my way to learn how to interpret the feedback of my sliders. This way, I can use them as a feeler to help me improve my lap times.

Semi-professional | Age - 29 | International circuits

How I use my sliders

Relative lifespan of sliders

Slider replacements

Slider position adjustments

My goals

- [x] Travel round of all international circuits
- [x] Win an endurance race with a team
- [ ] Break personal records of lap times
- [ ] Learn to use sliders for preventing crashes

BMW S 100 RR

999 cc | 210 hp | 303 km/h | 197 kg

Figure 4.2.1: Persona of a semi-professional user (BMW Motorrad, n.d.) (Kumaran, 2018) (Motorsportschool, 2024).

Figure 4.1.2: Realistic/real-life example of a professional user profile (Buis, 2024b) (KTM, 2024) (WorldSBK, 2024a) (Appendix 5).

Figure 4.2.2: Realistic/real-life example of an amateur user (Bazzaz, 2012) (RDW, 2023).

PERSISTENT PROFESSIONAL

What my passion for riding entales
I started riding at a very young age and have been motivated to continue riding since. I am always competing to win and take on the challenge to be the strongest rider in the group.

Why I ride in Damen leathers
I have always been riding with Damen leathers and I am very satisfied with them. The team knows me very well and they always make sure I am comfortable and safe before the race.

How I use my sliders
The knee sliders are the most important, because I use them to determine my lean angle. I sometimes use my elbow sliders to save myself from a crash. My sliders wear out in the same spot mostly and small variations even themselves out. A smooth glide and constant thickness means good feedback.

Champion | Age - 22 | Riding class - WSSP 300

How I use my sliders

Relative lifespan of sliders

Slider replacements

Slider position adjustments

My goals

- [x] Win races and world championships
- [x] Hold records
- [ ] Improve riding skills
- [ ] Transition to new riding class

KTM RC 390 R

373 cc | 43 hp | 190 km/h | 158 kg

AMBITIOUS AMATEUR

What my passion for riding entales
I have always loved activities that include adrenaline and speed. From a young age I have been dreaming of my own motorcycle and learning to ride on circuits. I feel free when riding and it clears my mind.

Why I ride in Damen leathers
I am a tall rider who has always dreamt of wearing a perfectly fitting one-piece suit. Standard sizing is far too short for me, which significantly limits my freedom of movement and causes intense pains. With Damen leathers, I am comfortable the entire day. Their leathers are very flexible, which is perfect for applying track riding technique.

How I use my sliders
My ultimate goal is to learn to get my elbow down, but for now I am focussing on using my knee sliders correctly. I do not have a go-to position for my sliders yet and sometimes switch them around to try and use them up more.

Amateur | Age - 23 | Riding national small circuits

How I use my sliders

Relative lifespan of sliders

Slider replacements

Slider position adjustments

My goals

- [x] Travelling to foreign countries
- [x] Learn kneedown
- [ ] Improve riding skills on circuit
- [ ] Ride (international) large circuits (own a circuitbike)

Suzuki SV 650 S

645 cc | 72 hp | 212 km/h | 195 kg

Takeaways | Chapter 4 – Users

4.1 Different user types who are using leather suits also use their sliders differently.

4.2 The elbow sliders require intense cornering with a sharp lean in the bike and are therefore used only by a small group of riders. This group consists mostly of professionals and few semi-professionals. Whether or not the elbow slider is used much is also a personal preference in riding style.

4.3 Some user-error occurs within the amateur group as a result of cultural status around scraped sliders, causing a need to reposition the sliders frequently or wearing them out too fast. This leads to different user needs and product experiences for this user group.

4.4 Professionals from different riding classes adjust their technique and body positioning to the type of bike and class they ride with. Personal preferences exist around slider use, which should be further analysed (Chapter 9). This emphasises the importance of personalisation in the product.

4.5 Elbow sliders are used mainly by professional riders, but also worn by amateur riders for a feeling of status and belonging. Professional riders have much more advanced technique, which they can also use to save themselves from crashing. This can point to new design focus areas.

Requirements

4.1 The sliders must be suitable for use by professionals and semi-professionals.

4.4 The slider system must be tailored or customisable.

Wishes

4.1 The sliders should be suitable for amateur use.

4.2 Different slider options should be available to choose from, that each fit different user needs and preferences.

4.3 The new slider system should guide amateur users towards correct use of sliders and better riding technique.

5. USER CONTEXT

As the previous chapter brings to light, there are important influences related to the user, that determine how the knee and elbow sliders are used. The context that the user is emerged in plays a big factor in this use. Since the highest requirements for knee and elbow sliders are found in the use context of professional motorcycle racing, the SSP world championship can help point out important design drivers. As indicated by the white Damen logo's in Figure 4.1.1, the WSSP (600) is the highest riding level and professional user context that Damen currently operates in.
Similar to the last chapter, this chapter's insights originated from the user context visits and corresponding interviews shown in Appendix 4 and 5.

5.1 World championship tour

A SSP world championship typically consists of 12 race weekends, spread across the race season, which usually ranges from the end of February until the end of October. Each race weekend is held on a different circuit, in a different country across the world. An example of a championship season calendar is shown in (Figure 5.1.1). In comparison, the SBK and SSP 300 class follow the same calendar, but the 300 class does not attend each race weekend, usually participating in eight out of the twelve rounds (WorldSBK, 2024c).

Riders travel to each circuit for the race weekend, during which they need enough supplies to finish the races. Since Damen does not follow the tour across countries, thorough maintenance needs to wait and the riders rely on a number of spare sliders and spare suits to get through the weekend.

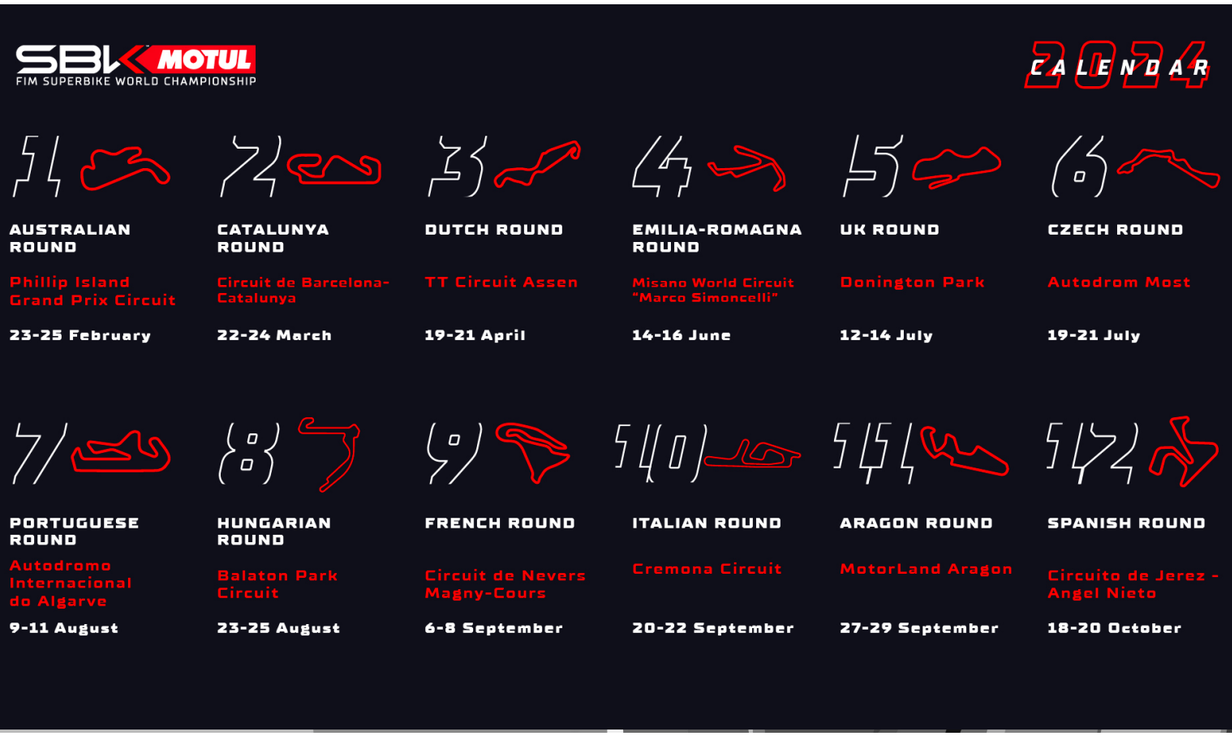
Ever-challenging circuit differences
As the different shapes in Figure 5.1.1 show, the circuits are all unique. They can be distinguished based on a few important characteristics. For example, most circuits are followed in a clockwise direction. This mostly also means that there are more right corners than left, and the sliders on the right half of the suit can thus wear out faster than the left side of the suit. In only few cases, the circuit is followed anti-clockwise, with the left corners and sliders being more dominant.
A second characteristic that differentiates circuits from each other is found in how the ride is executed. Where some circuits are "Fast & Flowing" with high corner speeds and agile and manoeuvrable riding, other circuits require a "Stop & Go" approach, where stability during breaking and powerful acceleration are more important.
Still, Every circuit has a typical collection of curves included, varying from high speed corners and tight slow corners to chicanes (fast alternating lefts and rights) and hairpins (180 degree corners). Each combination is designed specifically for a challenging ride (MotoGP, 2021a).

5.2 Race weekend

Each race weekend is scheduled similarly. An example of a race weekend schedule can be seen in Appendix 6. As illustrated, the classes of the SBK organisation that attend this round take turns each day. The race weekend is always three days for the public, but riders may get familiar with the circuit during a track walk on foot or by bicycle on Thursday.

Friday
Free practice starts on Friday. This practice is used to find the best

Figure 5.1.1: The WSSP season calendar of 2024 (WorldSBK, 2023a).



1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
25	20	16	13	11	10	9	8	7	6	5	4	3	2	1

Table 5.2.1: Scale of points to be awarded based on finishing positions (Fédération Internationale de Motocyclisme, 2024b).

bike setups and tactics for the race. The SSP class has only one round of free practice, in contrast to the three practices of the SBK class. In the afternoon, they ride the Superpole, during which they are qualifying for the starting grid positions. The grid positions are based on who rode the fastest lap within the 40 minutes they are allowed to ride.

Saturday & Sunday
A race weekend in the SSP class includes 2 races where points can be scored. The Saturday and Sunday of the SSP class are scheduled similarly. In the morning, the riders start with a short warm-up round. This session allows riders and teams to make last minute adjustments to their bikes and to get familiar with the conditions of the track and weather conditions. Especially with highly varying weather conditions like in the Netherlands, riders need to make quick decisions and switches between tires for dry vs wet conditions and, for their suit, regular sliders vs rain sliders.
The afternoon is when the actual race starts. On Sunday, starting positions are based on the results of Race 1 from Saturday. The length of this race is defined by a number of laps that falls within the minimum and maximum range of distance to be cleared. For the SSP class, this range lies within 70 and 110 kilometres (Fédération Internationale de Motocyclisme, 2024b), with the length of a circuit varying from 3.5 to 10 kilometres. At the end of the Saturday (Race 1) and Sunday (Race 2), a podium ceremony is held and points are assigned based on finishing positions, see Table 5.2.1.

Details matter
In championships like the SSP, riders are aware of the smallest details. For example, they notice differences in their bike's lean angle, which increases when their sliders wear off on the tarmac. This results in a higher risk of losing traction. Every small detail can help them ride just that bit faster.
On the straights in the circuit, the rider tucks their body in behind the windshield to reach higher speeds, as aerodynamics are a valued subject in the professional riding context. Aerodynamic optimisation is applied by directing the airflow around bike and rider to create downforce, reduce aerodynamic drag and "hide the rider". To achieve this, the shape of the fairings on the bike, the helmet and suit are carefully adjusted (MotoGP, 2021b, 2022), see Figure 5.2.2.

Less significant, but still important is that a slider design not taking into account aerodynamics could create a small disadvantage in airflow during these straights.

At the end of the season, the rider with the most points scored across all races wins the championship.

Figure 5.2.2: Riders tuck themselves behind their windshield for an optimal aerodynamic form during straights (Klein, 2024).

5.3 In between races

Riders are in and out of their race suits a lot in between races. Their weekend includes many more activities that are crucial to ensure good preparation and performance for each race session.
Examples of additional race day activities are technical and strategical meetings with the team, track walks, interviews and press conferences, but also include physical warm-ups and cool-downs, following a planned diet, and rituals for mental preparation. Each rider has a big team that surrounds them and helps them with all of these activities and more, such as checking the wear of the sliders after each session, replacing them if needed and fixing small suit issues to ensure the safety of the rider, so that the rider can fully focus on the racing.

Important design drivers for the professional use context are thus: variations in circuits, slider wear and contact points (see Chapter 10), aerodynamics and easy and quick replacements and repairs.

Takeaways | Chapter 5 – User context

5.1 Professional riders visit different circuits across the world, which require different riding techniques. Most circuits are ridden clockwise, meaning there are more right turns than left turns. Sometimes this is the other way around. For the sliders, this means that for each circuit there may be small differences in wear (locations), and the sliders can wear off unevenly with regards to the left and right sides of the body.

5.2 Because each circuit is in a different country, riders are travelling a lot and need to take enough supplies with them to be able to finish the race weekend. This includes enough replacements for sliders and spare racing suits for when the suit gets damaged.

5.3 During practices and superpoles and in between warm-ups and races, quick strategical decisions are made. Bike parts including wet tires and slicks may be switched and so are regular- and rain sliders. In between riding sessions, replacing sliders should be a smooth operation.

5.4 Professional riders can notice the smallest influences. When the thickness of the slider decreases from wear, the lean angle of their bike increases. Ideally, to stay in control, the slider should remain a constant thickness.

5.5 Aerodynamic optimisation is an important subject in professional motorcycle racing. A slider with an inferior aerodynamic form can negatively affect the speed a rider can reach.

5.6 During a race weekend, riders are too busy to be concerned about checking and fixing up their suit. Their team helps them with these and many other tasks.

Requirements

5.1 a The sliders must be able to last through an entire race regardless of what corner direction is dominant.

5.3 The slider must be easily replaceable by the rider or their team, within 10 seconds.

5.5 The form of the slider system must not cause adverse effects to the aerodynamics of the bike and rider.

Wishes

5.1 b Uneven slider use should not create a difference in slider wear bigger than 10mm within one race.

5.1 c Any variation in contact points with the tarmac should be covered by the slider.

5.2 The slider system should be easy to repair or replace by the riders' team when there is no damage to the surrounding leathers.

5.4 The thickness of the slider should remain as constant as possible.

5.6 The riders' team should be able to replace sliders in between rides without positioning error (the position should align with rider preference).

EXTERNAL PROTECTION

6. COMPETITORS

Naturally, Damen is not the only brand that provides professional riders with leathers. Many competitors include big and small brands, who all create slightly different race suits. Taking note of existing products is important to find areas for new development.

6.1 Suit brands used in different riding classes

To find out what brands are same-level competitors and what brands have become the most popular amongst professional riders, the brands used by riders in the MotoGP and SBK world championships were collected for insight (see Appendix 7).

Overall results show that in MotoGP, riders only wear suits from the biggest companies in the field, including Alpinestars, Dainese, Ixon, and REV'IT! (see Figure 6.1.1). In contrast, many of the smaller brands including Damen appear in WSBK classes (see Figure 6.1.2). This difference can be explained by the investments clothing company's make in popular riders. In MotoGP, sponsoring a rider is much more expensive than in WSBK, hence the domination of the MotoGP classes by major brands.

Another remarkable insight is that brands seem to strategically choose what championship exactly they are sponsoring. For example, big brands like Alpinestars and Ixon seem to purposefully avoid the WSSP 300 class and aim to get as many partnerships with riders in 1000cc classes as possible. Additionally, when looking at REV'IT!, IXS and Spidi, it seems they avoid the Supersport classes altogether and instead are focussing fully on the MotoGP classes they can find partners in, while also accepting some SBK (1000) partnerships. These 4 classes (MotoGP, Moto2, Moto3, World SBK) are the most well known in the media, making them the most appealing for big brands to invest in.

Without doubt, Alpinestars is the biggest player in the field. To no surprise, many riders aspire to be part of the Alpinestars team. To be sponsored by Alpinestars, they need to be performing at the very top.

For Damen, it is relevant to learn from the innovation of the biggest brands that are used by MotoGP riders. The MotoGP class (1000) is seen as the top level of all championships and uses only the best products, that are often highly customised. Thus, it is most relevant to analyse the external protection currently used by riders who are wearing Alpinestars-, Dainese-, Ixon-, and REV'IT! suits.

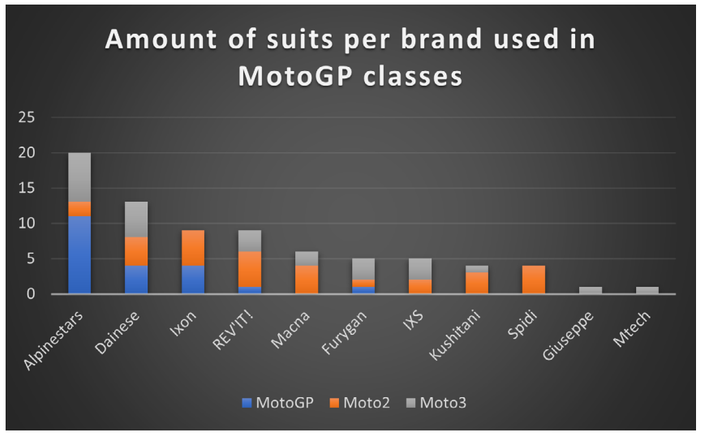


Figure 6.1.1: Overview of suit brands used by riders in each MotoGP class. Numbers derived from (MotoGP, n.d.-b, -c, -d).

Figure 6.1.2: Overview of suit brands used by riders in each WSBK class. Numbers derived from (WorldSBK, 2024b).

Takeaways | Chapter 6 –Competitors

6.1 Alpinestars, Dainese, Ixon and REV'IT! suits are used the most in the highest classes of professional motorcycle racing, including the MotoGP, Moto2, Moto3 and WorldSBK classes. These brands are the most relevant source to learn from when it comes to developing top of the line external protection.

Requirements

6.1a The new slider system must not interfere with patents owned by competitor brands.

Wishes

6.1b The new slider system should approach the level of innovation that is currently used by riders wearing Alpinestars, Dainese, Ixon and REV'IT!

7. EXTERNAL ELEMENTS

For a closer look at the external protection used in suits worn by MotoGP riders, this chapter distinguishes between knee, elbow and shoulder protection, as well as contact point versus crash protection. Though there are many different types available, the examples of the brands worn by the MotoGP riders are specifically selected for being used in the MotoGP. An understanding of the different protection designs was obtained by visiting garment stores and viewing the products op close.

7.1 External knee protection

Crash sliders
Crash sliders implemented in MotoGP suits come in a variety of shapes and materials, but are all positioned atop of the kneecap. The main function of these sliders is to help the rider slide during a crash, minimising the chance of severe injuries. The sliders are positioned in the spots that first touch the ground on impact. Their low resistance helps the rider glide instead of catching grip and making them tumble. Besides this, they also help absorb some of the impact before the internal impact protection takes over.
Dainese uses thermoformed plates, usually made of titanium or aluminium, which are fastened using tiny screws, whilst other brands, like Alpinestars and REV'IT!, use TPU inserts which are stitched into the suit. Alpinestars incorporates a small grip patch into the crash slider on the inside of the knee, which should help riders maintain grip on their tank while hanging off the side of their bike. The other brands, like Ixon, may also add a small grippy patch to the inside of the knee, but these are not integrated in the crash slider.
Damen has not yet designed their own set of sliders and are currently using standard parts for their external protection. As standard options are very limited, this project could help kickstart their own line of external protection.

Active sliders
Attachment and positioning
The knee sliders, also known as knee pucks or pads, are meant to be positioned just under the knee and towards the outside of the leg. With correct riding and body positioning technique, this should be where your leg touches down on the tarmac in a corner.
All suits compared in Figure 7.1.1 use adhesive to stick the puck to a leather and Velcro patch, for positioning the knee slider and keeping it secure. This very simple solution allows small rearrangements by translating and rotating the slider, to ensure that the position of the slider is in line with the riders' tarmac contact area.

Shapes and sizes
Each brand has their own slider design. Some brands offer several alternatives, for example different thicknesses in regular sliders or thicker sliders developed specifically for rainy circumstances. When it rains, riders cannot lean as much. A thicker puck helps them gauge a safer lean angle for the wet circumstances.
Damen uses standard sliders that fit onto their suit nicely. They offer various different options like the BETAC "Dropper", a standard thicker alternative and the Lightech rain slider. This slider is not only thicker, it also has a profile carved into the outer surface that helps drain the water when it slides across the tarmac.

Material Wear
The sliders are made of different plastic composites, which influence their weight, durability and the feeling of the feedback to

Figure 7.1.1: Active knee sliders used by MotoGP and WSBK riders (Alpinestars, n.d.) (Damen Motorkleding, n.d.-f) (DemoneRosso, 2024) (IXON, n.d.-b) (revitsport.com, n.d.-a).

the rider. Softer composites wear down a lot faster, whereas harder composites last longer. This also means that a harder compound has a more consistent thickness, which benefits the rider (Chapter 9). For this reason, many sliders are made of high density polymers, or dual compounds, such as REV'IT!'s TPU and PA6 slider (REV'IT! n.d.). Though some alternative plastics like ABS, Nylon or POM can be found on the market (Bison Track, n.d.) (Hotlantis, n.d.) (Webike, 2022), most brands, including the five brands analysed in this chapter, are using TPU compounds for their pucks (RevZilla, n.d.-a,-b,-c). The succes of this material can be explained by its characteristics (see Chapter 13).

In some sliders, like the Alpinestars GP sliders, there is a hollow structure (see Figure 7.1.2). A reason for adding these hollow structures in the sliders could be to reduce weight. Professional riders like to start every race with the same slider thickness, and thus the same 'measuring device' (Chapter 9). This means that the slider does not need more solid material than the amount that wears off during a single race, after which the sliders are often signed and tossed (Chapter 2.1).
The same concept applies to the Dainese RSS system, which uses a hollow base that attaches to the Velcro, combined with a very thin puck that can be replaced separately (Dainese, n.d.-a).
The Lightech rain slider uses a similar idea to save material, where the top half of the puck (red) detaches from the base puck (black) with screws. The base forms the extra thickness that is needed when it rains, yet the only part that is discarded and replaced is the top half, which is worn down towards the base. This concept however does not save weight the way Alpinestars and Dainese do.

Knee slider properties - Benefits

- Harder compounds have a more consistent thickness and thus form a more stable device to gauge lean angle. The difference in wear between the left and right slider will also be smaller with harder compounds. Softer compounds slide more smoothly, giving better feedback to the rider.
- Velcro attachments allow the rider to position the sliders in their preferred position, and to switch between different brands and versions of sliders like rain sliders, which help riders gauge less sharp lean angles.
- Hollow sliders reduce weight during a race. They also reduce the amount of plastic wasted after a race, when the sliders are replaced.

Knee slider properties - Downsides

- Velcro gets weak overtime and the slider may fall off when it bumps into tarmac edges (McLaren, 2010). Some sliders do not stick because there are too many folds in the leather suit (RevZilla, n.d.-b) (Appendix 5) (Chapter 10).
- In contrast, some Velcro sticks so hard that it requires screwdrivers or plastic 'knifes' to pull the slider off with great force (Chapter 11).
- Some sliders wear down faster than others, waiting too long to replace can cause damage to the suit.
- Hollow slider can be worn less far down and has short lifespan.

7.2 External elbow protection

With the elbow consisting of a smaller surface to protect, integrating protection similar to that on the knee has revealed to be quite a challenge. Many concepts have been tested by the first MotoGP riders to drag their elbows and quite a few different concepts have maintained their spot in the championship.

Crash sliders
On the knee, crash sliders were already integrated close to the active sliders. On the small surface of the elbow, it makes more sense to integrate the crash slider with the active slider into one neat solution. Whilst the two slider types now integrated into one solution brands, there are still similar differences in shapes and materials. Dainese is still the only brand that integrates metal plates on the elbow, and the other brands still use TPU. It seems as though REV'IT! has chosen to completely integrate the two sliders into one, by expanding the shape of the active slider slightly, to function as a crash slider.

Active sliders
Attachment and positioning
In case of the elbow, it seems the adjustable Velcro slider did not make it through the last years of development. Though Ixon still offers Velcro elbow sliders on their standard suits, all brands have implemented a pre-positioned slider into their MotoGP suits, which is not adjustable after attachment (see Figure 7.2.1). A reason for this permanent solution could be that the surface area of an elbow slider is too small for it to stay in place firm enough at the high speeds reached in the MotoGP.
Similarly to the crash sliders on the knees and elbows, all brands except Dainese use a TPU base that is sewn onto (Ixon, Alpinestars, Damen) or into (REV'IT!) the outside layer of leather for the elbow sliders. A replaceable puck is secured into these bases using tiny screws, with Ixon, REV'IT! and Damen using two screws and Alpinestars using only one.
Dainese once again has come up with a unique system, where the slider is rotated and clicked into a slot of the base, which sits underneath the leather.

Alpinestars has added extra features to provide their top few riders with the elbow protection they need. Two additional elements distinguish the elbow protection of these top riders from others:

1. A small aluminium patch is added on top of the plastic active slider. This helps increase the longevity of the slider, so that it can last through the entire race.
2. A clear patch is added to protect the arm of the rider when they use their elbow in an advanced technique, to save themselves from crashing (Patterson, 2018).

Elbow slider properties - Benefits

- A benefit of sewing the elbow slider on top of the leather is that if needed, it can be taken off and repositioned in case it does not align with the riders' elbow contact point.

Figure 7.1.2: Different shapes and sizes of active knee sliders used in MotoGP and WSBK (ABBIGLIAMENTO MOTO, n.d.) (Amazon, 2023) (Dainese, n.d.-a) (IXON, n.d.-b) (revitsport.com, n.d.-d) (RevZilla, n.d.-a,-b,-c) (Shopena.com, n.d.) (Sportbike Track Gear, n.d.).

Figure 7.2.1: Different elbow sliders systems used by professional riders in MotoGP and WSBK (Acosta, 2024a) (Martin, 2021) (motogp.com, 2024) (Patterson, 2018) (revitsport.com, n.d.-c) (The Grinning Dingo, n.d.) (tradeinn, n.d.).

- A benefit of sewing the slider into the leather is a smoother transition from the leather into the protector, which minimises the risk of the protector catching onto tarmac edges (MotoGP, 2015).

Elbow slider properties - Downsides

- Screws wear down together with the plastic, after which the slider cannot be removed from the base.
- Elbow sliders are not adjustable unless the base is detached from the suit and repositioned. The initial position is not perfect for every rider which can cause damage to the suit. At the wrong angle of attack, the slider will not last long enough.

7.3 External shoulder protection

Crash sliders

The crash sliders on the shoulder are mostly similar to the ones used on the knees. Whilst the general materials en styles of design remain the same as with the knee and elbow protection, there are a few different approaches between the brands.

Alpinestars and Dainese produce new shapes specifically for the shoulders, whilst REV'IT! and Ixon seem to be using the same crash sliders on the knees and shoulders.

Damen uses a standard part made of TPU with a small aluminium plate, which is a more flexible alternative to the plates Dainese uses. In this case, Alpinestars is the only brand that sews the shoulder slider on top of the leather.

Since dainese uses tiny screws to attach the protector and sells separate replacement sets, the brand's users are getting an opportunity to replace the metal plates on their own (Dainese, n.d.-b). The same goes for the knee slider plates. Dainese's reason for using metal plates is that the material can dissipate the impact forces towards a bigger area of the internal protector, which then does the job of absorbing the impact (DemoneRosso, 2023b).

Figure 7.3.1: Different crash sliders integrated on the shoulder of suits used in MotoGP and WSBK (Acosta, 2024a) (Damen Motorkleding, 2020b) (IXON, n.d.-a) (Motociclismo, n.d.) (revitsport.com, n.d.-b).

Takeaways | Chapter 7 – External Elements

(See also benefits & Downsides)

7.1 Nearly all existing active knee sliders use adhesive to bond them to a Velcro patch, which makes the plastic of the pucks hard to recycle.

7.2 Material characteristics lead to important trade-offs in the feedback and durability of an active slider.

7.3 Crash sliders are often integrated closely with the active sliders.

7.4 Some metals like aluminium are safe to use in sliders, as aluminum does not leave sparks behind when dragged across the tarmac.

7.5 Active sliders attached using screws get stuck to their base plate when the screws wear down simultaneously with the plastic of the active slider.

7.6 Knee sliders attached with Velcro can get caught on bumps or drains in the circuit. Sometimes a weak hold of the Velcro causes riders to lose their slider. Without a gauging device for their lean angle, riders cannot push limits to ride fast (Chapter 8), resulting in a more than significant disadvantage and risks for injury.

Requirements

7.1 The puck of the active slider must fully consist of a single material.

7.4 Metals used in (active) sliders must be spark-free when in contact with the tarmac.

7.5 The slider must not get stuck to its base as a result of normal slider wear.

7.6 The slider system must be minimalistic and relatively simple, to ensure smooth and safe integration.

Wishes

7.3 The implementation of crash sliders should be possible in combination with the new concept for active sliders.

7.6 The slider system should not be subjective to material ageing or unreliability which can cause a weak hold of the puck.

5. THE IMPORTANCE OF SLIDERS

Active sliders have the main purpose of preventing non-incidental road rash while riders use their knee as a guide to feel how far they are leaning into the turn (Gilbert, 2019). But why are riders gauging their lean angle in the first place, and why do they use their knees and elbows to do so?

First but foremost, the bike is a two wheeled vehicle of which the balance needs to be controlled constantly. The position in which the bike is in a balanced state varies depending on the forces that are acting on it (Bargy, n.d.-b):

When a rider is on a motorcycle, the forces act on the contact patches of the tires with the tarmac and on the combined centre of gravity of the bike and the rider. In Figure 8.1C, the latter is resembled by the orange dot.
Let assume that a rider with constant mass remains in the middle of their seat. When riding in a straight line, the gravitational force acts vertically above the contact patch. The bike is thus balanced in the upright position.

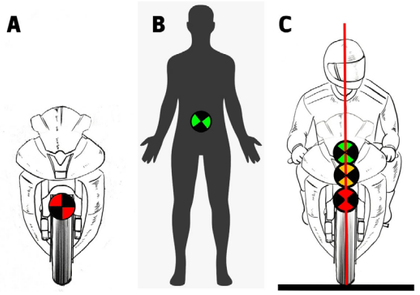


Figure 8.1: Combined centre of gravity of bike and rider (Bargy, n.d.-d).

When the rider slightly steers the handlebar to the left purposefully, a force of inertia starts to pull at the centre of gravity towards the righthand side. The vertical distance between the centre of gravity and the contact patch of the tire now form a moment arm for the inertia, which causes the bike to exit the balanced state as it tips over towards the right. This is called *counter steering*, where the rider needs to steer left to initiate turning right and vice versa. After counter steering to start the leaning motion in the bike, the rider can change the steering direction to the right. As the motorcycle falls further to the right, the lean angle creates a horizontal moment arm between the centre of gravity and the tire contact patch. This way, the gravitational force creates a moment that counteracts the moment caused by the inertia. Depending on the corner radius, speed and centre of gravity, the bike stops tilting at a certain lean angle, where equilibrium of the forces is reached and the balance of the bike is restored.

The inertia increases with higher speeds and with a smaller corner radius (see Figure 8.2). With increasing speed and inertia, the bike thus needs to lean more to stay balanced and keep cornering. Consequently, this means that when the rider increases his speed at the end of a corner, this automatically causes increased inertia, which in turn pulls the bike and rider back up towards upright balance.

This balancing game continues as long as the rider has enough *ground clearance* and *tire tread* left to lean (Bargy, n.d.-d). In fact,

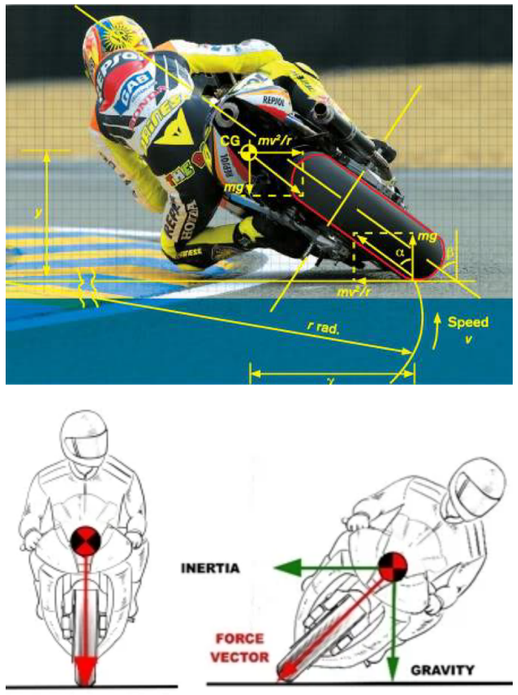


Figure 8.2: Moment of inertia acting on a turning motorcyclist (Pvs, 2021) (Bargy, n.d.-d).

tires have been developed to the extent that it is mostly these two limits of the motorcycle that have led to the evolution of body positioning over time. A long time ago, tires lost traction long before other limits were reached, but development of the tires has resulted in so much grip, that riders encountered new limits (Bargy, n.d.-c):

1. Ground clearance is the distance between the tarmac and the chassis (or hard parts) of the motorcycle. When there is no ground clearance left, exhausts, fairings, or foot pegs are scraping over the ground.
2. The tread of the tire is the area of the tire that makes contact with the tarmac. Motorcycle tires are not infinitely rounded, which means that when there is enough ground clearance left, the edge of the tire can be reached. The shoulder of the tread is the edge of the tire (see Figure 8.3). When the bike leans too much, the shoulder of the tread is reached, causing the contact patch area to decrease. This smaller contact area can no longer support the inertia that acts on the contact patch. As a result, the tire loses traction and the rider risks a crash.

In both cases, the rider can not go through the corner faster, since the bike can not lean more to reach balance at a higher speed. This is where body positioning comes into play.

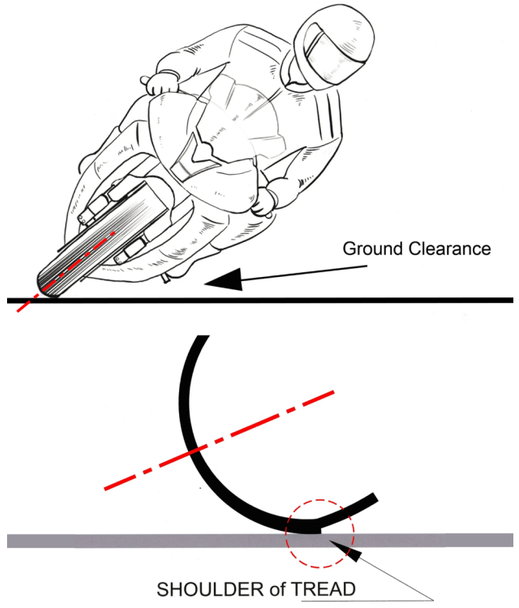


Figure 8.3: The visualised defenition of ground clearance and tire tread (Bargy, n.d.-d).

8.1 Body positioning physics

If a motorcycle is moving in a straight line, the combined centre of gravity is always located directly above the contact patch of the tires. In addition, the combined centre of gravity is always located in between the centre of gravity of the rider and the bike. From the perspective of the combined centre of gravity, this means that when the rider moves to the right edge of his seat and 'hangs off' his bike (action), the bike moves in the opposite direction, which is to the left (reaction).

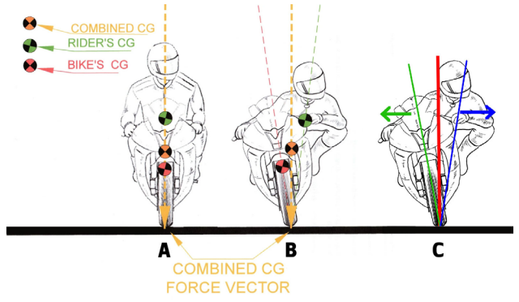


Figure 8.1.1: The effect of body positioning on the centre points of gravity (Bargy, n.d.-d).

If the rider now takes the same corner in which he reached the limits before, and he does so at the same speed, he starts the corner with a 'negative lean angle' (see Figure 8.1.1). Since the bike still needs to displace the same amount as before to reach cornering balance, the 'negative lean angle' the rider started with is now the amount of ground clearance he has obtained by moving his body to the inside of the curve. This means that the rider can now corner at a higher speed before he reaches the limit of ground clearance or tire tread (Figure 8.1.2).

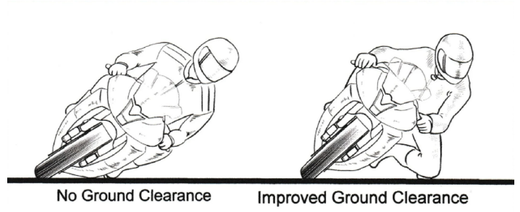


Figure 8.1.2: Improved ground clearance as a result of body positioning (Bargy, n.d.-a).

8.2 Complimenting use of body positioning

In professinoal motorcycle racing, riders are forced to apply body positioning techniques as a result of fast riding (Bargy, n.d.-a). The competition bikes are built to ensure ground clearance even past the shoulder tread. The result is that when a professional takes a corner too fast, their bike needs to lean so much that the shoulder of the tread is reached and the rider loses traction and risks a crash.

These facts explain why riders, who were already hanging close to the ground, started using their knee to gauge how far their bike is leaning. In other words, it is not necessary to scrape the knee over the ground, however, it can be a very useful measuring device when a rider wants to push the limits. Using their knees, and with increased tire gip in recent years also their elbows, riders try to estimate how far they are from reaching the edge of their tires and slipping.
Still, the limits are tested and reached every now and then. Through spending a lot of time getting a feeling for their tires through their knees and elbows, elite riders have started to learn defying the laws of physics, by using their knees or elbows to correct or control the slipping of tires, when the maximum inertia that can be held by the traction of the tires has already been exceeded.

This underlines the importance of active sliders, as without these sliders, riders can not apply this risk estimation and lean angle gauging to feel how much faster they can go through the corners.

8.3 Crashes

In professional motorcycle racing, riders are thus constantly pushing the limits of the bikes to be the fastest around the corner, making crashes inevitable. In one season, many crashes occur. Each year, a report is released of the amounts of crashes in each riding class and by what riders on which circuit. An overview of crash numbers per class is given in Figure 8.3.1, to sketch a clear picture of the big scale that summarises one season of crashes in the MotoGP versus the WSBK. These numbers come down to roughly 2-6 crashes per race.

As reviewed by Bedolla et al. (2016), there are four types of motorcycle crashes in motorcycle racing, named Highside, Lowside, Topside and Collision. These are similar to the types of crashes that occur in public roads (Petit et al., 2020). Each of these crashes has a different cause (see Figure 8.3.2) and different effects and each type has specific frequently occurring injuries as a result.

The most occurring crashes in MotoGP races are lowsiders, which occur when the rider loses traction of the front or rear wheel during a turn. The rider falls to the inside and continues to either slide or tumble in a straight line that is tangent to the point on the curve where they fell. An example of an injury associated with a lowsider crash is a thumb sprain.
The second most frequently occurring type are highsiders, which are often a result of riders oversteering to try and prevent a lowsider.

When the rider loses traction and tries to correct it, a sudden regain of traction on the rear tire causes a violent flip of the motorcycle, which suddenly stands back up a little. This catapults the rider off towards the outside of the turn, resulting in higher impacts and more significant injuries, like clavicle fractures, acromioclavicular separations and concussions.
In topside crashes, the rider is propelled over the front end of the motorcycle, which also results in higher impacts and more serious injuries than the lowside crash type, such as a vertebral body fracture and a metacarpal fracture (Bedolla et al.,2016).

As mentioned earlier, crash sliders (and active sliders) contribute to preventing serious injuries. They achieve this in two different ways:

1. Absorbing impact when the rider hits the ground, or during collision with motorcycles and other riders. Spreading the impact across a wider area when passing it onto the internal protection in the suit.
2. Providing low resistance between the slider and the tarmac upon impact, which is more likely to result in a slide rather than a tumble.

During a crash, it is important that sliders are integrated well with the leathers, so as not to catch onto parts of the motorcycle, kerbs or other bumps.

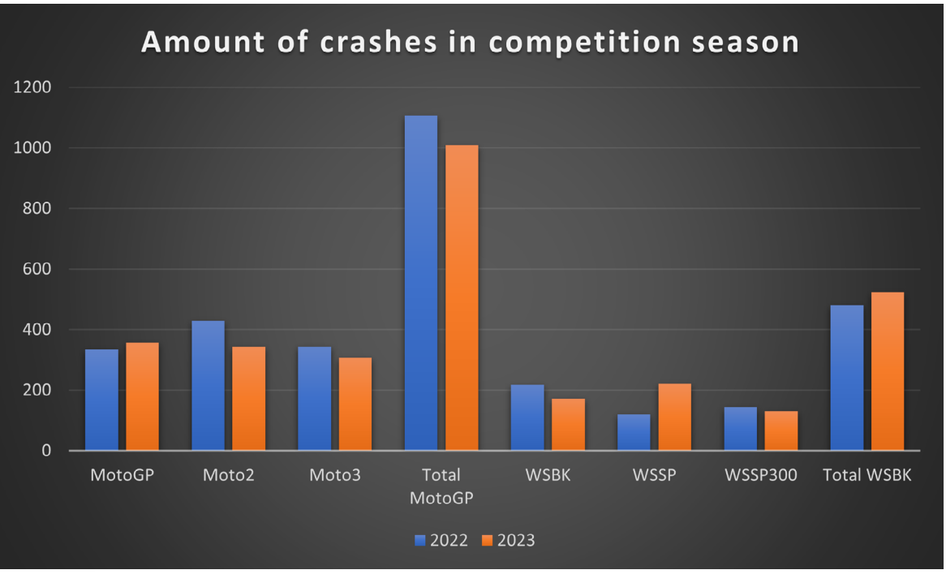
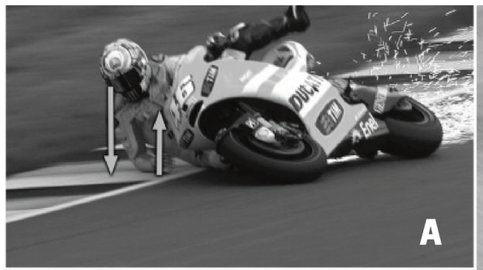


Figure 8.3.1: Amount of crashes per riding class in season 2022 and 2023, for MotoGP and WSBK. Numbers collected from (GPOne, 2024), (motogp.com, 2022b), (WorldSBK, 2022b) and (WorldSBK, 2023b).

Figure 8.3.2: Typical types of crashes in motorcycle racing (Bedolla et al., 2016).



A - Lowside
(Rider falls to the lowside of the lean angle)

B - Highside
(Rider falls to the highside of the lean angle)

C - Topside
(Rider flies over the handlebars)

Takeaways | Chapter 8 – The importance of sliders

8.1 Sliders help elite motorcycle riders transform their knees and elbows into a sixth sense for lean angle and risk measurement and are highly important for the rider to perform. Riders have obtained this skill from experience over a long period of time.

8.2 The sliders are positioned in locations that often are the first to touch down on impact after a crash.

8.3 Active sliders contribute to helping the rider slide during a crash, which helps reduce injury significancy. They also protect the rider when they try to save themselves from crashing and pushing the bike and themselves back up from the tarmac with high force (Bradley, 2016).

Requirements

8.2 a The sliders must exclude small edges and corner geometry that can get caught during a crash.

8.2 b The sliders must be able to transfer impact safely to the internal protection in the suit.

8.3 The active sliders must slide across the tarmac smoothly both during the ride and during a crash.

Wishes

8.1 A new concept for active sliders should not be too radically novel.

9. USER PREFERENCES

Three professional riders were asked to fill in a questionnaire about their preferences in terms of slider characteristics (see Appendix 8). The same riders were interviewed with open questions to obtain a better understanding of the questionnaire results and overall product needs for both knee and elbow sliders. Questionnaire results are visualised in Figure 9.1.

As can be seen from the unity in the rankings and as confirmed through the interviews (Appendix 5), all riders strongly agree that comfort is the most important product characteristic in motorcycle racing, no matter what part of the leather suit. Any small discomfort is distracting the rider from the race, which is why the suit needs to be a perfect fit and added protection should not take away from its comfort.
For other characteristics, preferences differ more between riders and between knee and elbow sliders. The class that the rider is in and their riding style are examples of factors that influence the riders' needs and preferences. For example, riders in higher, faster classes are more keen to value weight and aerodynamic optimisation above functionality and even safety. When asked if they are really willing to compensate safety for weight optimisation, it becomes clear that the rider is not worried about safety, as they trust the people who provide them with gear to keep them safe.

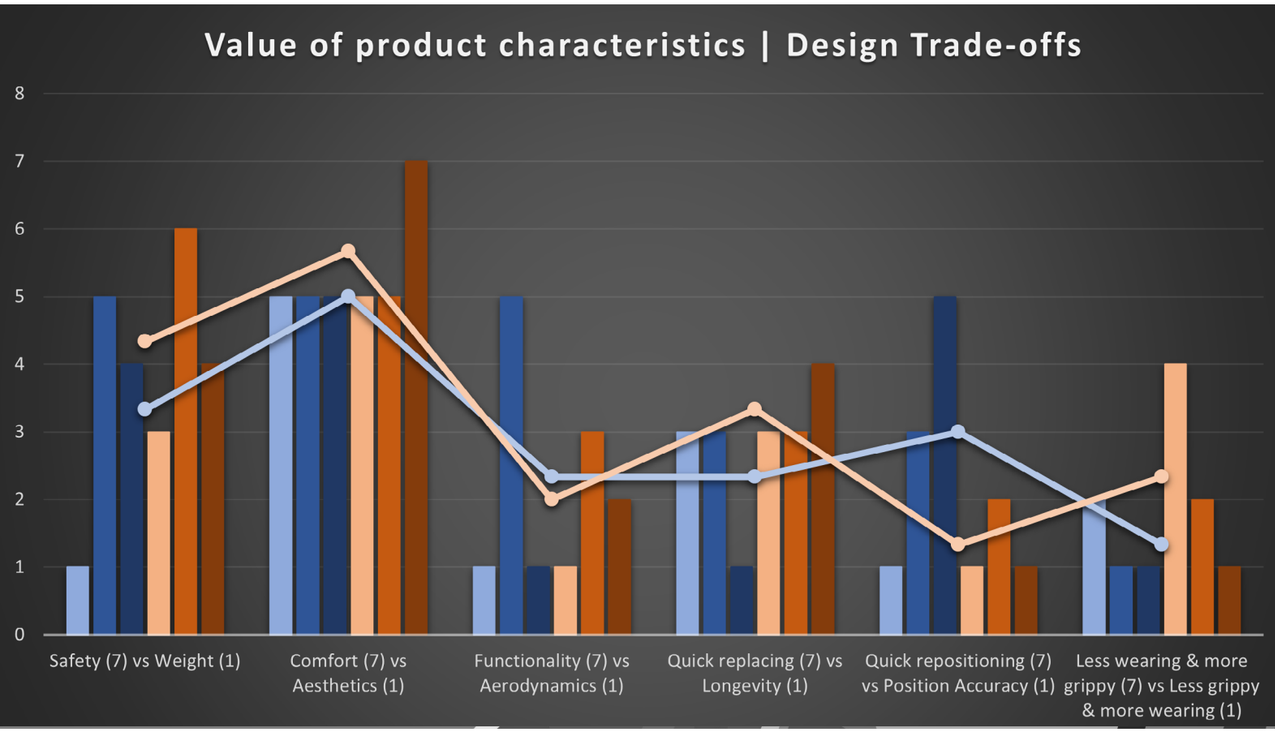
Besides preferences in characteristics, riders often also have a favourite suit within their collection of spares. The suits can feel slightly different, especially when one is worn more often than the other. This preference is important to consider, as for example, an elbow slider with worn out screws (see Chapter 11) cannot always be replaced in time. The consequence is that the rider needs to wear another suit in the next session. To prevent this issue, Damen advises the riders to wear all of the suits and take turns. Still, a switch between suits should not be caused by the irreplaceability of a slider.

In general, the current knee slider is rated lower than the elbow slider, however, the position of the elbow slider is rated lower than that of the knee slider. This can be explained by the difference of attachment methods between the elbow and knee slider and supports that a universal position for the sliders may not be ideal. These ratings are further supported by Chapter 10 and 11.
All of the riders agree that the knee slider is the most important, because the knee is the first to touch the ground and forms the most important guide in measuring lean angle.

To measure lean angle, riders need a puck with a thickness that matches their body position. Some riders need a thick puck to touch the knee down at a maximum lean angle of the motorcycle, while others need a thinner puck to feel how far they are leaning. This thickness preference is thus very personal, yet all riders agree that starting every session with a fresh slider is ideal, as they can notice their lean angle increasing as the slider wears down, increasing risk.

Riders report that the elbow always hits in the same spot. For the knee there can be minimal variation. (They pull their knee back up after touchdown when needed.) However, the riders report that minimal variation is evened out on the puck, which they therefore place in the same spot every time they go for a ride.
This suggests that at the least for professional riders, a single slider position is sufficient when the right location is ensured. Still, there is personal preference and some riders may choose to adjust the slider position, for example to fit their riding style for the specific circuit they are riding (Chapter 5). Thus, it is interesting to research if it would be beneficial and possible to integrate a tailor made slider (Chapter 10).

Figure 9.1: Visual overview of rider questionnaire results. Numbers collected from questionnaires (Appendix 8).



Takeaways | Chapter 9 – User preferences

9.1 Comfort is the number one characteristic that riders value in their race suit.

9.2 The knee is the most important guide to measure lean angle.

9.3 There are several preferences regarding the thickness of the slider, such as personal preference in relation to the rider's body position and bike type, weather type (affects the maxi. lean angle) and the preference of starting each race with a new slider to start with the same thickness for a constant and reliable measuring device. In an ideal situation, the slider should not wear down at all.

9.4 The championship class which the rider is in can also influence the rider's preferences regarding weight, aerodynamics and functionality.

9.5 Most riders' contact points do not change between races. They use the same spot for their slider every race, which suggests that a single possible slider position for one rider can be sufficient.

9.6 Riders have a preference for a slider that provides a smooth glide and feedback, even if this means that the slider wears down faster. Sliders wear down faster on new tarmac, which means that slider durability may vary between different circuits.

Requirements

9.1 The slider system must not take away any comfort of the suit or cause any type of new discomfort.

9.3 The puck must be optimised regarding material use to prevent high amounts of plastic waste after each race, but durable enough to last an entire race on new/rough tarmac.

Wishes

9.4 The new slider system should be more aerodynamically improved with regards to the existing system.

10. CONTACT POINT INFLUENCES

To tailor the position of the slider, it is important to know what variables are influencing the position on the knees and elbows where riders touch the tarmac during a corner. These positions are referred to as contact points. A study was conducted to find out if tailoring the position of a slider could be possible and to gain insight into the influence of anthropometry and body positioning on active tarmac contact points.

The study is aimed at finding answers to the research questions as shown in Figure 10.1. These questions can be summarised into the following hypothesis:

H0: A tailored solution is needed in leather motorcycle suits, for accurate knee and elbow slider puck positioning.

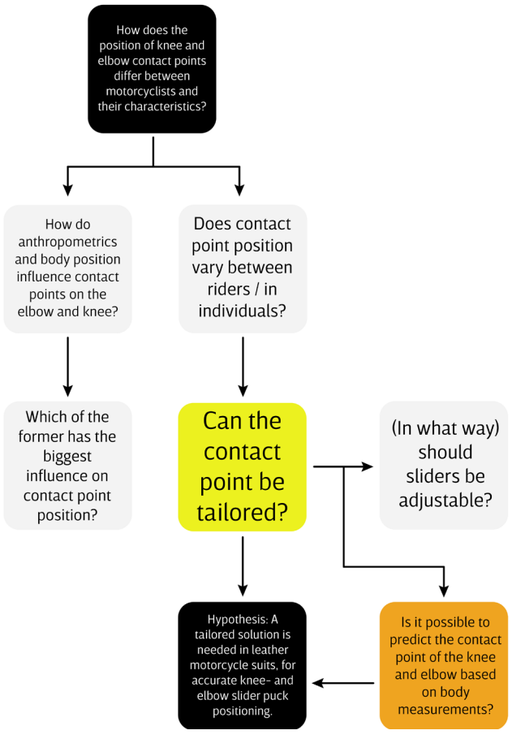


Figure 10.1: How multiple research relate to the hypothesis of the study.

10.1 Research Method

To answer these questions, the research method was carefully determined after various tests (see Appendix 9).
To prepare the execution of the study, several steps were taken to ensure safe participation for human subjects (see Appendix 10-16). Research ethics on several aspects including physical and digital safety and risk management have been carefully evaluated. Checks by professionals confirm that minimal risk has been ensured for participants of this study.

Setup
The setup of the research (Figure 10.1.1) uses a full body scanning assembly with a demo motorcycle (meaning it has been emptied of electrical and mechanical components). As can be seen from Appendix 10 and 11, a stand was built from aluminium profiles used in mechanical engineering, to ensure the demo bike is standing upright and is stable enough for the participants of the study to perform their tasks, including hanging off the side of the motorcycle like they are used to when they ride through corners at high speeds. As explained by Chapter 8 and considered in Appendix 9, the bike and the rider are in a balanced state during a race. Hanging off the side of a bike that stands still and upright might seem less representative than tilting the static bike, however, without inertia on the rider, tilting the bike only requires the participant to carry a bigger portion of their body weight on their own. For this reason, the motorcycle is set up vertically during the study.
To help with the lack of inertia during this static representation of taking a corner, the full body scanning assembly was used for scanning the riders, as it only takes a fraction of a second to capture the 3D image. This means that riders do not need to hang onto the bike for longer than a few seconds, allowing them to maintain their body positioning technique.

Figure 10.1.1: Setup of the research.

Participants
Professional circuit racers with custom Damen suits were asked to participate in this research. Participants were recruited for having a custom suit, as ill-fitting suits can strongly affect research results (see Figure 10.1.2). Two professional riders were able to attend the study.

Figure 10.1.2: Ill-fitting standard size suit resulting in contact point aberrancy (suit protection does not align with joints in body and therefore the suit does not accurately represent where the rider touches the tarmac) (De Zilveren Naald, 2021).

Execution
Several pilots were conducted to test multiple research aspects (see Appendix 9):

- The motorcycle and the rider are bigger than the capturing range of the scanner. During pilots, optimal positions of the motorcycle for maximum capturing range of each body position were determined and marked so that the motorcycle could quickly be re-positioned in between scans.
- The scanner can have a hard time scanning shiny and dark materials. Several objects like helmets, the motorcycle itself and polyester baselayer (undergarment) suits were tested during the pilot to ensure riders could be captured sufficiently.
- A hand scanning pilot was done to get familiar with the device before scanning the missing parts of the motorcycle, which fell outside of the range of the full body scanner.

Participants were asked to bring their helmet, race suit, boots and baselayer. They were asked to get dressed in these items and to take place in the 3D-scanning assembly on the demo bike. They were asked to take on a tucked position, followed by a position they would take on in a left corner and a right corner. Lastly, they were asked to stand in the scanner wearing only their baselayer and standing straight while taking on a relaxed posture (Figure 10.1.3).

After scanning with participants, the collection was completed with the handheld scanner, which was used to obtain a detailed scan of the entire motorcycle without rider.

Processing
After all scans were collected, the frame that kept the bike upright was removed from the detailed hand-scan. The scans of the riders were then aligned with the scan of the motorcycle to complete the missing areas of the full body scans and obtain a full image of bike and rider (Figure 10.1.4).

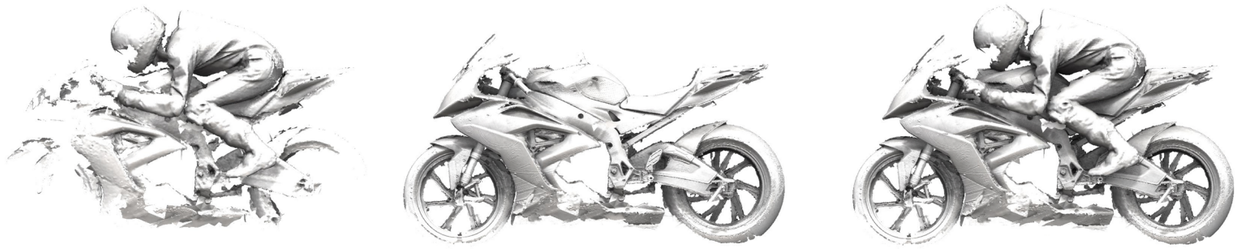


Figure 10.1.4: Combining 3D-scans of rider (full body scanner) and bike (hand-scanner) to obtain full 3D image of rider and bike.

Figure 10.1.3: Research execution.

10.2 Rider anthropometrics (Results Part 1)

Using the full body scans of the participants in their baselayer, the body proportions of the riders were compared to determine if and what influence they could have on their contact points with the tarmac. A visual comparison in Figure 10.2.1 demonstrates the variation in body proportions.

Results show that both participants share similar leg lengths with a small deviation in upper/lower leg proportion, where P1 has the slightly longer lower leg. The most significant difference is located at the lower back, which is taller in P1 (Participant 1). P3 has a shorter lower back, which forms the origin of the height difference. When approached from the top down, both participants have similar head-to-shoulder distances. This means that P3's slightly taller upper back is the area that partially compensates for the shorter lower back. As a result, the final deviation of stature is smaller than that of the lower back heights.
Lastly, a small difference can be found in the arms, where P1 has slightly longer upper arms and shorter lower arms and vice versa.
The scans of both riders in the tucked position were aligned to see how these differences in body proportions could result in different body positioning on the motorcycle. The deviations from Figure 10.2.1 are evident in Figure 10.2.2, where the shoulder and upper arm of P1 are slightly forward in comparison to P3. This can be explained by the longer lower back and shorter lower arm of P1. The longer upper arm of P1 shows in the slightly lower position of the elbow of P1.
Though the foot positions are different, it seems safe to assume that with similar foot positions, the knee of P1 is still situated slightly higher than that of P3, who has the slightly shorter lower leg and longer upper leg. This longer upper leg shows in the position of P3's knee, which is slightly forward from P1's knee.

These results thus show that differences in body proportions result in a difference in body positioning. Consequently, when hanging off the motorcycle, body proportions can thus contribute to change the angles of attack of the elbow and knee towards the tarmac.

The riders who participated in this study share only minimal differences in body proportions, and are reasonably similar in height. Therefore, it is assumed they provide a sufficiently stable base for researching the influence of deliberate body positioning, which concerns range of motion and technique or personal style, which evidently looks different between riders (see Figure 10.2.3).

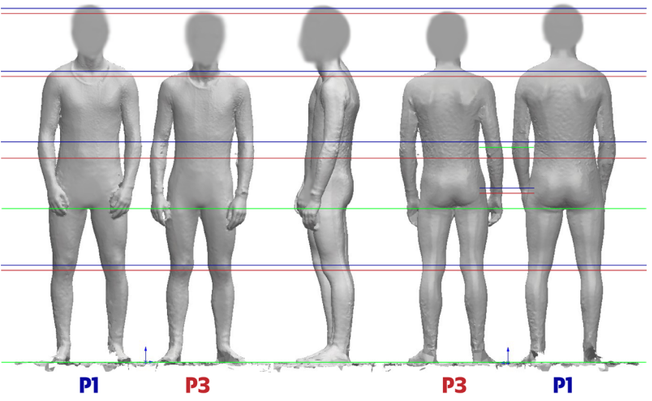


Figure 10.2.1: Visual comparison of body proportions between the participants.

Figure 10.2.2: Comparison of body positioning on a motorcycle as a result of body proportions (Blue: P1, Red: P3).

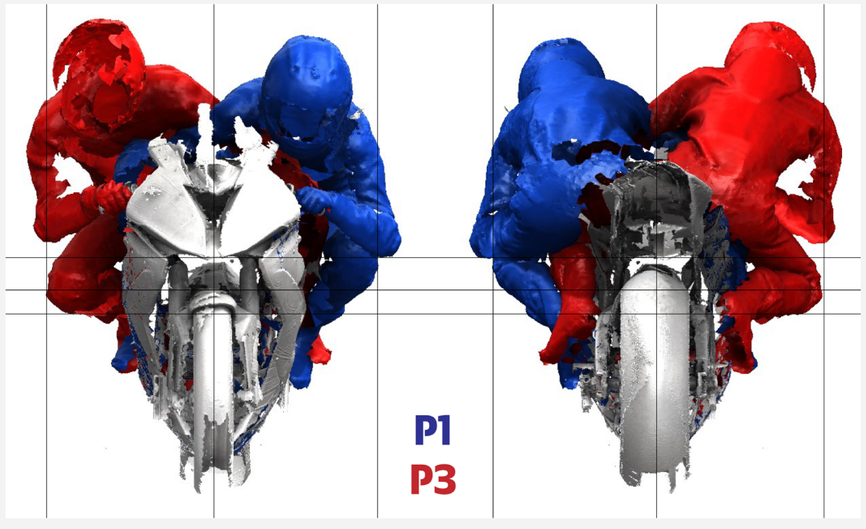


Figure 10.2.3: Visible differences between riders' cornering positions.

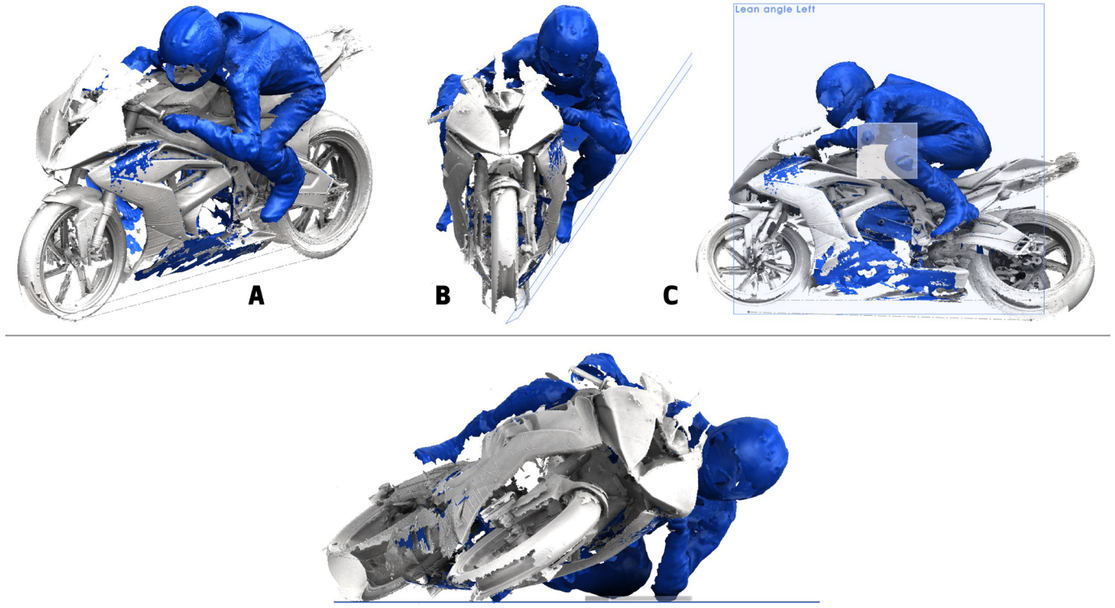


Figure 10.3.1: Processing of scans to determine contact points and lean angle.

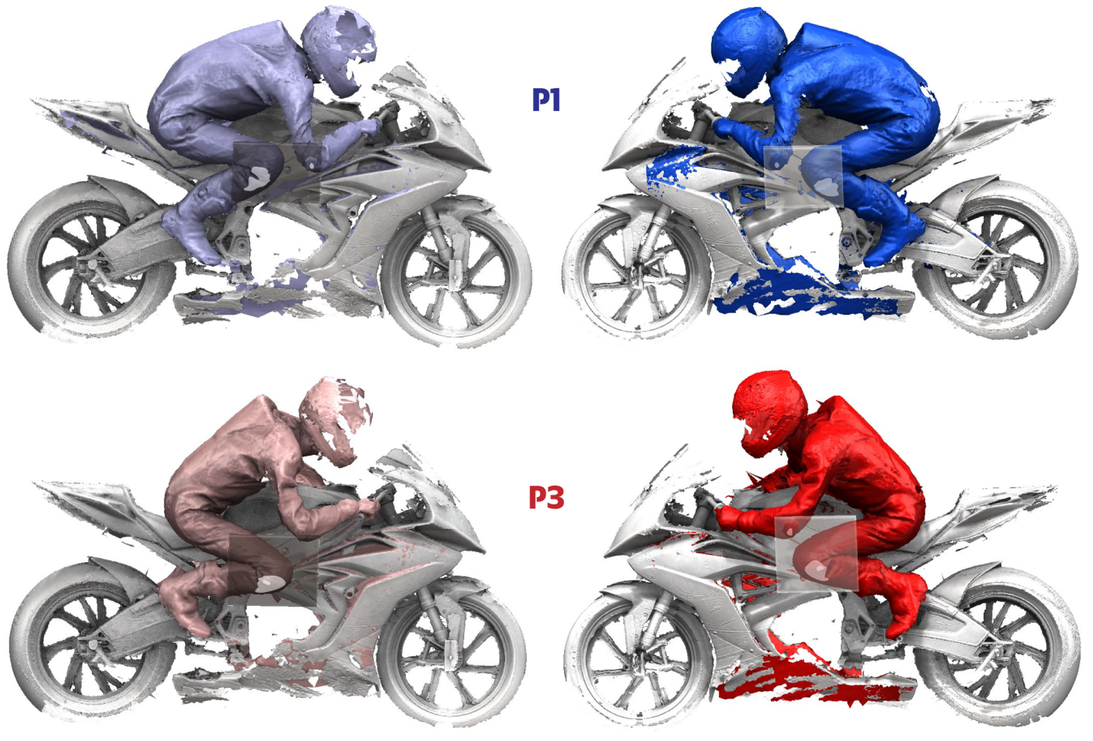


Figure 10.3.2: Contact points of left and right turns marked on the scans of the participants.

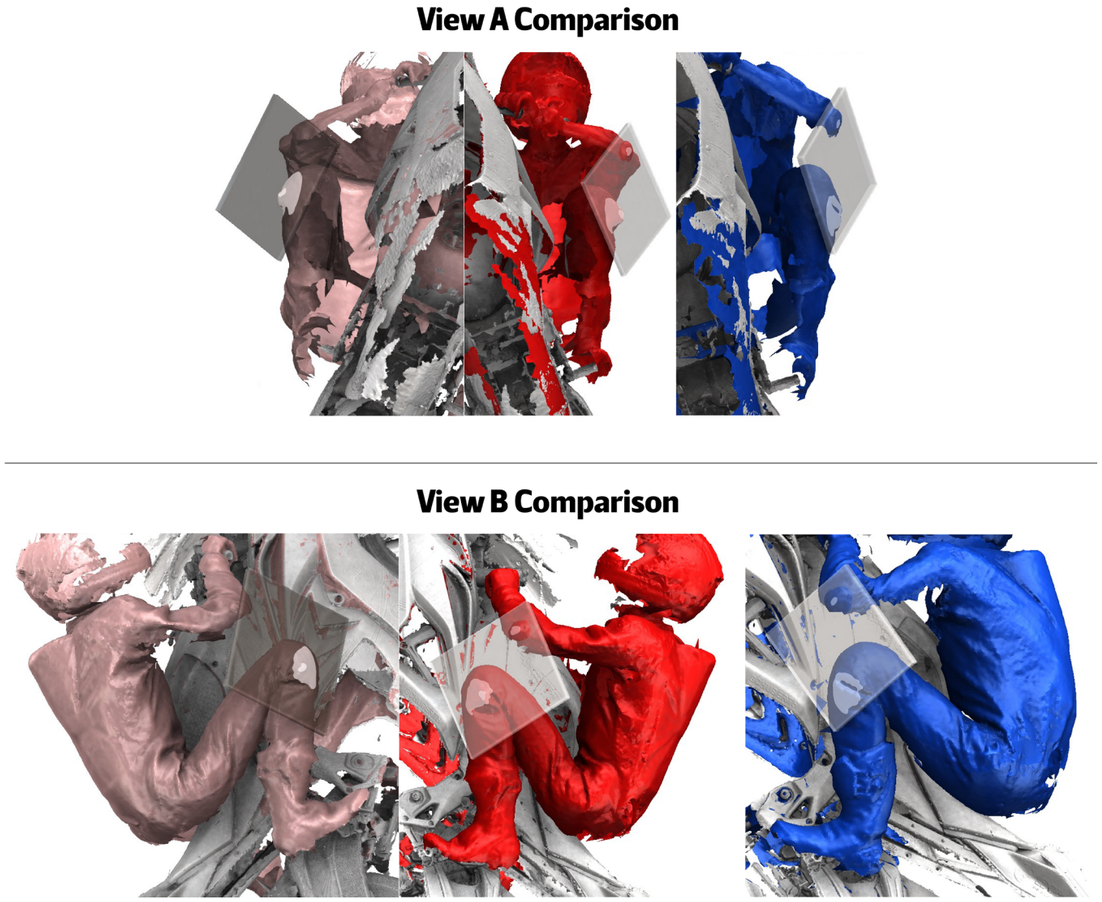


Figure 10.3.3: Comparison of Contact points between P1 (blue) and P3 (red) from different views.

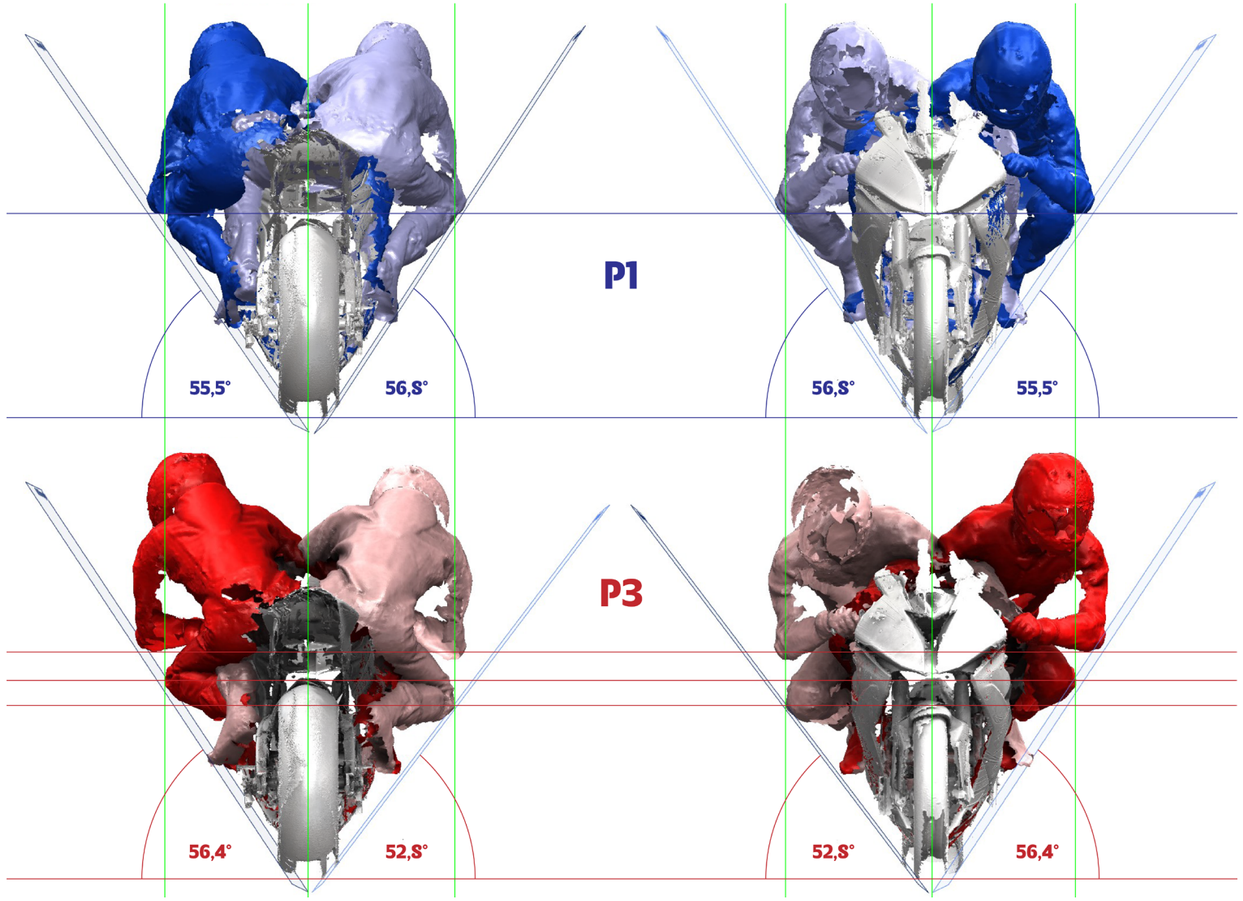


Figure 10.3.4: Comparison of left and right corners of P1 and P3.

10.3 Tarmac contact points (Results Part 2)

To analyse the tarmac contact points, a simulation of the tarmac was added to the scans. To imitate the bike riding on the tarmac, a line was drawn between the front and back tire (Figure 10.3.1A). Since the participants are professional riders, their body position is used when they are pushing the limits of the bike. For this reason, the line between the front and back tires was drawn from two points close to the shoulder of the tread, as this would be where the contact patch of the tires with the tarmac was situated in a real-life scenario.

After drawing the line between the tires, a plane that hinges at this line was tilted upwards until it touched the elbow or knee of the rider (Figure 10.3.1B). This first touchpoint is the determined contact point of the rider with the tarmac. Simultaneously, the lean angle of the rider at contact can be derived from the angle of this plane.

To help visualise the contact points, a plate was extruded from the lean angle plane. As shown in Figure 10.3.1C, this highlights the contact points on the rider. Completing these steps for all scans results in the overview of Figure 10.3.2.

Contact point height

At first sight, the contact areas marked on the riders seem nearly identical. A closer look from a different angle proves differently. In Figure 10.3.3 view A and B, a difference shows up, where the contact area of P1 appears lower on both legs than that of P3.

This difference can be explained by the variation in body positioning. As indicated in Figure 10.3.5 and visible in Figure 10.3.2 and 10.3.3, P3 uses a different foot position, where the toes are flexed using the foot peg. This creates a sharper angle between the upper and lower leg, which is additionally influenced by the more forward seating position of P3. P1 uses a more centred foot position and is sitting slightly more towards the back of the seat. This gives the rider a wider angle between upper and lower leg.

Important to consider is the influence of the amount that the leg is pointed outward from the motorcycle. When looking at the comparison in Figure 10.3.4, no significant difference is showing in how much each leg is sticking out. This suggests that the angle between upper and lower leg is the main cause of the difference in contact point position between P1 and P3.

Consequently, a rider with longer legs and thus a sharper upper/lower leg angle may have a higher contact point than a rider with shorter legs and who uses the same foot position.

By comparing Figure 10.3.3 and 10.3.4, another cause can be found which results in a higher contact point on the leg. The comparison of the left and right corner position of P3 shows a height difference between the left and right knee. P3's right knee is pointed downwards more. When comparing the contact points of P3's left and right knee, the contact point shows up slightly higher on the right knee. This suggests that pointing the knee down also results in a higher contact point (Figure 10.3.5).

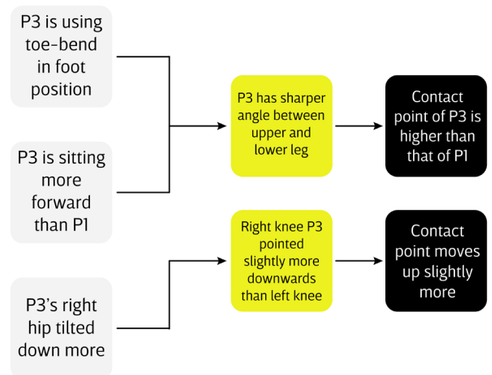


Figure 10.3.5: Causes of contact point height on the leg.

Lean angle

Besides a higher contact point, a smaller lean angle is created by pointing the knee down, as can be seen from Figure 10.3.4. Whilst left and right legs of both participants are all a similar distance away from the bike's chassis, the right knee of P3 touches the simulated tarmac (diagonal plane in the figure) much closer to the contact patches of the tires. For this reason, the lean angle needed to touch the ground is less sharp. Alternatively, with the knees at the same distance from the contact patch of the tires (= same vertical height in the figure), the knee that sticks out further from the chassis is the one that causes the knee to touch down at a less sharp lean angle (see Figure 10.3.6).

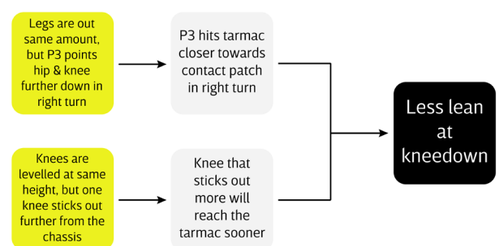


Figure 10.3.6: Influences that determine lean angle at kneedown.

Figure 10.3.4 shows that P1 has remarkably symmetrical overall body positioning for left and right corners. In this case, the sliders

could be placed symmetrically on the suit. However, in the example of P3 shown in the same figure, some significant deviations can be found between the left and right side. This suggests that an asymmetrical ideal knee slider position in accordance with the previously discussed contact point deviations is the most accurate for the rider.

Upper body influences

The differences in P3 also show in the upper body. Again, looking at Figure 10.3.4, it is apparent that P3 is laying his shoulders lower in the right corner. As a result, the lower arm and elbow are pointing down more. Alternatively, a longer versus a shorter upper arm in similar positions could also influence this angle of the lower arm and elbow.

Figure 10.2.3 and 10.3.4 also show that P3 is moving the shoulders further out than P1. With the inside hand holding the handlebar, this however seems to only affect the position of the upper arm and the angle between the upper- and lower arm, but does not necessarily influence the position of the lower arm and elbow.

Important to note is the difference between the angle at which the elbows touch the tarmac (Figure 10.3.4). Although both elbow contact points are positioned on the slider in Figure 10.3.2 and 10.3.3, they do not wear down the same way. With the elbows of P1 pointing down, the sliders on the elbows touch the tarmac almost parallel, whereas the more horizontal left arm of P3 causes the slider on the elbow to touch down at a slight angle. At this angle, the slider is not aligned flat with the ground, wears down faster and the slider placement is thus slightly inaccurate. This principle is also important to take into account when placing knee sliders.

10.4 Discussion

Though the study results are promising, limitations should be carefully considered

First of all in terms of the research method, which was a static simulation of a dynamic reality. The following factors could influence the accuracy of results:

- A lack of inertia and lean angle makes it harder to find and maintain the body position used in dynamic riding. Riders move in harmony with the bike a lot, which it is static during the research. Participants need to support their own weight during the research, which is not as much the case during dynamic riding.
- Riders are used to preparing for the turn when the bike is still upright, getting into position before leaning into the curve, however, when they are in the midst of a curve, they lean in more than during preparation. Only one position per rider is used in the analysis.
- Riders were not on their own motorcycle. The chassis is different, meaning body position may not be in completely in harmony with the demo motorcycle. This is especially true for P3, who is used to riding a bike with more significantly different measurements than the demo bike used during the research (see Confidential Appendix 4).
- Riders are not looking into the turn in the processed scans as they are in a room and sitting on a vertical bike. Their head position being slightly off from the real scenario does however, not influence the position of the rest of the body and the contact point analysis.

To validate the research method, Figure 10.4.1 visualises that the static scenario can be and is an accurate representation of the dynamic reality. To achieve this accuracy, it is important for the rider to be familiar enough with the measurements of the motorcycle, informed well about the task to be performed and comfortable enough with static practice of body positioning.

Figure 10.4.2: Maximum lean angles of different motorcycle types (see Chapter 8) (MotoGP, 2013).

Another variable that helps determine the accuracy of the research is the lean angles derived from the 3D-scans. These were ranging from 52,8 to 55,8 degrees. As indicated by Figure 10.4.2, this is a realistic range for the supersport bikes used in WorldSBK championships.

Thus, it is possible to determine the contact areas of the rider when the rider can reproduce their technique on a static bike. The contact areas illustrated in Chapter 10.3 are in accordance with the actual slider positioning that is currently used by the rider (P1) in Figure 10.4.1.

Still, for further implementation of 3D-scanning for developing external protection, more extensive research is recommended to ensure that every rider is able to recreate their riding positions. More detailed instructions to riders may be needed, as well as using a motorcycle setup that is close enough to their current bike. The best set of tools for an accurate representation should be further researched for a final integration method. Testing with (used) sliders by professionals who always use the same position (Chapter 9) could help further define the accuracy of the method.

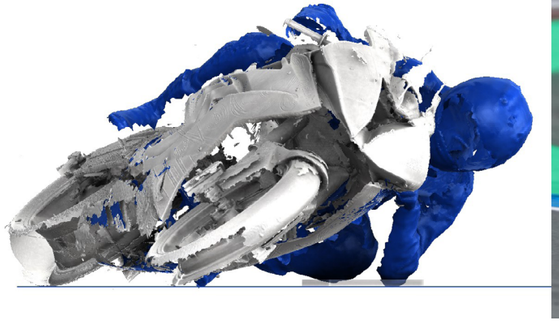


Figure 10.4.1: Comparison of body positioning with the same rider in static (left) vs dynamic (right) scenario (van Straalen, 2024a).

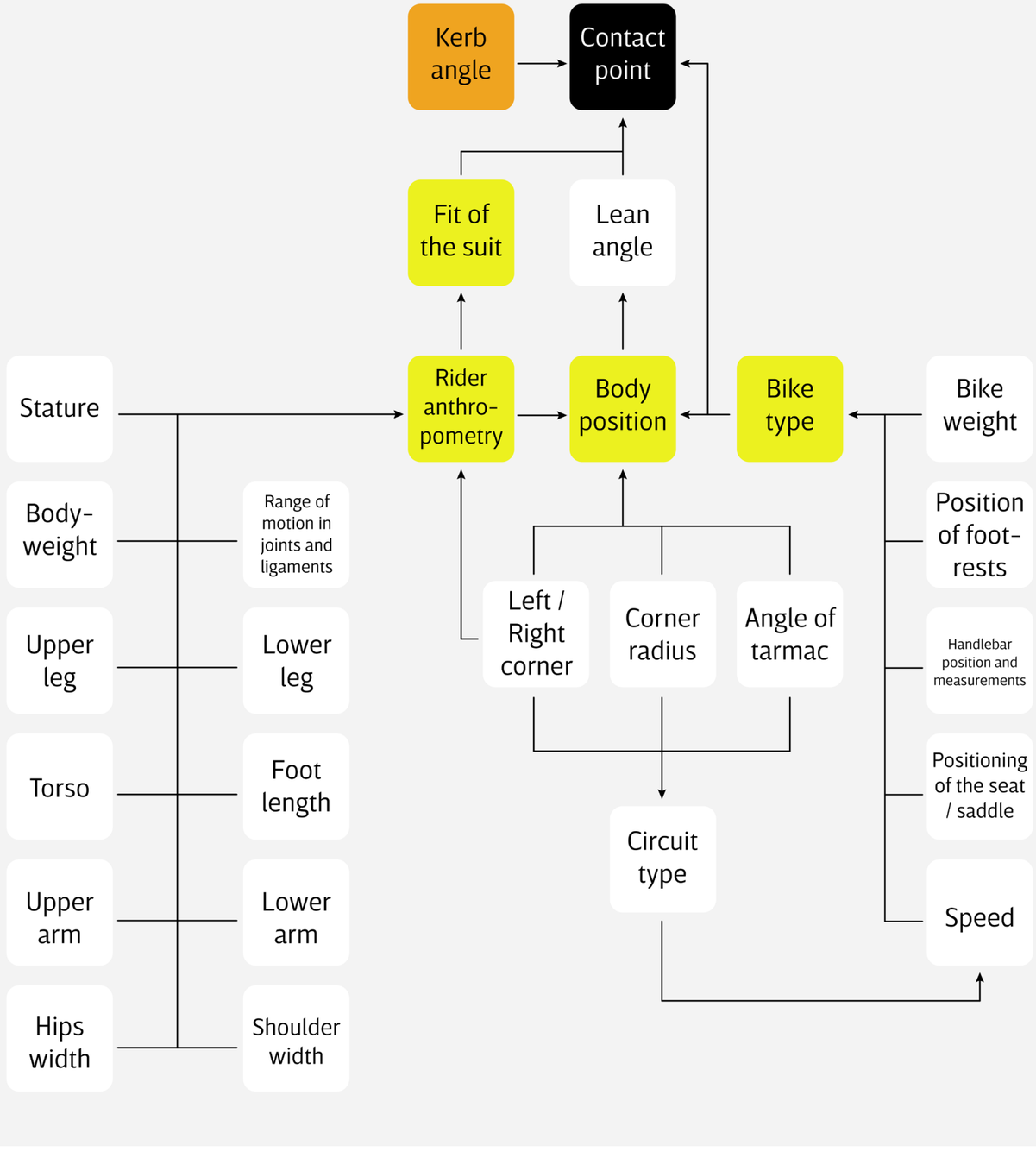


Figure 10.4.1: Comparison of body positioning with the same rider in static (left) vs dynamic (right) scenario.

10.5 Conclusion

From the body positioning of the two professional riders in this study, the foot position used by the rider was determined to be a main cause of contact point difference, where a foot position that positions and flexes the toes on the foot peg results in a sharper angle between the upper and lower leg and consequently a contact point that is higher on the leg. In contrast, a position where the centre of the foot is on the foot peg results in a less sharp angle between upper and lower leg and a lower contact point.
The anthropometry of the rider can also influence the contact point, as the body proportions and maximum range of motion of the rider also influence the angles of the limbs.

Riders need to find a body positioning technique that is complementary to their own boy proportions, range of motion, the motorcycle chassis and the maximum lean angle at which they want to ride. Many variables, as visualised in Figure 10.5.1, need to be considered and controlled in order to determine in what way the contact point is influenced. To determine the influence of all variables in the figure, a larger study is needed. Each variable must be individually tested, while all the other variables are controlled to be constant.

The study has proven that that the contact point positions vary between riders and that both anthropometrics and deliberate body positioning can influence the contact points. These two types of body positioning (2BP) can be distinguished by their cause:
1. Body position as a result of body proportion and range of motion.
2. Body position as a result of technique or personal style.

Both variables need to be accounted for in the attachment of a slider.

The influence of deliberate body positioning (technique) proves that it is not possible to predict the contact points of the knee and elbow based solely on body measurements.
The research method can however be used to measure the contact points of the rider and to tailor the position of the slider.
Thus, research results support the null hypothesis, which states that *"a tailored solution is needed in leather motorcycle suits, for accurate knee- and elbow slider puck positioning"*.

The elbow slider is currently in a pre-determined position which is universal for every rider. Research results which include the influence of the 2BP do not support this approach, as there are visible differences in contact points between users. This is evident in practice, as customers occasionally return to Damen for an adjustment of their elbow slider (Chapter 11).

It can however be argued that the Velcro system which is currently used on the knee is adequate to obtain an accurate slider position. Still, the range of positioning that the Velcro system allows is not suitable for everyone, has its downsides (see Chapter 11) and covers much more surface on the leg than a tailored slider system would need. Above all, it requires the rider to carefully determine correct placement each time the slider needs to be replaced.
A tailored solution could ensure perfect placement every time from the first use and minimises the chance of suit damage through user error. As good placement is very important for the rider to get through the entire race, these reasons support that the null hypothesis is accepted.

The research method presented above can also be used to determine a universal placement area that is suitable for more users. The range of contact point positions between users highly differs, so for a universal product, more scans of many more people are needed to find the overall range for repositioning that is needed.

In a more detailed scan (higher quality camera's), seams of the fabric can be used to trace back the ideal position of the pucks for an individual as well as the overall gathered area of touchdown to develop a universal positioning area.

As concluded from the user interviews (Chapter 9), many riders only use one position on their Velcro patch, once they have figured out the ideal position through trial and error. The research method used in this study has been proven to be an accurate method for determining personal contact points, without the need to practice riding. This is a promising start to the integration of personalised puck positioning for riders who are interested in this type of innovation.

Requirements

10.1 The puck of the slider system must lay flat on the tarmac to ensure even wear distribution, safety and durability.

Wishes

10.2 The position of the active sliders in the leather suit should be tailored by measuring the contact points, for example using 3D-scans.

11. AREAS OF IMPROVEMENT

11.1 Frequently occurring issues in active sliders

Throughout the research documented in all previous chapters, several issues were identified both for elbow and knee sliders, which are currently used in leather motorcycle suits.

Frequent issues for existing knee sliders can be listed as follows:
- With the ergonomically rounded underside of many knee sliders, it can be misleading to estimate if replacement is needed, as the centre of the puck can be worn down before there is no thickness left on the sides of the slider. Riders occasionally wait too long to replace the sliders, or the sliders do not last long enough during a race. This results in worn down patches and damaged leather on the suit as shown in Figure 11.1.1B.
- A hook & loop system for slider fastening with a big patch on the knee asks for trial and error to find the right position for the slider. Inaccurate positioning of the slider can cause the slider to wear down under an angle, instead of flat to the ground. This results in damage to the leather and attachment patch that surround the puck, as shown in Figure 11.1.1D.
- Velcro systems can become weaker overtime with frequent use. Besides this, the loop patch on the knee creases heavily when the knee is bent. These creases, shown in Figure 11.1.1A, are lost area for the hard puck to attach to, resulting in a weak hold. Gaps between the puck and the suit can also be dangerous, as they can catch onto obstacles on the ground. To compensate for the lost area and smooth the transition from the slider to the suit, knee pucks are glued or stapled to a flexible leather patch, which helps the puck to stick all around the edges. Still, sometimes pucks are lost, resulting in suit damage as visualised by Figure 11.1.1C.
- Though the extra border around the puck is supposed to provide more safety and security, many riders position the sliders beyond the patch on the suit, so that the leather border around the puck is sticking out loosely (Figure 11.1.1E). Especially with a non-flexible border around the puck (Figure 11.1.1F), this creates new safety hazards (and aerodynamic disadvantage).
- In other cases, the slider is stuck so firmly that the rider requires a tool to function like a 'knife' for removing the puck from the suit, see Figure 11.1.1G. This slows down the process, after which the rider needs to find the same position carefully when they place the new slider.

In current elbow sliders, a few issues are also frequently occurring:
- One of the issues has to do with the attachment method. In many elbow sliders, screws are used to attach them to the suit. When the screws are placed in the contact area, they are worn down together with the slider itself. As a result, they cannot be unscrewed and are firmly stuck to the base in the suit (see Figure 11.1.2A, B and C). This makes replacement a challenge and in professional contexts, may require the rider to switch suits.
- Figure 11.1.2C shows an example of a slider that has been repositioned. Elbow sliders are not tailored, but their position on the suit is marked on the pattern universally (see Confidential Appendix 3). As the slider base plate is sewn in place and is attached with screws, it is not repositionable, which raises issues like the damage shown in Figure 11.1.2D. The base which the slider attaches to is damaged as a result of a position error. This requires a new base to be sewn onto the suit.

11.2 Design directions

These issues - or areas of improvement - in current protection, can be gathered to form potential design directions, visualised in Figure 11.2.1.

Figure 11.1.1: Frequent issues encountered in current knee slider use (Bradley, 2016) (De Zilveren Naald, 2019) (MotoGP, 2023) (Vietti, 2023).

Figure 11.1.2: Frequent issues encountered in current elbow slider use (Swarts & Roadracing World Publishing, Inc., 2021).

A - Modularity
Riders have different preferences for the thickness of the slider, to help them determine their lean angle. They need to be able to switch quickly between rain and dry weather sliders. A modular slider or slider system that allows easy and quick interchanging between different slider types can attend to all the different needs of riders quickly.

B - Constant thickness / Longevity
Elbow sliders do not last long when they are used frequently as a part of riding style. In addition, inefficient wearing of both elbow and knee sliders shortens lifetime. Changes in puck thickness as a result of wearing causes a noticeable increase in lean angle, which can be risky if the rider was already riding at the limit of the bike's lean angle. A slider that remains a constant thickness would be perfect as a consistent measuring device and eliminates the worry about the slider being used up too much or the lean angle increasing too much before touching the tarmac.

C - Tailored puck positioning
Inefficient wearing as a result of imperfect positioning shortens the slider lifetime and increases the gauged lean angle sooner. With a tailored puck position, the material of the puck can be fully used up and big black patches that show even when the slider is attached on the suit are no longer needed.

D - Velcro and screw system alternative
An alternative attachment system to the Velcro solution could minimise the frequency of repairs to the attachment system and increase aesthetic quality of the suit. In the elbow slider, it could prevent the issue of screws getting stuck by wearing down with the slider. A new attachment system could also prevent the knee sliders from becoming lost during the ride, as a result of old or damaged Velcro patches.

All four areas could be implemented in a single concept design, however, for the time frame of this project, this is not realistic. To maintain project quality and propose a valuable solution, the relevance of the areas needs to be considered.

For sliders and the leather suit to last through a race in the first place, a correct position and wear-resistant attachment system are the most important. This will help both slider and suit last as long as they potentially can. Areas A and B are relevant and can be implemented in a later stage, but for former reasons, area C and D are considered priority in the development of the external protection.

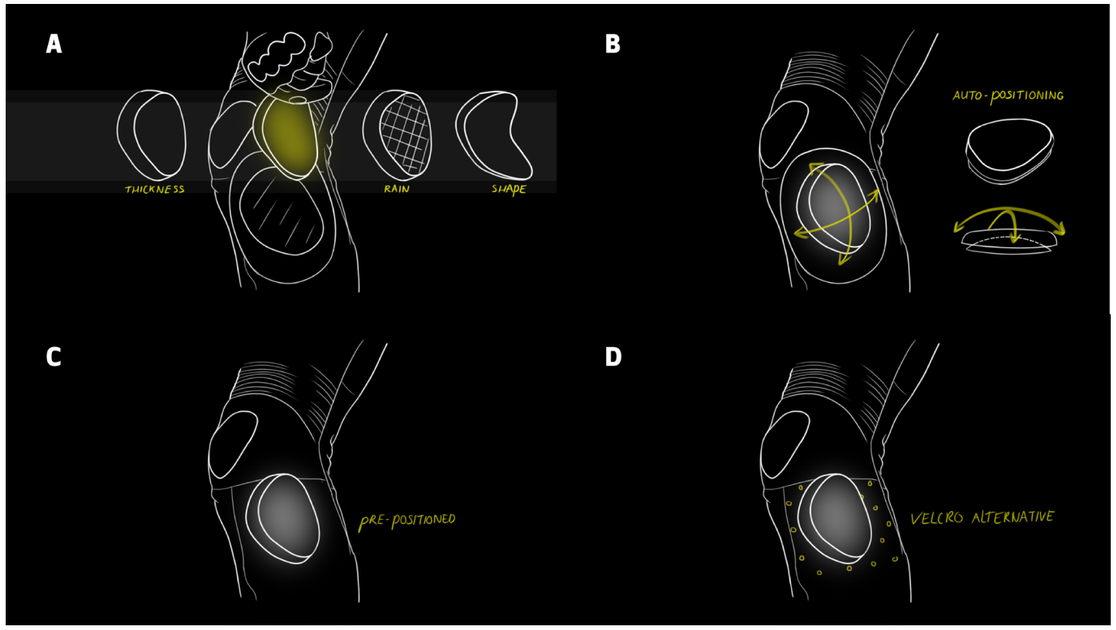


Figure 11.2.1: Visualisation of potential design directions.

11.3 Improvement focus area

During interviews (Chapter 9), riders reported that the knee is the most important contact point, as the knee is still used the most for gauging the lean angle. With the many issues identified for the Velcro system that is still used today and the alternative attachment systems already being developed for the elbow slider, arguably, it is time for innovation in the knee slider attachment system.
A positive impact could be created by developing an alternative attachment system, that helps eliminate the issues currently associated with knee slider use, which cannot be resolved solely by implementing a tailored slider position.
For these reasons, the chosen design direction to focus on in the implementation of a tailored slider concept is the attachment system alternative.

TAILORED ACTIVE SLIDERS

12. VISION & DEFINITION

12.1 Product vision

Chapters 9 and 10 show that there is promising potential for implementing a tailored knee slider in the suits of elite motorcycle racers. As confirmed by Chapter 11, the addition of an alternative attachment method to the personal positioning of the slider can be very beneficial.

The new design is thus aimed at providing a more consistent and reliable slider to the user, empowering elite racers with a new level of precision and safety, reducing risks associated with improper slider placement and other shortcomings of the traditional Velcro solution.
By enhancing the durability of the slider system, the rider can focus on the race without getting distracted or worried about the issues that are currently associated with the knee sliders (Chapter 11).

"I want to create a reliable and user-friendly knee slider attachment system that ensures precise and consistent placement, enhances safety, and integrates seamlessly with motorcycle racing suits, increasing their durability and aesthetic quality."

An important goal within this vision is to achieve a significant reduction in suit damage and slider detachment incidents.

(Acosta, 2024b)

12.2 Requirements

Design requirements form the base for making this vision a reality. To keep track of requirements introduced by different stakeholders and contexts, each of the research chapters described in this report includes an overview of the research findings and the requirements that correspond to them. All requirements strictly necessary to achieve the vision described above are combined and/or gathered into a final list of requirements to focus on in the next project phases:

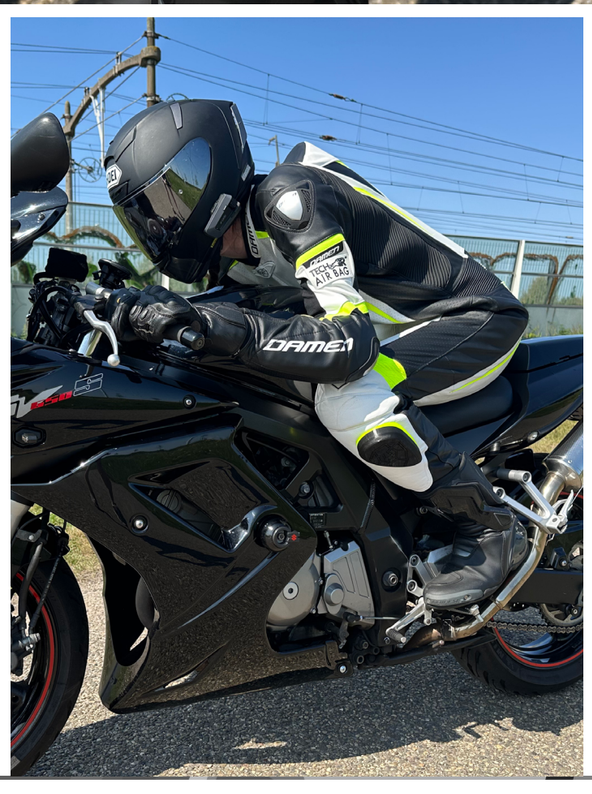
Requirements

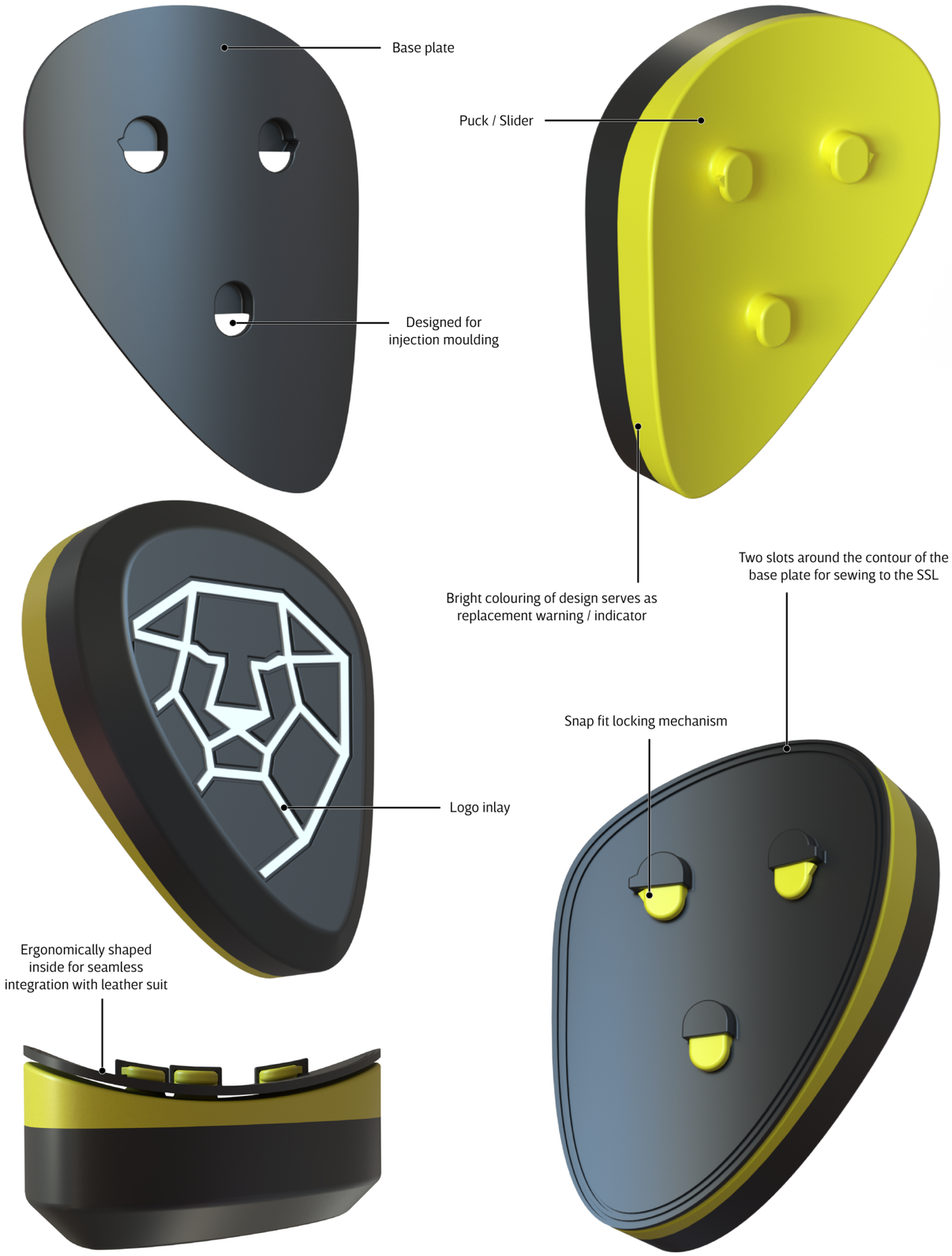
- 2.4 a The new slider system must be more durable than the current system.
- 2.5 a Sliders must comply to regulations of the FIM (Appendix 2).
- 2.5 b The new slider system must not interfere with the European regulations concerning internal protection, impact zones and abrasion resistance (Confidential Appendix 1).
- 2.6 a Batch sizes must not exceed 200.
- 2.6 b Production costs of slider set must not exceed €30,-.
- 2.7 Workshop employees and shop assistants must be able to implement the new slider system into the suits' tailoring and assembly.
- 3.3 The new system must be visually novel and attractive, to catch the interest of potential users.
- 3.5 Repair time for the slider system must not exceed 2 hours.
- 4.1 The sliders must be suitable for use by professionals and semi-professionals.
- 5.3 The slider must be easily replaceable by the rider or their team, within 10 seconds (single slider).
- 7.1 The puck must fully consist of a single material.
- 7.5 The slider must not get stuck to its base as a result of normal slider wear.
- 7.6 The slider system must be minimalistic and simple, excluding offsets from the leather surface (except the puck) for safety.
- 9.1 The slider system must not take away any comfort of the suit or cause any type of new discomfort.
- 10.1 The puck of the slider system must lay flat on the tarmac to ensure even wear distribution, safety and durability.

Wishes

- 2.2 d The new slider system should enhance safety.
- 4.1 The sliders should be suitable for amateur use.
- 5.2 The slider system should be easy to repair or replace by the riders' team when there is no damage to the surrounding leathers.
- 8.1 The new system should not be too radically novel.
- 9.4 The new slider system should be more aerodynamically improved with regards to the existing system.
- 10.2 The position of the active sliders in the leather suit should be tailored by measuring the contact points, for example using 3D-scans.

13. THE DAMEN GRID SYSTEM





13.1 Concept Functionality

The Damen Grid System encompasses the research insights into a new attachment system for active sliders in leather motorcycle suits.

Attachment
The design solution consists of two parts that lock together:

1. Semi-Flexible base plate. This plate is sewn to the backside of the outer layer of leather of the suit. The leather is punched to match the openings in the front of the plate.
2. The slider design has pins that are aligned with the holes in the leather. Once the pins touch the back of the integrated plate, the user pushes the puck down to lock it into place. To unlock, the user pushes the puck back up to release the lock. The puck can then be retrieved from the gaps.

This locking attachment system was designed using snap fits to ensure that the puck does not come loose during the ride and can only be released by the user's hands. To ensure that the snap fits can be released by pulling the puck back up, the exit angle of the snap fit must be greater than 90 degrees with the vertical wall of the pin (Tres, 2024). The design therefore uses a snap fit with a 115° exit angle. A larger angle in the snap fit requires less force to push the puck in place, which is beneficial for easy attachment. For this reason, the snap fit uses a 147° angle on the entrance side. In contrast, the 115° exit angle requires more force and thus ensures that the slider does not come loose unintentionally during a race or a crash.

Material
The materials used in existing sliders have been extensively tested with professionals in the MotoGP and WSBK. The material is selected to provide great feel in corners, while the thickness of the slider ensures it lasts trhough the race. They provide smooth gliding to the rider as well as even wear distribution and they are weight-optimised (Chapter 7.1). These sliders, which can be found on the market in many different shapes and colours, are typically made of TPU polymers, though the composites of the TPU may vary between brands or models.
As elite riders with REV'IT! suits are using a dual compound puck consisting of both TPU and PA6 (Chapter 7.1), both materials were considered to be used for the final design.

The research by Zhou, Huang, and Zhang (2012), perfectly compares the material properties of TPU and PA6 that are playing an important role in the application for knee sliders:

- TPU has a lower friction coefficient than PA6 and is known for its smooth glide across the tarmac. This is a result of the material's softness and flexibility, which allows it to melt from transient friction heat and form a low-shear-strength interfacial layer at the sliding surface. This interfacial layer acts as a lubricant, which lowers the friction coefficient of the material.
- On the other hand, PA6 is known for its durability and good wear resistance. "It is well known that the wear resistance of polymers depends largely on their ability to form thin, uniform, and adherent transfer film on the counterface. PA6 can form adhesive transfer film during sliding, which prevents direct contact between the polymer surface and the hard counterface. It can reduce abrasive action, resulting in lower wear volume (Zhou et al., 2012)."
- In contrast, the interfacial layer of TPU is peeled off as a result of the material's low shear strength, wearing it down faster. This also makes TPU more susceptible to higher loads, as increased friction heat melts a bigger portion of the TPU, which is then transferred away from the friction surface as demonstrated by Figure 13.1.1.

Since the composite's material properties determine the feedback the slider gives as well as its wear resistance, the preference of the exact material blend is personal. During their research, Zhou et al. (2012) found that the materials showed a compatible structure for a PA6 and TPU blend. On the general market of motorcycle clothing, this would propose an attractive balance between durability and smooth feedback, however, professional riders reported to prefer a smooth

Figure 13.1.1: Kneeslider with molten TPU which has been transferred away from the friction surface as a result of high friction heat.

glide (Chapter 9 / Appendix 5), even when this means that the material wears down faster. Therefore, the active slider should be produced using TPU.

The base plate needs to be semi-flexible to maintain the comfort of the suit, but sturdy enough to form a stable base for attaching the slider. At the same time, a slightly softer material allows elastic deformation when releasing the snap fits of the puck. This ensures that the base plate will last through many use cycles with new pucks. TPU, with its flexible nature, is once again proposed as the most suitable material for this component. Evidently, this is supported by the bases of the external protectors analysed in Chapter 7, which are also made of TPU.

Manufacturing
Sliders are typically injection moulded, however, Damen only works with very small product batches of 50-100 pieces. At the high costs of creating a mould, this makes additive manufacturing methods seem like an attractive option for manufacturing the slider system.
Both FDM (Fused Deposition Modeling) and MJF (Multi Jet Fusion) were therefore tested during the design process (see Appendix 17).

Although the MJF-printed prototype has a very nice surface quality which could qualify as a final product, several issues surfaced in the prototype:

- The materials used in MJF (and SLS) printing are very much restricted to a small selection of options; PA 12, PA 11 and TPU (Xometry, 2024a, -b). The TPU option was selected as this is the material which should be used in te final product, yet the TPU that was used in the print is far too soft and flexible to be compared to the TPU composite that would be used in the final product with injection moulding.
- In the MJF printed prototype, the part still behaves anisotropically, as it easily tears along printing lines and/or layers (Figure 13.1.2).
- The MJF printed base plate is far more fragile than the FDM printed base plate. Whilst both prints used a TPU with a hardness of Shore 95A, the materials are very different.

In contrast, the FDM printed plates are very durable and less flexible, which provides a more stable base to the puck. On the other hand, their surface quality is limited.
Still, the anisotropy in the FDM part causes the forces of the snap fits to separate the layers of the print in the base plate. Though the affected area is in this case limited to the area which is in direct contact with the snaps and the prototype is still functioning, the FDM printing method is also not sufficient for a final product.

Undoubtedly, the active slider attachment system has a very important functionality and must be both durable and reliable to be viable in the

user context of motorcycle racing. Thus, issues that appear as a result of additive manufacturing should be avoided at all costs.
In conclusion, the best way to create a durable and reliable product with the right TPU composites and to preserve the material properties - which are highly determining for the experienced slider quality - is to use the traditional method of injection moulding.
Therefore, the design was adjusted for injection moulding by removing undercuts (Klahn, Singer, & Meboldt, 2016) and ensuring the possibility to de-mould the parts alltogether, with a minimum amount of mould sections. As illustrated by Figure 13.1.3, the base plate can be produced using two mould halves. The slider itself uses one bottom mould half and two sliding top sections.
Both parts thus consist of injection moulded TPU, but may use different composites to aquire the properties needed for each parts' purpose (e.g., a higher density for the puck vs lower density for the base plate).

Figure 13.1.2: Anisotropic fragility of the MJF printed base plates.

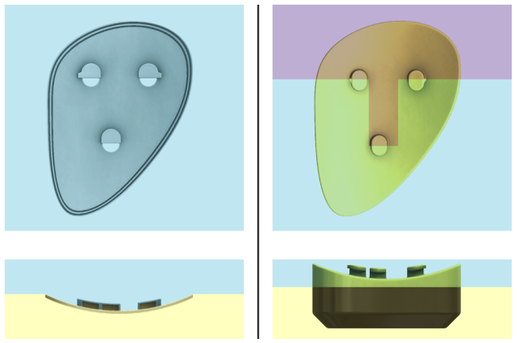


Figure 13.1.3: Rough indication of mould sections for production.

Shape
Although the focus area of the design phase was not about the shape of the puck itself (Chapter 11), but more so the attachment system, several aspects are worth mentioning to point out the direction that the shape design was aimed at, for further development.

Colours
The distinction between the yellow and black half of the puck has the important use of warning the rider that a replacement is needed to ensure the puck will last through the next riding session and the leathers will remain undamaged. Colours were based on Damen's branding, but can be adjusted to match the suit design of the rider. It is adviced to use a neutral black and white front at all times, in combination with a bright underside to clearly communicate the need for a replacement. The Logo on the front can be the same as the base, or the opposite (black/white).

Dimensions
The width, length and thickness of the slider (see Appendix 18) were derived from the "Damen kneeslider", which is currently used by most #TEAMDAMEN riders (Damen Motorkleding, n.d.-b,-c).

Aerodynamics
The triangular shape of the slider was inspired by the form of the contact areas resulting from the 3D-scanning research (Chapter 10). The shape was aimed to balance several functions:
- Create a sense of direction which supports the user's intuition in the attachment of the slider.
- Following the direction of the force that wears down the slider when the rider puts their knee down (Chapter 16).
- Slightly approaching the direction of the airflow that runs along the side of the bike, to aid the airflow from the fairings around the body of the rider (Chapter 18).

13.2 Concept implementation

Integration
The attachment system (base plate) is integrated behind the first layer of leather in the suit, which protects it from abrasion (Figure 13.2.1). It also ensures that the surface of the leathers remains smooth and it significantly increases the reliability of the attachment system:
- The Velcro patch and stitching which are currently used, cover an area larger than the puck itself. The Velcro and stitching surrounding the slider itself can in this case become loose from abrasion damage in a crash or from inaccurate slider placement (Chapter 11.1). Since the stitching of the Damen Grid System lays under the puck itself, the base plate does not come loose during a ride or a crash.
- When a rider forgets to attach their slider before leaving the pit lane (WorldSBK, 2022a) and still touches the tarmac with their knee, the leather will suffer the abrasion, whilst the base plate remains intact. In contrast to an abrased Velcro patch, which can no longer hold a slider in that exact spot, the unaffected base plate allows the rider to make a quick pit stop and attach the slider without needing to switch the entire suit.

To assist the integration and ensure there is no discomfort to the user, the slider and base plate are ergonomically curved to match the shape of the leg. To implement the base plate in the suit, the following steps will be executed by the workshop employee:
1. The position of the base plate will be marked on the outer layer of leather.
2. The base plate openings that will later fit the pins of the slider are punched from the leather.
3. The base plate will be stitched to the outer layer of leather using two rows of stitching (Figure 13.2.2) according to NEN-EN-17092-2:2020 (see Confidential Appendix 1) (European Committee for Standardization, 2020b).
4. A layer of foam is placed on top of the leather and base plate using an adhesive.
5. The completed assembly is stitched onto the base of the suit (which is the first layer of leather).

In this process, steps 1,2 and 3 are new steps added to the traditional production process of the suit. Steps 4 and 5 remain unchanged. As the workshop employees are familiar with sewing TPU base plates to the the suit (for example with the elbow and shoulder protection, see Chapter 7), the implementation of the Damen Grid System will come natural to them after a short explanation.

Maintenance
Since the outer layer of leather protects the base plate from damage, maintenance to the system itself is not expected to be needed. However, when serious abrasion damage to the outer layer of leather affects the safety of the suit, the area may be deconstructed to replace the leather using steps similar to steps 1-5 above.

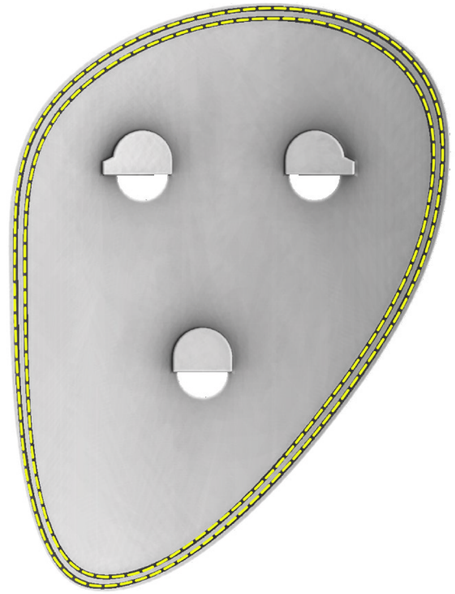
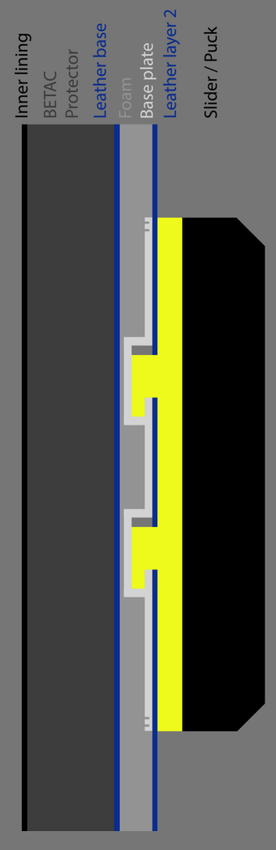
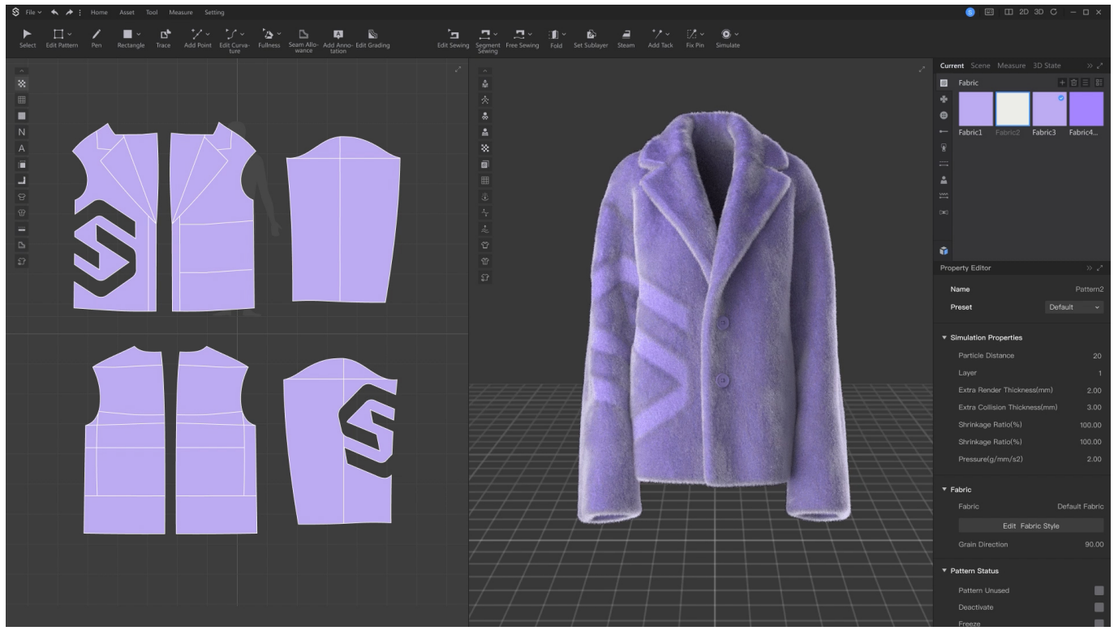


Figure 13.2.2: Integrated double-row stitching in the base plate.

Figure 13.2.1: Visual representation of integration method of the attachment system in the suit (Left: BETAC protector, attaches to backside of Leather base using Velcro).





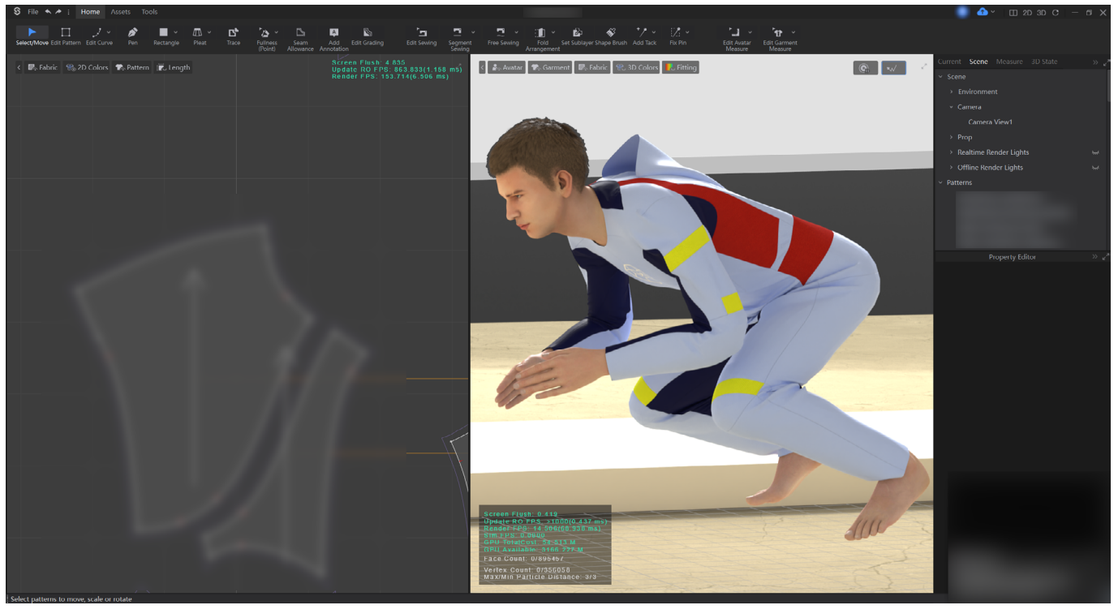


Figure 13.2.3: Fashion designing software Style3D, which allows working on designs from both 2D and 3D views (Style3D, n.d.).

Positioning
Since the final concept was developed for a tailored position, a method is required to translate the contact areas determined by the 3D-scans into a position on the sewing pattern of the suit. A fashion design software used by the pattern designer at Damen, called "Style3D", allows the designer to compare 2D pattern drawings with the 3-Dimensional result and vice versa (Style3D, n.d.) (see Figure 13.2.3). Style3D uses avatars, which the fabrics are draped over in a simulation to create a 3D garment. Though the software has avatars that can be adjusted in size and body posture / position, alternatively, 3D-scans can be uploaded and used as avatars.

Therefore, tracing the contact points on the 3D garment or measuring the 3D model in Style3D allows the designer to use the software for accurately calculating the slider location in the 2D pattern piece.

13.3 Opportunities

The final concept of the active slider attachment system presented in this chapter can be applied beyond the tailored knee slider application it was initially designed for. Two of these interesting opportunities are the implementation of the concept in an elbow slider and a universal knee slider attachment.

Elbow Slider
The locking system used on the knee can be scaled down and adjusted to fit the elbow. Integrating the concept into the elbow slider will help eliminate the issues associated with current elbow slider solutions (Chapter 11.1).

Universal Knee slider
To assist the transition from a widely adjustable slider to a tailored slider position and provide a suitable alternative for amateur riders, the Damen Grid System can be further developed into a universal knee slider attachment solution.
A universal solution can be achieved by expanding the base plate and adding multiple additional holes to the base which the slider can be positioned into. This creates a grid similar to the starting grid in motorcycle racing, which allows the user to move the puck around to a number of different positions (see Figure 13.3.1).

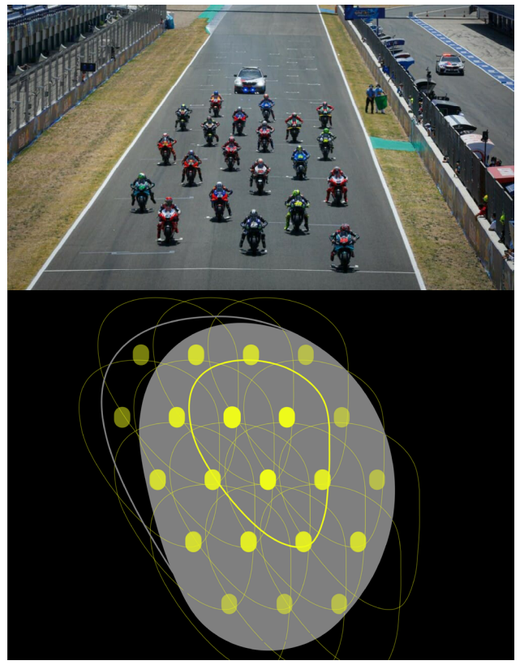


Figure 13.3.1: Universal application of the Damen Grid system (Cycle News Staff, 2020).

(Repsol, 2019)

14. CONCEPT EVOLUTION

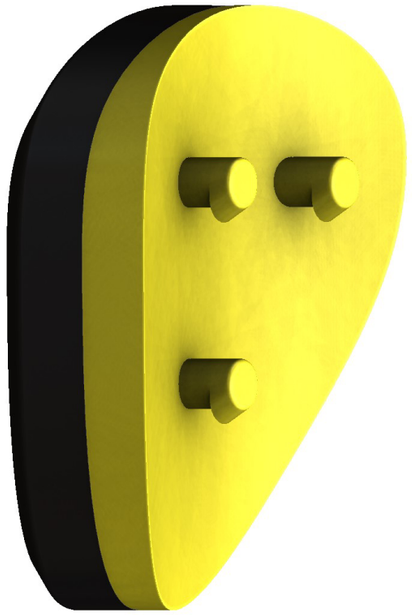


Figure 14.2: Concept 1 CAD-model.

The final concept was developed after several iterations of prototypes (see Figure 14.1). Since the functioning quality of a locking system like the one used in the Damen Grid System comes down to the smallest details, the iterations of development for this project were focused mostly towards getting the locking mechanism to work and adjusting it for reliability and for comfortable and seamless integration in the suit.

Concept 1
The first concept (Figure 14.2) was created by making a CAD-model of the puck with the final ideation sketch as a reference (see Appendix 19). This idea consisted of using pins that are each pushed through a rubber grommet in the leather suit and would not yet require a base plate to be sewn into the suit.
However, the easiest way to pull this puck out of the suit is similar to the force that acts on the puck when it catches onto an obstacle during the ride.
After creating the model, which helped visualise and realise this issue, it was thus concluded that this system is not reliable enough.

Additionally, it was determined that the next concept should include a new two-step detatching method, where the puck needs to be unlocked before it can be pulled away from the suit. With the help of the inspiration gathered during the ideation process (see Chapter 15), a new concept was created.

Figure 14.1: Overview of prototypes created throughout the design phase.

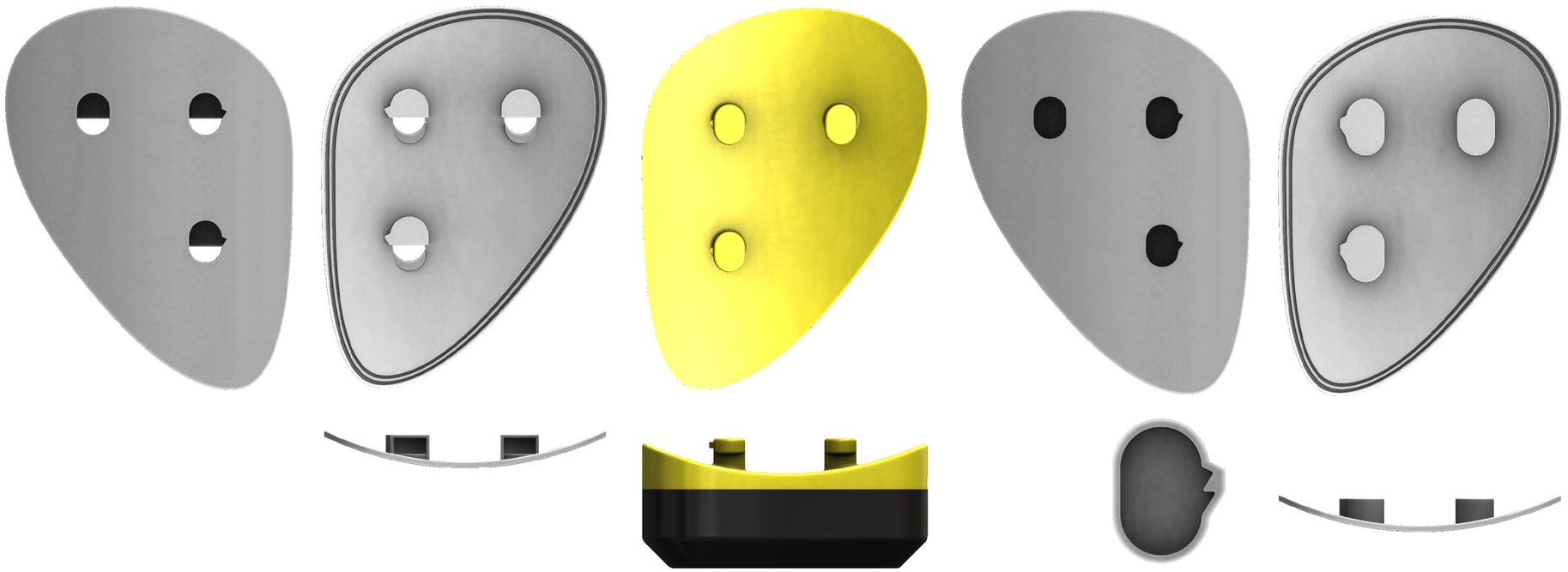
Concept 2.1
The new concept integrates snap fits to lock the puck for the ride. As explained in Chapter 13, the snap fits need to be unlocked before the puck can be released, ensuring that the puck does not come loose during the ride.

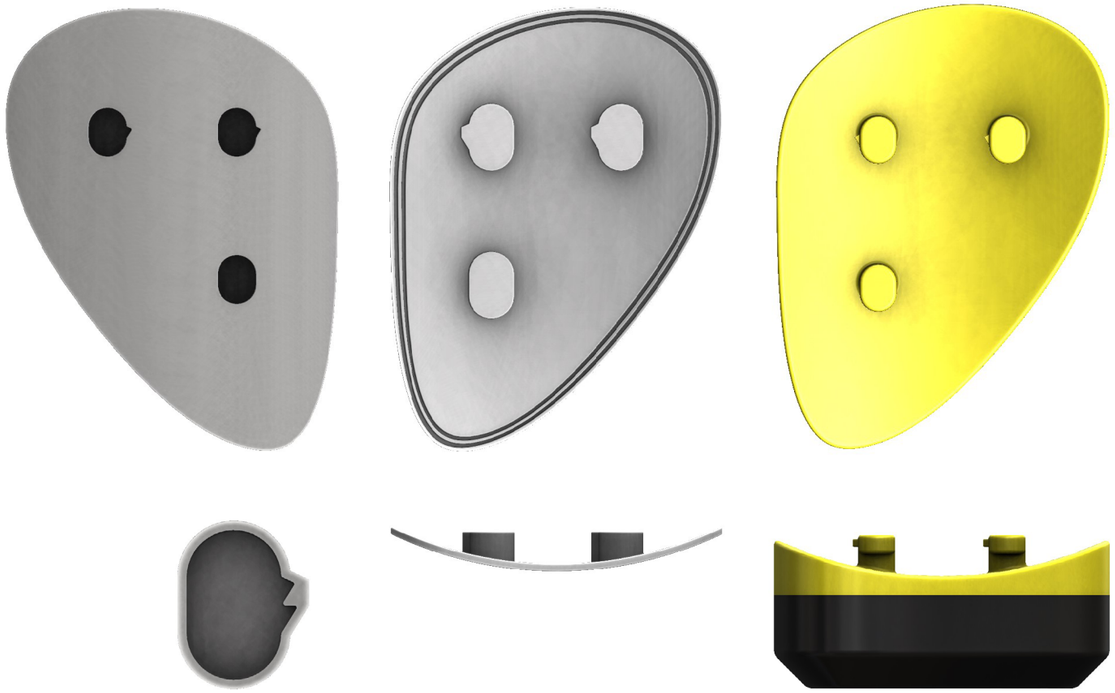
This first version of the final concept uses two snap fits, which were placed vertically.

To facilitate a reliable and strong attachment, a base plate was designed in addition to the puck. concept 2.1 knows two versions of the base plate that were prototyped with the same puck design:

Base plate 2.1.1
The first base plate has an open design, which allows the snaps on the sides of the puck pins to hook underneath the open edge of the 'pin cap' in the base plate. The prototype locked and clicked into place nicely, however, trying to release the snap fits caused the material of the base plate to be pulled up with it and curled inwards, instead of being pushed outward by the snaps to release the puck pins.

Base plate 2.1.2
In an attempt to make the base plate behave more rigidly and allowing the snap fits to release, a closed version of the base plate was prototyped. The puck now succesfully locked and unlocked with the base plate, but with the two pins placed vertically, the force that needs to be applied by the user's hand to unlock the mechanism feels unnatural. To make releasing the puck feel more natural and to balance the forces, the snap fits required relocation.





Concept 2.2
In concept 2.1, when the user tries to pull the puck straight upwards, the force the user applies is naturally positioned around the center of the puck. This creates a moment arm between the force applied by the user and the resistance of the snap fits, causing the base plate to rotate. This makes it harder to release the snap fits.

Both the puck and the base plate thus needed to be adjusted in order to create a more natural and succesful release to the snap fits.

In this new concept, the bottom snap fit was moved to the upper pin to position the snap fits horizontally. With the two top pins already centered, this eliminates the previous moment arm. Prototyping and testing this position proved that this alignment creates a more balanced and controlled release to the snap fits.

Tough the unlocking of the pins was now more smooth, the ergonomic shape of the puck does not reach its full potential with the current pin design. Though the ergonomic shape of the puck helps the puck lay flat against the leather, creating more ergonomic pins will ensure that the system is not actively noticed by the user, or causing any discomfort.

Another important issue is that with the bottom pin aligned directly under the top pin, the design is not optimised for injection moulding. The same is apparent for the base plate, which proposes an even bigger issue; as the closed base plate design would not allow de-moulding.

Optimizing the design for injection moulding is beneficial to reduce production costs and is thus integrated into the final concept design.

Concept 2.3
This concept is the final design of the Damen Grid System. The ergonomically curved shape of the puck is now also integrated into the pins. Additionally, the pins are thinner, to ensure the rider does not feel them. This way, the system will not result in any additional thickness to the existing leather suit and is integrated neatly into the existing garment.

The bottom pin is moved sideways to allow the top half of the production mould for the puck to consist of two sliding halves.
The snaps are now symmetrically placed on the outsides of the pins to balance / center the forces during the release of the snap fits even more.

The base plate now uses the reinforced ‘pin caps’ from the closed design, to ensure that the snap fits unlock smoothly, but the caps are re-opened to remove the undercuts from the model and allow the base plate to be moulded using only a top and bottom mould half.

15. IDEATION

After the extensive research phase of this project, only limited time was left to integrate the findings into a new design. To speed up the process and bring order in the chaos of ideation, several methods from the Delft Design Guide, by Van Boeijen, Daalhuizen, & Zijlstra (2020) were selected to form a structured proces and prevent mental blockages.

To gather inspiration, the ideation started off with a *flower association* combined with *how-to's*. This flower association was used to research existing mechanisms for inspiration (see Appendix 19).

15.1 Morphological chart

Next, the findings were combined into a morphological chart, containing several different design aspects. Multiple combinations were made to generate ideas for new attachment methods of the sliders.
Since integrating a new slider system with a tailored position is quite radical, the ideation phase also explored solutions which allow the user to still adjust the position of their slider slightly. Creating a system which allows both tailored and universal integration is great for supporting the transition from an adjustable to a fully integrated slider system.

The initial sketching and the five resulting concept ideas that were inspired by the morphological chart can be found in Appendix 19.

15.2 Weighted objectives

The final concept ideas were gathered for a criteria-based evaluation using the *weighted objectives* method (Figure 15.2).

The criteria were derived from the design requirements found through each research area (chapter takeaways) in this report. The weights of the criteria were based on the overall research insights and rider preferences of Chapter 9.

The resulting scores show a clear distinction between the first three and the last two concept ideas. This is a logical outcome, given that

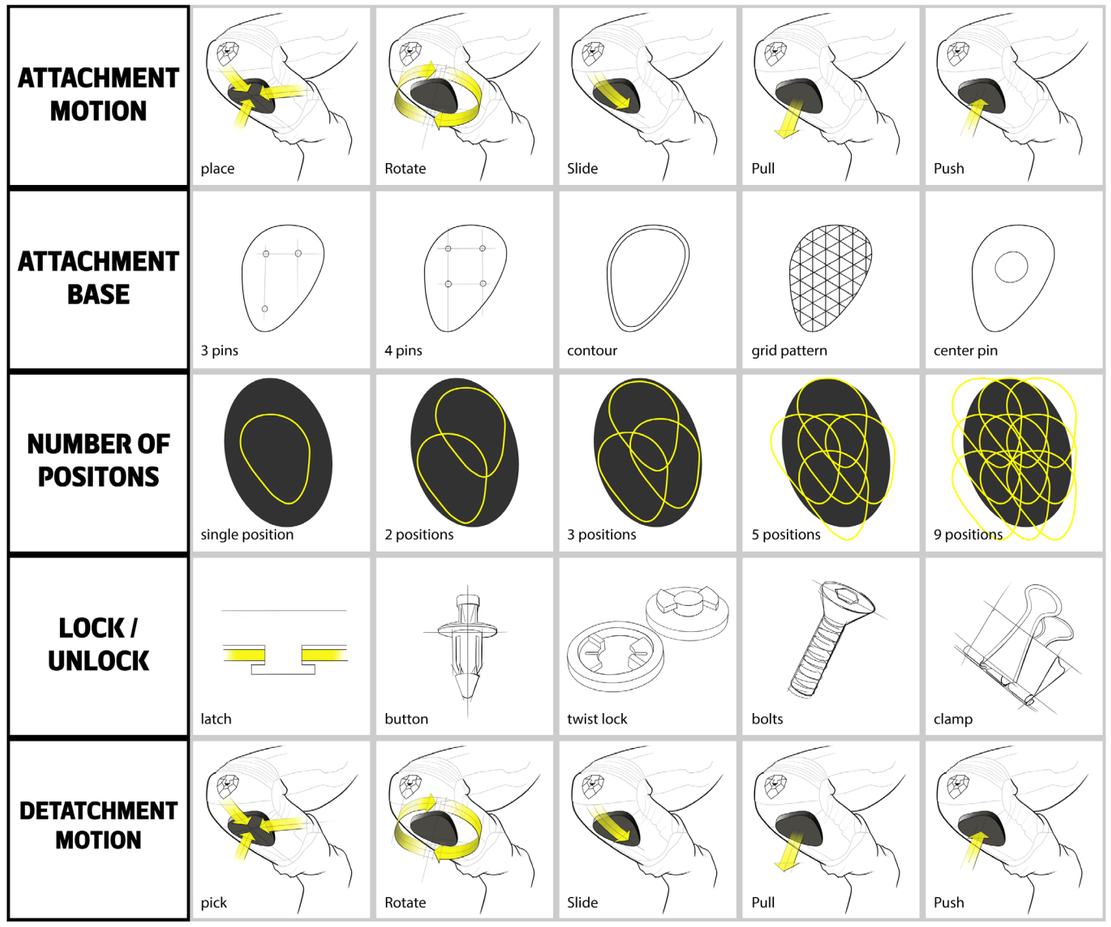


Figure 15.1: Morphological chart of design aspects for a new active slider attachment system.

	Weight		Score	Total		Score	Total		Score	Total		Score	Total		Score	Total
Ease of maintenance	3		7	21		6	18		6	18		4	12		4	12
Support of different user types (prof, semi and amateur)	2		2	4		7	14		8	16		6	12		6	12
Aerodynamics	3		9	27		9	27		9	27		4	12		6	18
Longevity	5		7	35		7	35		7	35		10	50		7	35
Ease of slider replacement	4		8	32		9	36		6	24		7	28		6	24
Innovation level	3		8	24		5	15		7	21		7	21		8	24
Integration of crash slider	3		9	27		8	24		8	24		5	15		6	18
Weight optimisation	3		10	30		9	27		9	27		4	12		5	15
Secure attachment	5		7	35		6	30		10	50		8	40		7	35
Crash safety	5		10	50		8	40		8	40		7	35		6	30
Comfort	5		9	45		7	35		8	40		6	30		6	30
Personalisation	5		5	25		7	35		7	35		8	40		7	35
Position accuracy	5		9	45		6	30		6	30		7	35		7	35
Sustainability	2		8	16		8	16		6	12		7	14		7	14
				416			382			399			356			337

Figure 15.2: Overview of scores for each concept idea in the weighted objectives method.

these two ideas are a lot more bulky and less attractive in general. Their bulkiness takes away from the practicaltiy of the ideas, which can be traced back to the scores on the criteria.

The scores of the first three concept ideas are closer together, with the first idea scoring the highest and being followed by the third and second idea. The highest score has fallen onto the first idea, which is mostly optimised for a tailored solution. Research results have already shown that a tailored solution is beneficial, so to no surprise, this shows in the criteria scores. This first idea for a tailored solution would be able to offer the most clean and seamless integration in the leather suit, but since this integration is a very radical change from the current Velcro system and does not allow a smooth transition to tailored sliders, the third and second idea are a more viable base for the design of a new attachment system. Since their scores are close together and the concept ideas are a bit more similar, they are both selected to combine into a final concept idea.

Idea three locks the puck in place, but requires a tool to release it. Idea two may come loose too easily, so the combined concept idea resulted in a system that locks into place, but must be released by hand before it can be taken off the suit.
This idea formed the start of the concept evolution that was described in the previous chapter. A sketch of the final concept idea can be found on the last page of Appendix 19.

16. EVALUATION AND VALIDATION

16.1 User evaluation

A user evaluation was conducted with the participants from the contact point research (see Confidential Appendix 5). As the riders have a very busy schedule and are always travelling between international circuits, a demonstration video of the Damen Grid System was sent to them in addition to extra visual and annotated material. The riders were asked several open questions about their impression of the system.

The most remarkable about their feedback is the difference in their overall impression.

One of the riders believes the system is easier to use than the Velcro attachment and states that the Damen Grid System is far more aerodynamic, which the rider finds very important during their time on a racing motorcycle.
On an overall positive note, this rider thinks the attachment system is trustworthy and would like to test the system to discover its ease of use and how the system behaves when the slider hits a kerbstone with significant force (Figure 16.1.1).

Figure 16.1.1: Ribbed kerbs (view is opposite from riding direction) (Flickr, n.d.).

On the other hand, the second professional shows an overall critical response, questioning the shape, durabillity and positioning of the slider. In terms of the attachment itself, this rider believes its trustworthyness is okay and similar to that of the Velcro attachment.

An interesting difference is found between the interview answers (Appendix 5) and the answers to the evaluation questions. During the interview, both riders answered that they do not need to adjust the position of their sliders. However, when presented with the design, both riders mention the non-adjustable position of the slider as a disadvantage to the system. This disadvantage is valid when the rider uses several different types of motorcycles for training, yet it seems that one of the riders has a hard time imagining the application of the 3D-scanning for personal slider positioning, leaving them hesitant about the accuracy of the slider position with a (tailored) single placement system.

The Damen Grid System is a very novel innovation compared to the Velcro attachment that has been used for decades. It will thus be helpful to introduce riders to new innovations thoroughly and creating a smooth transition to those who are open to test new concepts.

16.2 Cost estimation

During the conceptualisation phase, it was concluded that the slider system should be injection molded to obtain good product quality with the right material. To get an idea of the production costs of the slider system and the consumer price of a set of sliders, an estimation of the production costs was calculated using an injection moulding price calculator (QDP, 2023), see Appendix 20.
Since Damen works with small batches, the minimum batch size of 500 pieces was selected for this calculation. Production prices were calculated both for PA6 and TPU, the two materials that were considered for the final design earlier in the project. Results are illustrated in Table 16.2.1.

Part	Puck	Puck	Base	Base
Material	PA6	TPU	PA6	TPU
Batch	500	500	500	500
Price	€ 5206,40	€ 6072,07	€ 3812,21	€ 3879,01
Sercice costs	€ 195,-	€ 195,-	€ 195,-	€ 195,-
Production costs slider set	€ 21,61	€ 25,07	€ 16,03	€ 16,30
Production costs system TPU				€ 41,37
Production costs system PA6				€ 37,64

Table 16.2.1: Production costs estimation of pucks and base plates.

Although PA6 is slightly cheaper, the material of the final design was determined to be TPU. The production costs of a complete set of base plates and sliders is in this case €41,37. Since the base plates will be integrated in the suit, they will become part of the suit's price.

With replacement pucks being sold separately, their consumer price can be calculated using a margin of prifit on top of the production price. For mass sales, this margin is ideal around 10-15%, versus 40-45% for more expensive products (Rutger, 2023). The knee sliders of the Damen Grid system are most likely marketed as an innovative and premium product, with a profit margin of at least this 45%. With the production costs of a TPU slider set at €25,07, this would result in a consumer price of €35,01. This price is a middle ground between the different options on the market, however, considering that the puck needs to be moulded using two or three colours, the production price could become slightly higher than the result from the calculator used in this example. The calculated production costs can however be reduced by 30% when producing in a non-western country (HordRT, 2024), leaving room for a bigger profit margin and a good consumer price. Nonetheless, the calculated prices are very reasonable and aligned with the product category.

The downside to injection moulding is the investment in the moulds themselves, which in this calculation requires a capital of rougly €20.000 and 4 times a batch of 500 sliders/base plates. Adjusting the design so that both left and right sides are produced using the same moulds could break the investment costs down to half the costs of mirrored left and right sides. Alternatively, a company with no minimum batch, like HordRT (2024) can be selected for production.
For Damen, creating and producing innovative solutions like the Damen Grid system can boost the succes of the company. Investing in the production of their own unique product line is therefore a realistic step to take, especially with possible negotiations for production.

16.3 Requirement evaluation

Designs can be improved and iterated on infinitely. As mentioned in Chapter 12, design requirements form a very important base and can be used to evaluate wheter a design is feasible and viable after each iteration. Each of the requirements and wishes from the final list in Chapter 12 is therefore evaluated in Tables 16.3.1 and 16.3.2 below.

This requirement evaluation shows that all requirements are positively evaluated, ensuring the viability and feasibility of the concept. In addition, 3 out of 6 wishes are positively evaluated.
To further improve the design, additional requirements and wishes which were gathered during the research phase could be attended in the next iterations and real-life user testing should be included to further confirm that the requirements are met.

	Requirement	Evaluation		Validation / Recommendation
2.4 a	The new slider system must be more durable than the current system.	✓	The case	Base plate integrated under leather, base plate is protected and remains functional after crash.
2.5 a	Sliders must comply to regulations of the FIM (Appendix 2).	✓	The case	No metals are used in the design, so there are no visual disturbances from contact with the tarmac.
2.5 b	The new slider system must not interfere with the European regulations concerning internal protection, impact zones and abrasion resistance (Confidential Appendix 1).	✓	The case	The base plate is attached with a double stitch row according to NEN-EN 17092-2:2020 en. No abrasion tests are required for the slider and base plate materials.
2.6 a	Batch sizes must not exceed 200.	?	Likely	No minimum batch required (HordRT, 2024).
2.6 b	Production costs of slider set must not exceed €30,-.	✓	The case	Estimated calculation at €25,07, see Chapter 16.2.
2.7	Workshop employees and shop assistants must be able to implement the new slider system into the suits' tailoring and assembly.	✓	The case	Demo bike stand can be used in story by shop assitants with 3D scanner. Base plate was succesfully implemented in final prototype.
3.3	The new system must be visually novel and attractive, to catch the interest of potential users.	✓	The case	No bulky or big black Velcro patch, clean look and focus on the slider.
3.5	Repair time for the slider system must not exceed 2 hours.	✓	The case	Timed at 2 hours during prototyping.
4.1	The sliders must be suitable for use by professionals and semi-professionals.	✓	The case	They are both skilled riders with consistent body positioning.
5.3	The slider must be easily replaceable by the rider or their team, within 10 seconds (single slider).	✓	The case	Timed at 6 seconds using the prototype.
7.1	The puck must fully consist of a single material.	✓	The case	100% moulded from TPU, single part.
7.5	The slider must not get stuck to its base as a result of normal slider wear.	✓	The case	No screws that can get stuck. Pins can be lodged out of the base plate if slider is worn down too far.
7.6	The slider system must be minimalistic and simple, excluding offsets from the leather surface (except the puck) for safety.	~	Partially the case	Smooth surface. Solely puck on top of leather. Figure 16.3.1: Improve safety by placing pins towards puck edge and adding puck rim.
9.1	The slider system must not take away any comfort of the suit or cause any type of new discomfort.	?	Very likely	User test (riding) by myself. The system can not be felt. Yet to be experienced in crash scenario.
10.1	The puck of the slider system must lay flat on the tarmac to ensure even wear distribution, safety and durability.	?	Likely	3D-scan implementation shows promising results. It has yet to be tested in real life.

Table 16.3.1: Evaluation of final design requirements.

	Wishes	Evaluation		Validation / Recommendation
2.2 d	The new slider system should enhance safety.	?	Likely	To be tested. Less bulky, no loose Velcro patches.
4.1	The sliders should be suitable for amateur use.	?	Unlikely	Create universal base plate to allow repositioning.
5.2	The slider system should be easy to repair or replace by the riders' team when there is no damage to the surrounding leathers.	X	Not the case	Though self-repair is not possible, the system was designed to be durable. When the leather in front is too damaged, this is the reason for a repair.
8.1	The new system should not be too radically novel.	?	Uncertain	Execute more user tests and evaluations.
9.4	The new slider system should be more aerodynamically improved with regards to the existing system.	?	Very Likely	Confirmed through user evaluation, can be supported and optimised through flow analysis with 3D-scan.
10.2	The position of the active sliders in the leather suit should be tailored by measuring the contact points, for example using 3D-scans.	✓	The case	Contact points are measured using 3D-scans and can be translated to suit using 3D fashion designing software Style3D.

Table 16.3.2: Evaluation of final design wishes.

A first user test proves its efficacy of finding new design aspects to improve (see Figure 16.3.1). During this user test, the prototype was fully functional, however, when the knee protector was not in its proper position, a gap appaered under the slider, as a result of the bended leather under the puck. In a next iteration, the safety of the system can be further improved by placing the pins on the puck further towards the edges and adding a thin rim of TPU around the bottom edge of the puck. By pointing this rim downwards, the leather of the suit can be sandwiched tightly between the puck and the base plate, ensuring that no gaps will appear between the puck and the leather.

With that, it can be concluded that the concept can be both feasible and viable.

Figure 16.3.1: First user test shows new design aspects which call for attention and improvement as a gap shows up between slider and leather.

16.4 Validation

Visual support is presented to further support the feasibility and viability of the design.

Aesthetics
The aesthetic improvement between the Velcro attachment system and the Damen Grid System is presented in Figure 16.4.1. The clean, simple and minimalistic look that was aimed for with the new attachment system becomes evident in this comparison.

Tailoring
To simulate the result of a tailored slider, the contact point measured in the 3D-scan was traced and the slider was aligned to this location on the scan (Figure 16.4.2). The result shows that the slider aligns with the tarmac perfectly, which ensures an even wear distribution, safety and the durability of the slider.

Reliability
Both professional riders felt confident about the reliability of the attachment. This is further supported by the release direction of the slider, which is bottom-up. Forces during the ride are acting in the opposite direction, which is very much top-down. Figure 16.4.3 shows how sliders universally wear down from the inside-top corner of the slider to the outside-bottom corner of the slider.
Tthe inside edge of the slider follows the direction of this force.

Sustainability
Although the industry of motorcycle racing is not sustainable to say the least, this does not take away the importance of considering material use and possibilities for more sustainable product use.
Since the base plate is integrated behind the leather, it should not suffer abrasion as much, allowing it to be re-used when replacing the leather of the suit during repair.
Many sliders are disposed of each racing season, yet the adhesives used make it impossible to recycle these sliders.
The Damen Grid System uses a slider made out of one piece and 100% TPU. This allows the material to be recycled. As PA6 is easier to recycle, offering a PA6 alternative (which has good material properties, costs less and also lasts longer), can be another step towards more sustainable slider use.

Figure 16.4.1: Aesthetic improvement between the current Velcro attachment system (left) and the new Damen Grid System (right).

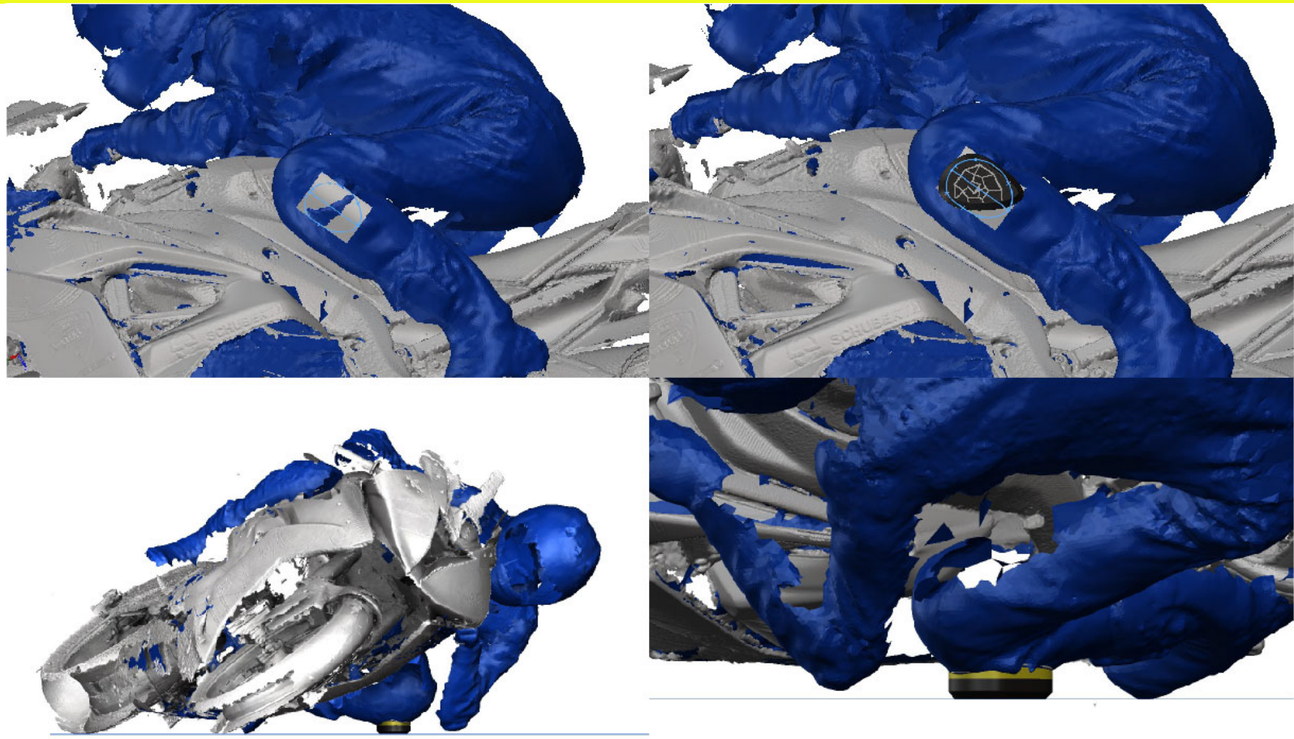


Figure 16.4.2: Visual validation of the result that can be achieved after implementing the Damen Grid System into the leather suit according to the tailoring method defined during this project.

Figure 16.4.3: Universal shear force direction on sliders during cornering.

REFLECTION

17. CONCLUSION

This research and design project has explored wether or not tailored sliders are beneficial and how they should be integrated in the suit for optimal performance quality.

Active tarmac contact points of riders were researched and variables determining the contact point locations were identified. From the results, it was concluded that a rider's contact points of the body with the tarmac are personal and depend on many variables. These variables can be summarised into two causes:

1. Body positioning as a result of anthropometry. This encompasses variables regarding the body proportions of the rider and personal biomechanics: range of motion.
2. Body position as a result of technique or personal style. This comes down to preferences and skill levels. Examples of influencing variables are the position of the feet, the amount of crouching and how far the rider is sitting towards the front, back or edge of the seat.

A slider which is positioned correctly wears down evenly, ensuring durability, good feedback and safety. A personalisable system like the Velcro solution requires trial and error before the ideal position is found and still does not provide enough range of positioning for every individual rider. It is thus beneficial to tailor the slider position, for allowing a safe, durable and realiable knee slider.

Desirability
The Damen Grid system was developed to realise these findings.The concept was designed on a base of extensive context research with a focus on the attachment system, which formed a complementary approach to the research results: The new attachment system supports the tailored position of the sliders by eliminating the problems that can not be solved using a tailored solution (e.g. Velcro occasionally detaches mid-ride) and moves towards a more painless solution.

The importance of the knee slider is stressed by professionals who were interviewed and supported by physics theory. Without a fully functional knee slider, riders can not estimate risks they are taking in an exchange for higher cornering speeds. With a design process focussed on simplicity and reliability, the final product qualities offered by the Damen Grid System are very desirable to the user group, which was confirmed in a user evaluation of the final concept.

Viability
The Design solution proposes many possibilities and directions for further development:

- The implementation of the locking mechanism in a universal base plate, which allows the user to place the slider to multiple positions. This can help users who are hesitant about new innovations gain confidence in the transition from the decades-old Velcro attachment to this novel concept.
- The implementation of the locking mechnism in other locations on the suit, such as in an elbow slider. This eliminates issues associated with the current attachment of elbow sliders. For example, the slider would no longer be stuck in the base plate like the current elbow sliders are when the screws that attach them are worn down.
- The concept also offers possibilities for weight & material use optimisation for performance and sustainability through minimal material use and recycling.

User evaluations show the desirability to test the concept in a real use scenario. Ensuring that the concept prototype is developed thoroughly will most likely result in a positive testing experience, stimulating the viability of the concept.

Feasibility
In the final Damen Grid System concept, the feasibility is ensured through preparing the design for injection moulding, the production technique used for most knee sliders on the market. This technique ensures product quality, which in turn assists the desirability and viability of the product. The simple design allows for easy injection moulding ensuring full feasibility in terms of production and quality.

To ensure the feasibility of the concept for a smaller company like Damen and reduce investment costs from 4 different production moulds to 2, the design may be adjusted for use on either leg.

The final concept of the Damen Grid System supports the variety in the user's body and riding technique and was validated both by user and requirement evaluations as a reliable and user friendly system. It integrates seamlessly with the leather suit, increasing aerodynamics, safety, consistency, durability and aesthetic quality.
This concludes the completion of the project with a promising and succesful result.

Recommendations for further development and implementation support the potential of these project results.

18. RECOMMENDATIONS

With the project coming to an end, several recommendations can be made to support further innovations, developments and implementations around the research executed and design concept presented. These could help bring the concept to the market as a fully functional end-product.

Research amplification
Executing similar research to the contact point research presented in this report, but on a bigger scale, is suggested to further define the influence of the many different variables associated with body positioning and active tarmac contact points.
Using different motorcycle types with the same users is advised as an additional step. Each variable must be as stable as possible, except the variable that is being researched. This means that participants will need to complete the tasks multiple times in order to test the influences of different chassis measurements.

Using many more participants with different body proportions and more riders with similar body proportions will help create a database in which scans can be aligned and riders can be selected for comparisons based on what variable is researched.

Implementation
Sewing pattern
In the current pattern designs of Damen's leather suits, the two layers of leather on the knee area are stitched together (see Figure 18.1). When the ideal slider placement crosses this seam, the base plate can not be placed between these two layers. Two different solutions are suggested for succesful implementation:

1. Adjust the sewing pattern, so that there are no seams in the general area the slider is usually positioned in.
2. Create separate seams for the top and bottom layer, leaving the two layers separate, so that the base plate can still be stitched to the outer layer.

The first of these options is recommended for the best implementation of the attachment system.

Measuring appointments
Both the amplificated research and the final implementation of the design would benefit from the creation of a universal motorcycle stand similar to the demo bike stand used in this project, which can be used to support any motorcycle for 3D-scanning the rider. To implement the design solution, the production could use the following steps:

1. Measuring appointment where body measurements of the rider are collected for a custom suit.
2. Production of the suit. The lower leg assembly is limited to the bottom layer of leather.
3. 3D-scanning appointment with a fitting for the custom made suit for determining the contact point and making adjustments if necessary.
4. Integration of tailored base plate and final production steps of the suit.

Design focus areas
In the design areas which were not the focus of this project, there are great opportunities for improvements to the final concept:

Weight & Material use optimisation
The yellow section of the puck can be hollowed to minimize the weight the rider carries with them during a race with strict weight regulations. At the same time, this reduces waste after the end of the race. The material can also be optimised to last precisely one race to reduce material waste associated with the replacement of sliders after each race for a fresh measuring device.

Figure 18.1: A sewing pattern adjustment is recommended to acommodate smooth integration of the system in higher positions.

Aerodynamics
As mentioned in Chapter 5, aerodynamic details are valuable to professional riders. To no surprise, they have become an increasingly popular topic in MotoGP, where bike fairings are carefully analysed and designed to optimize airflow for better performance (e.g., less aerodynamic drag and more downforce to prevent unwanted wheelies) (MotoGP, 2021b)(MotoGP, 2022). Flow simulations and shape optimisations of the puck can be executed to increase the concept's aerodynamic performance even more.

Modularity
Different versions of the puck can be designed to supply different user's needs. Interchangeable puck designs can include different materials, shapes, hollow vs non-hollow, thicker and thinner sliders, rain optimised sliders and different aesthetic designs.

A more modular base plate could be considered as a solution for training with different bike types, allowing multiple tailored positions to be recorded and implemented in the base plate.

Real use context testing
Last but not least, user testing in the professional use context is advised to optimise the design and test its behaviour with different kerb stones, tarmac edges and in crash scenario's, as well as to find out the best ways of introducing this novel system into the highly critical use context.

19.PERSONAL REFLECTION

Leading a research and design project like this was something I knew was completely out of my comfort zone. To conquer this challenge of stepping into a leading role, I was determined to radiate my passions through this project. Even though I have had moments where I was super nervous about contacting different stakeholders and professionals, I am grateful that I got to learn first hand how important it is to get the right people together and what a difference this makes in the quality and value of both the research and design.

Before I started this project, I did not as much consider myself a team player and proposed the goal to develop the skills I need to function as an individual designer. For example, I wanted to improve my planning and organising skills:
Planning and executing different collaborative activities in a highly constrained timeframe, such as the 3D-scanning, interviewing and prototyping was quite a challenge and I often felt guilty asking people to put time and effort in my project. In this area, the project has taught me to hesitate less about the details of the planning and to start by contacting the people I wanted to involve, followed by building my own planning around their availability. Although it did not always come together perfectly, I am glad to say I managed to fill in any gaps in my plan and was able to find a flow within the many different project focusses that were running simultaneously.

Multitasking between the different project aspects, such as organising the scanning research, building the setup, writing a report, doing context research, making visits, interviewing and so on used to be one of my biggest struggles in previous design projects, as I often became overwhelmed by the many different things that needed to be done. This used to cause serious mental blocks, which is exactly what I aimed at pushing through during this final project. I took on this project wanting to learn how to keep the project rolling steadily and minimising the amount of time pressure and stress.
I was surprised to find that my biggest fear - working on many things at the same time - turned out to be my way to succeed in preventing mental blocks. By pausing an area that I got stuck on and working on a different area, I could keep moving forward. Most of the time, when I came back to where I left off earlier, I managed to continue with a 'clean visor' and work through the issues that held me back earlier. Looking back, I am proud to say that this project has mostly felt less stressful than many other courses I followed during my time at the faculty of IDE.

Not my proudest moment were the last few weeks, which I had planned to spend on a final sprint to finish the project confidently.
Due to private circumstances, my emotional state had changed and taken control over the last few weeks, taking me out of the project flow and keeping me from doing my final sprint. Although gaining back the project flow I had achieved before was a challenge too big, this event tought me the importance of communicating and taking action.

Lastly, what I wanted to learn more about is who I am as a designer. After starting the project, I very quickly found myself looking for input and feedback from other stakeholders. So, against my initial belief, I learned to appreciate the design team that I did not have during this project. In a future workfield, I would therefore seek to take on much more of a team player role than I thought I would when I started this project.

It was an honour to work with world-class riders and I am beyond grateful for the opportunity to apply what I have learned in the past years of my studies in this niche workfield. It has been an inspiring end to my studies and I am excited to further explore the worlds of design and motorcycle racing in the years to come.

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APPENDIX

A1 – PROJECT BRIEF

7095

TU Delft

IDE Master Graduation Project

Project team, procedural checks and Personal Project Brief

In this document the agreements made between student and supervisory team about the student's IDE Master Graduation Project are set out. This document may also include involvement of an external client, however does not cover any legal matters student and client (might) agree upon. Next to that, this document facilitates the required procedural checks:

- Student defines the team, what the student is going to do/deliver and how that will come about
- Chair of the supervisory team signs, to formally approve the project's setup / Project brief
- SSC E&SA (Shared Service Centre, Education & Student Affairs) report on the student's registration and study progress
- IDE's Board of Examiners confirms the proposed supervisory team on their eligibility, and whether the student is allowed to start the Graduation Project

STUDENT DATA & MASTER PROGRAMME

Complete all fields and indicate which master(s) you are in

Family name	Houtepen
Initials	N.C.A.
Given name	Nola
Student number	5016347

IDE master(s) IPD ✓ DfI SPD

2nd non-IDE master

Individual programme *(date of approval)*

Medisign

HPM

SUPERVISORY TEAM

Fill in he required information of supervisory team members. If applicable, company mentor is added as 2nd mentor

Chair	Dr. ir. Marijke Dekker	dept./section	Applied Ergonomics & design
mentor	Ir. Anna Ruiter	dept./section	Applied Ergonomics & design
2nd mentor	Maarten Alewijn		
client:	Damen motorkleding		
city:	Breda	country:	Netherlands
optional comments	Marijke Dekker has experience in the workfield of comfort & wellbeing and the design of protection and rescue equipment, with an IPD background. Anna Ruiter has experience in DFI, design aesthetics, mobility & transport and understanding lifestyles, ensuring heterogeneity.		

! Ensure a heterogeneous team. In case you wish to include team members from the same section, explain why.

! Chair should request the IDE Board of Examiners for approval when a non-IDE mentor is proposed. Include CV and motivation letter.

! 2nd mentor only applies when a client is involved.

APPROVAL OF CHAIR on PROJECT PROPOSAL / PROJECT BRIEF -> to be filled in **by the Chair** of the supervisory team

Sign for approval (Chair)

Name *Marijke Dekker* Date *22 maart 2024* Signature

CHECK ON STUDY PROGRESS

To be filled in **by SSC E&SA** (Shared Service Centre, Education & Student Affairs), after approval of the project brief by the chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total _____ EC

Of which, taking conditional requirements into account, can be part of the exam programme _____ EC

X	**YES**	all 1st year master courses passed
	NO	missing 1st year courses

Comments:

Sign for approval (SSC E&SA)

Name _____ Date 26-03-2024 Signature _____

APPROVAL OF BOARD OF EXAMINERS IDE on SUPERVISORY TEAM -> to be checked and filled in by IDE's Board of Examiners

Does the composition of the Supervisory Team comply with regulations?

YES	V	Supervisory Team approved
NO		Supervisory Team not approved

Comments:

Based on study progress, students is …

V	**ALLOWED** to start the graduation project
	NOT allowed to start the graduation project

Comments:

Sign for approval (BoEx)

Name _____ Date 26/3/2024 Signature _____

Personal Project Brief – IDE Master Graduation Project

Name student Nola Houtepen **Student number** 5,016,347

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT

Complete all fields, keep information clear, specific and concise

Project title Designing a tailor-made solution for external protection in custom leather motorcycle suits.

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

Damen motorkleding specializes in providing tailor-made clothing to motorcyclists and sponsors competitive riders from various countries with their tailor-made onepiece race suits. The leather suit (Fig. 1), personalized using body measurements, provides the most suitable protection on the circuit. For this purpose, external protectors, called 'sliders' are added to the exterior of the suit. External protection ensures that the rider does not start tumbling after falling on the tarmac, but instead slides forward, decreasing the risk of serious injuries.

Another type of slider is used to protect the rider when taking corners. Riders hang off the bike with the goal to take the corners as fast as possible. When hanging on the inside of the bike, riders often scrape their knees and elbows over the tarmac (Fig. 2A). Thick, replaceable pucks are added on the knee and elbow to prevent abbrasion of the leather and body of the rider (Fig. 1).
Overtime, riders have learned to use these bodily contact points to gauge their distance from the maximum possible lean angle and control the bike precisely, to keep it from losing traction and dropping too low.

Riders in Damen suits become the company's number one advertisement. It is thus important for Damen to show that their product can deliver the comfort the rider needs to win a race, but at the same time does the job of protection.
The ongoing development of protection is thus a shared interest for company and rider and could help both stakeholders stand out.

➔ *space available for images / figures on next page*

introduction (continued): space for images

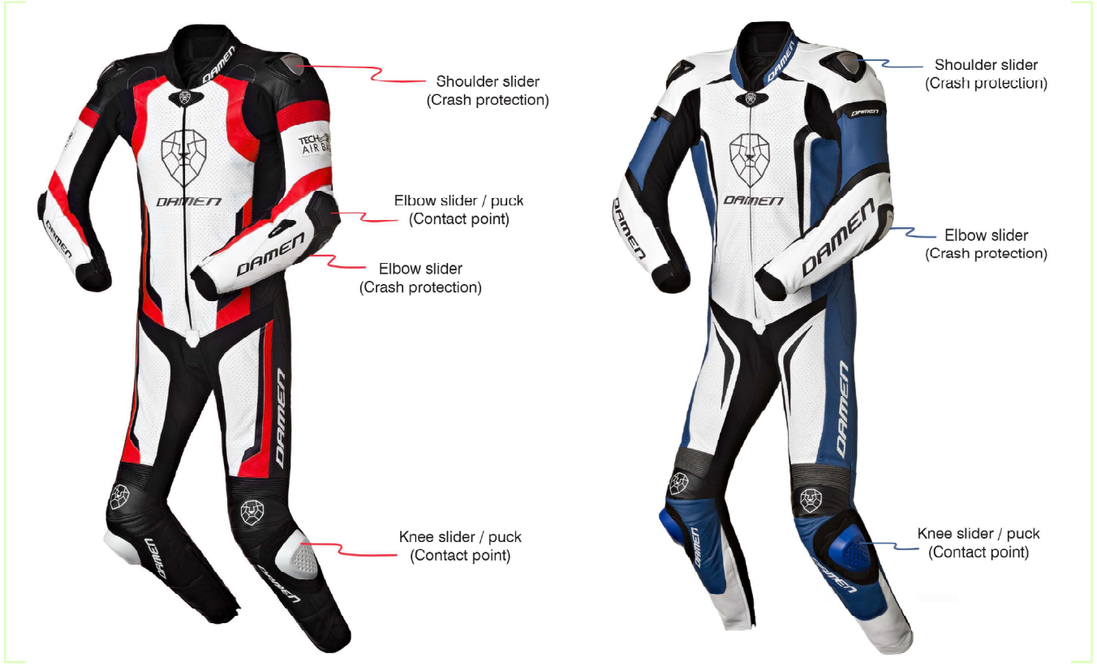


image / figure 1 Damen 'Tailor-made Race overall', including elbow puck (left) and excluding elbow puck (right).

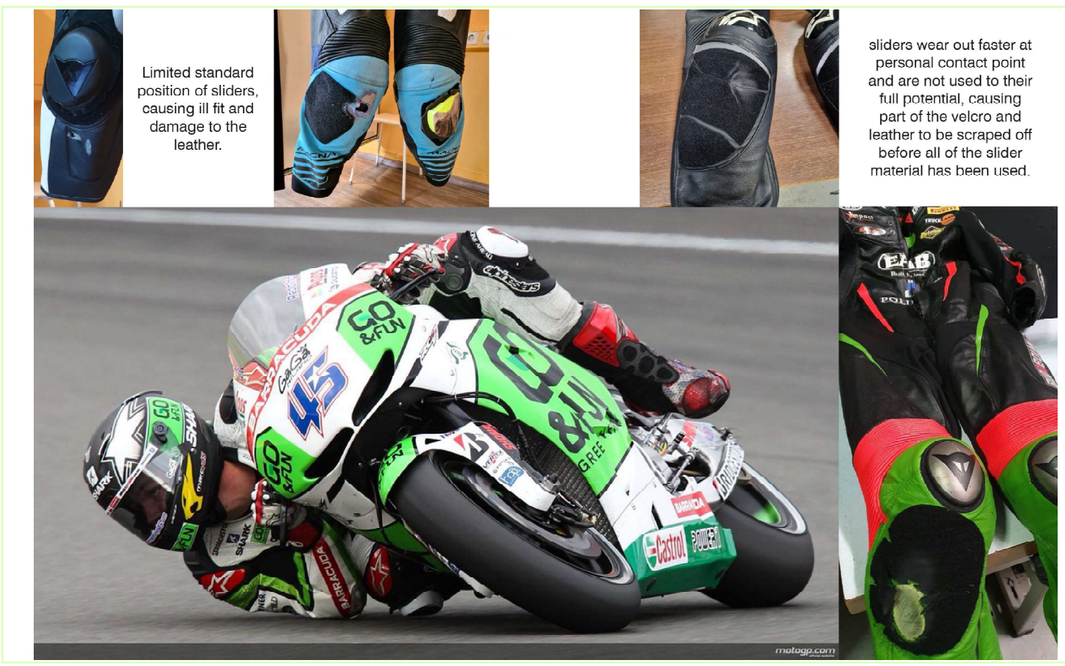


image / figure 2 A) Rider bringing knee, elbow and shoulder down to the tarmac. B) Suit damages caused by slider issues.

DESIGN FOR our future

TUDelft

Personal Project Brief – IDE Master Graduation Project

Problem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.
(max 200 words)

Tire grip has increased significantly over the years. Therefore, the maximum lean angle of the bike has also become sharper, bringing riders increasingly closer to the ground when hanging beside their bikes in corners. As a result, riders now occasionally manage to scrape their shoulders over the tarmac.

This trend of increasing tire performance and lean angle goes hand in hand with the technique of the riders, who keep developing their own style over time. Every rider has different preferences, body dimensions and different ranges of motion, resulting in varying body positions and tarmac contact points. Still, slider placement is very much standardized, which can result in insufficient, inconsistent or unstable contact points and damage to the suit. For example, velcro patches are used to stick on replaceable knee pucks. Currently, slider placement and design is estimated by the wear and tear of previous versions. Frequent suit damages caused by inaccurate puck placement prove this solution insufficient (Fig 2B).

For precise control, it is important that pucks are positioned in the exact spots where the rider makes contact with the tarmac. The slider can make the difference from a fall to a record-breaking corner speed, as a stable contact point can give professionals the power to keep the tires from losing traction and the bike from dropping too low. A tailor-made solution could thus increase the performance of the rider and lifespan of the suit, as well as form a better protection.

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence) As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Design a tailor-made solution for external protection in custom leather motorcycle suits, to support sharper lean angles and variety in rider body and riding technique, and to improve suit lifespan, for professional and amateur track riders, in the context of professional and amateur motorcycle track racing.

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

To start, I want to broaden my knowledge by researching the existing standard- and brand owned protectors that are available on the market. Besides this, I want to gain insight in the different user groups (amateur and professional track rider), context of use, user needs for the sliders in the leather suit and trends and tactics regarding riding technique. I want to gain knowledge via interviews, observations and some desktop- and field research, during which I can get to know the stakeholders.
I want to create a test-setup that allows users to take on their riding position. With this setup, I aim to learn more about the range of contact point locations between different users and the relations to their anthropometry and riding style.

I then want to iterate towards a design solution by creating, testing and evaluating multiple prototypes, with the help of Damen. To be able to evaluate the iterations I would like to research the relevance and use of different technologies and materials, the acceptance of design aesthetics and functionality in the racing culture and ergonomic qualities. To evaluate the final design, I want to use the test-setup in a user test with the final prototype.

Project planning and key moments

*To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a **kick-off meeting**, **mid-term evaluation meeting**, **green light meeting** and **graduation ceremony**. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).*

Make sure to attach the full plan to this project brief.
The four key moment dates must be filled in below

Kick off meeting 19 Mar 2024

Mid-term evaluation 17 May 2024

Green light meeting 12 Jul 2024

Graduation ceremony 23 Aug 2024

In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project

Part of project scheduled part-time	
For how many project weeks	
Number of project days per week	

Comments:

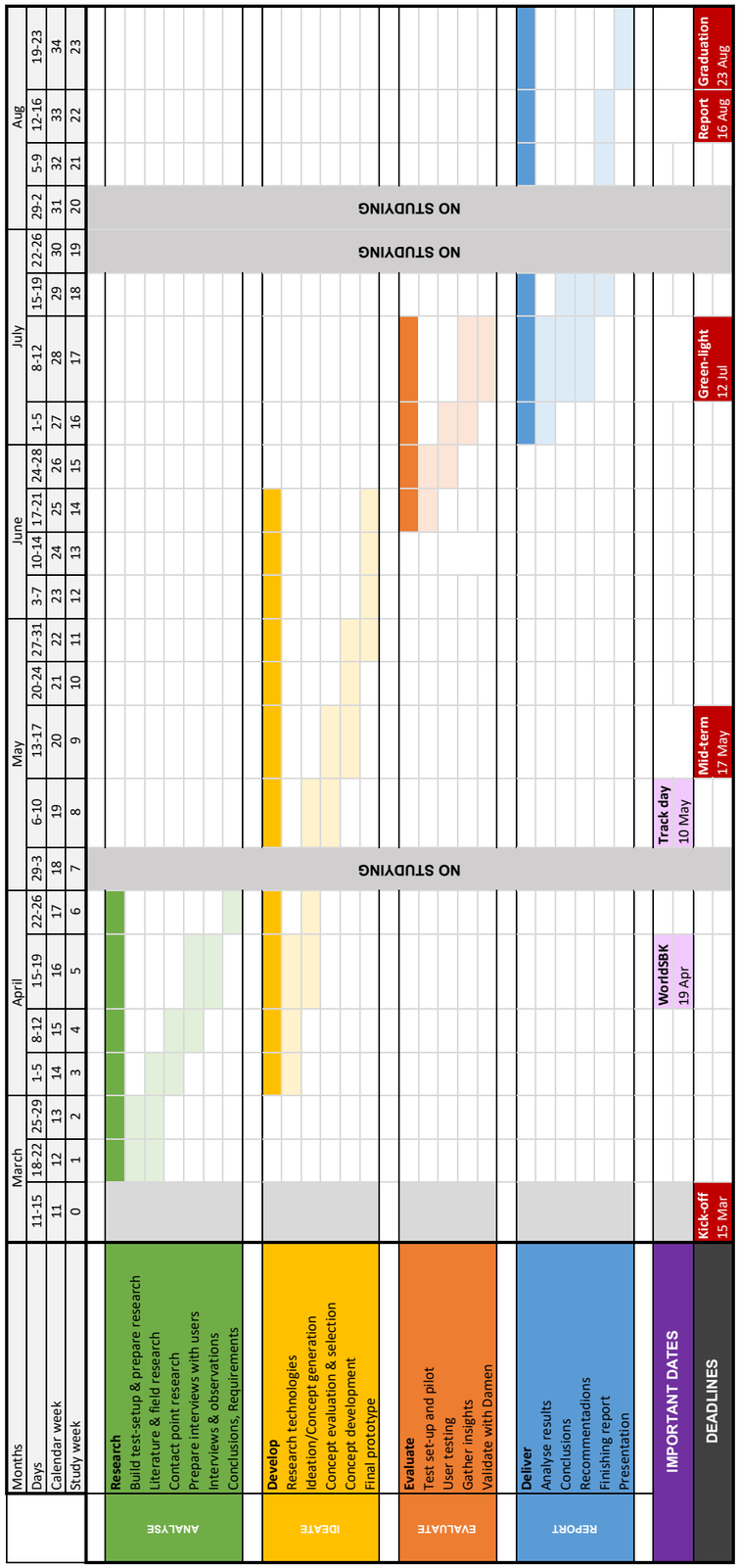
Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.
(200 words max)

It is my future goal to combine my passions for motorcycles, sewing, embroidery and practical garments with industrial design in the form of tailor-made solutions. Hence, I would like to explore the workfield around motorcycle clothing, to hopefully continue to grow in the field after my graduation. I see this graduation project as the first step to combining my passions and my professions and to get the most out of my graduation. I would like to gain more knowledge about the profession of motorcycle racing, the innovation behind the gear that the riders wear and the world around this racing sport.

Besides this, graduation is the perfect opportunity to further develop the skills I need to function as an individual designer. Besides improving in terms of planning and organising, I would like to use this opportunity to get a better idea of who I am as a designer and to piece together design methods that I learned at the faculty into a process that suit me. As I often feel stuck in my design processes, I would like to learn how to push through my mental blocks and keep my process rolling, by getting out of my comfort zone.



A2 – FIM REGULATIONS 2024

2.10 PROTECTIVE CLOTHING AND HELMETS

2.10.1

Riders must wear a complete leather suit with additional leather padding or other protection on the principal contact points, knees, elbows, shoulders, hips that conform to EN1621-1:2012.

The use of sliders (specific parts of the riders safety equipment, either permanently fixed or removable, intended to make regular contact with the track surface to assist the rider while cornering), is permitted on the knees, elbows or any other parts of the race suit, where it is deemed necessary. They must not be manufactured from or contain any material that when in contact with the track surface may cause visual or other disturbance to other riders.

The use of an airbag is compulsory. The equipment must be presented to the technical control for inspection prior the start of the event.

2.10.2

Linings or undergarments must not be made of a synthetic material which might melt and cause damage to the riders' skin.

2.10.3

Riders must also wear leather gloves and boots, which with the leather suit provide complete coverage from the neck down.

2.10.4

Leather substitute materials may be used, providing they have been checked by the Chief Technical Steward.

8. Fuel Handling Safety

- The use of anti-static mats and grounding wrist straps is mandatory when filling fuel containers used for transferring fuel to and from motorcycles.
- The use of approved fuel fillers/fuel dumps is mandatory when adding or removing fuel to/from motorcycle fuel tanks.
- All fuel handling equipment must be approved by the Technical Director.

2.4.5.2 Rider's Safety Equipment

1. It is compulsory that each contracted rider must begin each race event with at least two complete sets of undamaged safety equipment. A complete set of safety equipment shall contain:

- Helmet
- Leather Suit, 1-piece
- Gloves
- Boots
- Back Protector
- Chest Protector

The equipment must be worn, correctly fastened, at all times during on-track activity. **In certain cases (for example the Airbag system) the equipment must be present and functional at least at the start of each track session. The decision of the Technical Director is final in matters of rider equipment.**

The only purpose of any part of the rider's race suit, boots and gloves should be to protect the rider in an incident. Therefore, any part of these items of equipment that is deemed to be solely for the purpose of aiding the rider's aerodynamic effect will not be permitted. The decision of the Technical Director will be final in determining what constitutes an item solely for aerodynamic effect.

- Each individual design or model that has passed the tests will be self-certified by the manufacturer, using the official document, stating that the item conforms to the FIM requirements.
- A copy of this compliance certificate must be sent to the MotoGP Technical Director (Danny Aldridge danny@irta.org.uk) and to the FIM Racing Homologation Programme (frhp@fim.ch).
- For leather suits only, the manufacturer must complete and maintain the "Riders Race Suit Database" file for each of their riders.
- This database must be submitted to the MotoGP Technical Director, and updated each time a leather suit is supplied to or withdrawn from a rider.
- The Technical Director and the rider also have the right to withdraw a race suit from the database.

c) Standards for Leather Suit, Gloves, Boots, Back & Chest Protectors

i) Leather Suit

- Shall be constructed from leather or an equivalent material which satisfies the requirements of Table 1, column 1.
- The use of abrasion-resistant stretch material is permitted up to a maximum of 50% of the surface area, provided that the requirements of Table 1, column 2 are met**, but stretch material is forbidden for the Zone C indicated in figure 1**.
- The use of sliders (specific parts of the riders safety equipment, either permanently fixed or removable, intended to make regular contact with the track surface to assist the rider while cornering), is permitted on the knees, elbows or any other parts of the race suit, where it is deemed necessary. They must not be manufactured from or contain any material that when in contact with the track surface may cause visual or other disturbance to other riders.
- The main closure zip must be an autolock system meaning when the zip puller is flat the zip cannot come undone until pressure is applied to the puller.

- All suits must be fitted with a clasp system to secure the zip in position when fully closed. The system must work in such a way that the zip cannot come undone until the clasp has been released. In determining the legality of any such system, the judgement of the Technical Director will be final.
- Shall contain armour certified to EN1621-1:2012 in the shoulders, elbows, knees, and legs.
- It is mandatory for the leather suit to be fitted with an Airbag system, with the following requirements:
  - All Airbag systems must be approved according to clause b), above.
  - Every rider must start each track session with a functional Airbag system. Once the airbag has been deployed, the responsibility for continuing the practice or race rests with the rider (For the purposes of this regulation, MotoGP Free Practice **2**, Q1, Q2 are considered as one track session).
  - For substitute or replacement riders, the use of an Airbag system is recommended for their first event of the season, and is compulsory for any further events of that season.
  - For MotoGP Wild Card riders the use of an Airbag system is compulsory. Wild Card riders equipment must be presented to Technical Control for inspection prior to the start of the event.

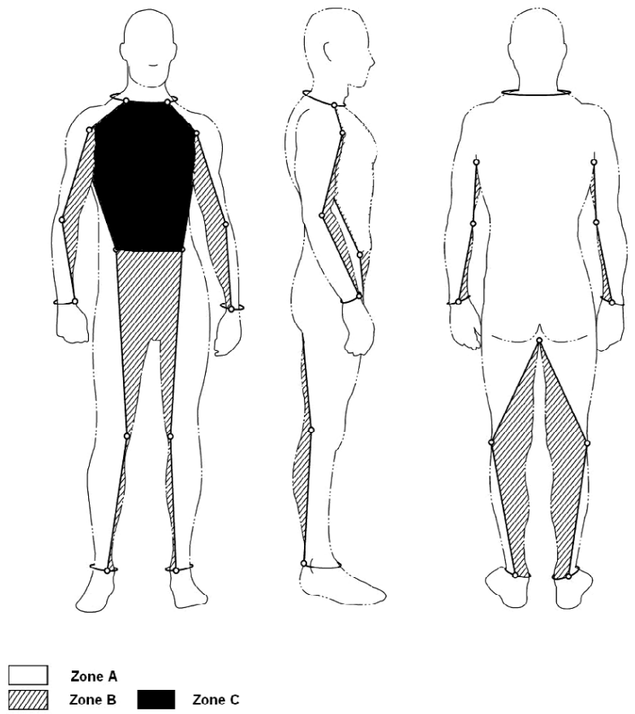
ii) Gloves

- Shall be constructed from leather or an equivalent material which satisfies the requirements of Table 1, column 3.
- Shall have a cuff length sufficient to overlap the leather suit by at least 50 mm.
- Shall have a means of fastening to secure them to the hand (an elastic closure alone is not acceptable).
- Shall have suitable knuckle protection.

MotoGP

Seam (in Newton/ millimetre	**EN17092-1 (for suit & boots) EN13594 (for gloves)**	**≥12**	**≥8**	**≥8**	**≥15**	**≥15**

The zones A, B and C are defined in the drawings hereunder.



4. Post-crash Riders Safety Equipment Check

   After a crash the Technical Director may at his discretion request that the rider's safety equipment is checked prior to the start of the following practice session, warm up or race.

   In the event that any item of equipment is considered, by either the Technical Director or the representative of the manufacturer of the item, to be too damaged for use on track, the rider will be required to replace or repair the item before being permitted on track.

MotoGP

A3 - DAMEN BRAND ANALYSIS VALUES & IMAGE

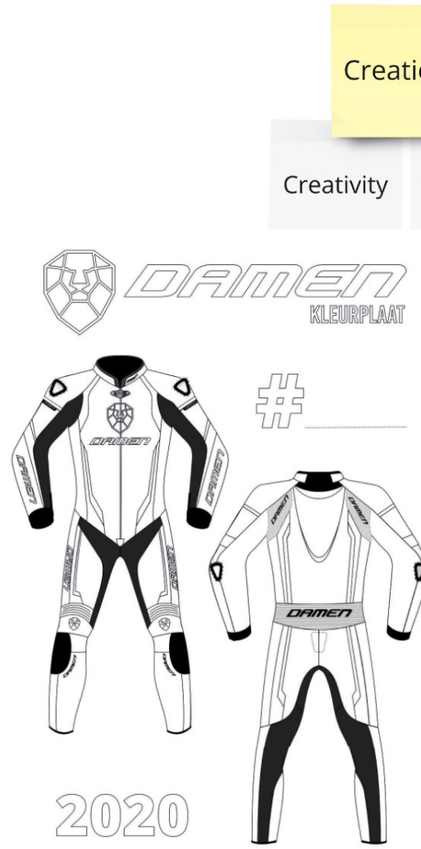
BRAND VALUES

Started as Family business
Small international range (NL, BE, D) which is growing to countries further away via mouth to mouth recommendations. Power of the company is to work on small scale to stay customer-focussed.

Many slogans:

- Functional motorcycle equipment
- The power of tradition
- Pole position in maatwerk

- Safety at any speed
- Tailor made by Damen
- Your safety, our passion
- Speed Passion Safety



Creation

Creativity

Traditional

Comfort

Uniqueness

Freedom

Accuracy

Support

Persistence

Consistency

Passion

Service

Speed, passion, safety → Creation, Comfort, Persistence

Safety and comfort from start to end. Creating unique pieces together.

Quality & Fit

16 dec 2012 #7

Maatpak van damen is top. Ik heb er twee laten maken, eentje voor op de weg (combie)is nu 13 jaar jong en ziet er nog top uit en ziet ook nog goed. De andere is een overall voor op circuit en heb ik nu 4 jaar en is ook nog super. Je moet ze natuurlijk wel goed onderhouden. Als je een keertje valt en ze moeten gaan repareren dan vindt ik ze wel duur!

Laatst bewerkt: 16 dec 2012

16 dec 2012 #19

Damen Leathers heeft top service en super pakken, ik ben met mijn pak een x of 9 gevallen met de racer en nog veeeeel vaker met de minibike en is nog steeds goed veilig ect als er wat is met je pak dan word je goed tewoord gestaan en er is vaak wat te regelen.

kortom gewoon doen!

16 dec 2012 #6

Mijn eerste twee maatpakken waren van MJK, mijn laatste van Damen.

Volgende wordt zeker weer Damen.
Veel soepeler en zit veel lekkerder op de motor.

Leer van MJK voelt idd wat harder maar weet niet of dat ook meer veiligheid betekent.
In ieder geval minder comfort.

Service is trouwens bij beide zaken prima.

Weet niet of je een standaardmaat hebt, maar ik zou niet in een confectiepak willen.

16 dec 2012 #7

Maatpak van damen is top. Ik heb er twee laten maken, eentje voor op de weg (combie)is nu 13 jaar jong en ziet er nog top uit en ziet ook nog goed. De andere is een overall voor op circuit en heb ik nu 4 jaar en is ook nog super. Je moet ze natuurlijk wel goed onderhouden. Als je een keertje valt en ze moeten gaan repareren dan vindt ik ze wel duur!

Laatst bewerkt: 16 dec 2012

Local Guide · 186 reviews · 400 foto's
★★★★★ 6 jaar geleden
Heel fijn geholpen bij het uitzoeken van een nieuw motorpak. Alle tijd, kopje koffie erbij en goed advies. Het pak zit als gegoten. Zeker een aanrader voor de veeleisende motorrijder.

H 66 reviews · 13 foto's
★★★★★ 7 jaar geleden
Een paar maanden geleden een nieuwe motorbroek besteld bij Damen omdat mij Revit (goretex) gewoon lek bleek te zijn.
Na bijna 8 weken komt de broek aan en uiteraard meteen aan...
HELAAS, de rits blijkt niet op de juiste wijze vast gezet (gulp) en de hele rits komt gewoon los.
Uiteraard contact opgenomen. Men vroeg mij de broek terug te sturen.
Na ruim 1 week komt de broek gerapareerd retour maar zag er NIET uit.
Gelukkig had Thomas van Dartel (medewerker) dat zelf ook gezien en hij bood uit zichzelf aan een nieuwe broek te leveren.
Gelukkig kon ik de gerepareerde broek blijven gebruiken totdat de nieuwe binnen was.
Inmiddels bijn 4 maanden na eerste bestelling, maar.... ik heb hem.
Mijn echter DAMEN broek. Hij zit perfect. Echt een absolute aanrader,
Wellicht een fractie duurder dan een GoreTex Revit, maar heeeeel veel beter van kwaliteit.

Dankjewel Thomas voor het zo netjes oplossen

2

M 4 reviews
★★★★★ een jaar geleden
Inmiddels rij ik een paar maanden met een motorpak van Damen.
Voor ik een review plaats wilde ik eerst weten hoe het pak zich houdt in verschillende weerstypen. Inmiddels heb ik warm en koude, regen en stormwind meegemaakt. Met 25.000 a 30.000km per jaar mag ik mijzelf wel een frequente motorrijder noemen.
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Fantastisch geadviseerd! Motorpak met airbagvest aangeschaft. Geen moment spijt van. Inmiddels 12000km uiterst comfortabel mee gereden. Zit lekker, fijne ritsen, goede bewegingsvrijheid. Lekker warm in de winter, lekker koel door de vele ventilatie in de zomer. Superhandige magneetsluitingen.
Als je veeleisend bent, goed geadviseerd wilt worden en waar voor je geld wilt hebben beveel ik Damen 100% aan.

Damen Motorkleding / Top Skin Trading bv (eigenaar)
een jaar geleden
Beste , wat een mooie en uitgebreide review! Wat ontzettend fijn om te lezen dat je zo tevreden bent met onze kleding en het Airbag vest van Alpinestars, de beste keuze die er is! We wensen je heel veel mooie en veilige kilometers toe in het nieuwe jaar!

MVG
Team Damen Motorkleding

9 reviews · 2 foto's
★★★★★ een jaar geleden
Laatst een eendelig maatpak laten maken. Een absolute topzaak als het aankomt op maatpakken. Persoonlijke service, ze nemen de tijd voor je, ook tijdens de productie ('kan ik toch nog een logo wijzigen?').

Vergeleken met mijn andere motorpakken (allen confectie) valt mij vooral de bewegingsvrijheid en souplesse van Damen op. Bovendien maken ze mooie (persoonlijke) lederlogo's.

Absoluut een aanrader!

Damen Motorkleding / Top Skin Trading bv (eigenaar)
een jaar geleden
Wauw, Wat een mooie review, dank je wel!! Zo blijven we gemotiveerd. We wensen je heel veel mooie en veilige kilometers toe met je Damen pak. Nogmaals dank namens Team Damen Motorkleding

W 5 reviews
★★★★★ 3 maanden geleden
Vakmanschap van de medewerkers staan op een zeer hoog peil.

Damen Motorkleding / Top Skin Trading bv (eigenaar)
3 maanden geleden
Dank je wel voor de mooie review . Heel fijn om te horen, dit doet ons goed!

B 3 reviews
★★★★★ een jaar geleden
Van aanmeten tot levering top geregeld kan niks anders zeggen.
Ben met mn 2.02mtr lengte heel blij met mn maatwerk pak.
Top kwaliteit en top pasvorm.
Damen motorkleding bedankt.
Mvg

1

Damen Motorkleding / Top Skin Trading bv (eigenaar)
een jaar geleden
Beste , dank je wel voor de mooie review! Fijn om dit te lezen, doet ons goed en we blijven daarom ons uiterste best doen. Hele fijne feestdagen en een mooi 2023!

MVG
Team Damen Motorkleding

Mega blij met mijn pak! Eindelijk is een pak wat wel goed zit. Echt klasse👌

14 w Leuk Beantwoorden

2

Auteur
Damen Motorkleding
gave actie foto!! En super leuk en fijn om te horen 😃 Hier doen we het voor!

zo ik ben uitbesteed. Alles voor de pro. En geen gezeur NL product..

13 w Leuk Beantwoorden

raadt **Damen Motorkleding** aan.
15 maart 2019 ·
Ein sehr zu empfehlender Hersteller von maßgeschneiderten Lederkombis. Super Beratung und Vermessung vor Ort in Breda. Sehr kompetente Leute, man fühlt sich sehr gut aufgehoben.
Qualität ist spitzenmäßig und das Preis-Leistungsverhältnis stimmt absolut!
Würde dort immer wieder meinen Anzug schneidern lassen. 👍👍👍

Vertaling weergeven

1

Knowledge, experience

13 reviews
★★★★★ een jaar geleden
Ging ff kijken wat ze hadden na een paar andere zaken bezocht te hebben. En dan exact wat ik wilde aantreffen. Met veel deskundigheid, oog voor detail en niet onbelangrijk klantgerichtheid, perfect geholpen.

Damen Motorkleding / Top Skin Trading bv (eigenaar)
een jaar geleden
Dank je wel voor de mooie review!

5 reviews
★★★★★ 3 maanden geleden
Vakmanschap van de medewerkers staan op een zeer hoog peil.

Damen Motorkleding / Top Skin Trading bv (eigenaar)
3 maanden geleden
Dank je wel voor de mooie review . Heel fijn om te horen, dit doet ons goed!

9 reviews · 29 foto's
★★★★★ 3 jaar geleden
Great place! Always give practical advice. Very helpful and knowledgeable people. Love their race suits!!! 🤩
Always doing their best to accommodate customer requests.
Plus I don't speak Dutch and they all speak great English with me 👍
Vertaling bekijken (Nederlands)



Local Guide · 39 reviews · 1 foto
★★★★★ 2 weken geleden NIEUW
Gewoon een adres waar ze nog de tijd nemen en je begeleiden bij de keuze

Loyal customers

Topfan
Van harte proficiat met jullie 60 jarig jubileum, mijn 1ste leren motorjack heb ik in 1983 gekocht en heb hem nog steeds in de kast hangen, kan hem niet wegdoen. Inmiddels ben ik van mijn 3de **Damen** motorpak aan het genieten, weliswaar van textiel, maar nog steeds van geweldige kwaliteit. Ga zo door, op naar een volgend jubileum!
4 w Leuk Beantwoorden

Topfan
Ik zou er eigenlijk 1 moeten hebben aangezien ik nooit anders dan **Damen Motorkleding** op de motor aan heb. En dat al 41 jaar lang.
3 w Leuk Beantwoorden

Bedankt voor alle steun en gezelligheid!🤩💪
24 w. 4 vind-ik-leuks Reageren

graag gedaan 🙏🙂
24 w. Reageren

damenmotorkleding
mooie momenten! 🙂💪
24 w. Reageren

Mooiste winkel van de beurs!!!
2 w. Reageren

Antwoorden verbergen

damenmotorkleding
Super leuk om te horen 🤩
dank je wel!
2 w. Reageren

Topfan
4 w Leuk Beantwoorden

Personal, transparent

7 reviews · 5 foto's
★★★★★ een jaar geleden
What a great company! Although there was a few weeks delay in the delivery of my custom made pants, they know how to make it about you. A very personal touch and very transparent ...The pants came great and they helped me adjusting the zipper of the jacket (another brand) so it will match the zipper of the pants. I will continue to buy from them because they are awesome!
Vertaling bekijken (Nederlands)

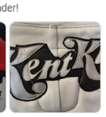
Damen Motorkleding / Top Skin Trading bv (eigenaar)
een jaar geleden
Dear ,
Thank you so much for the nice review. Sorry for the delay, we are always working for the best quality. We wish you lots of happy and safety rides in the new year!

Best regards
Team Damen
Vertaling bekijken (Nederlands)

9 reviews · 2 foto's
★★★★★ een jaar geleden
Laatst een eendelig maatpak laten maken. Een absolute topzaak als het aankomt op maatpakken. Persoonlijke service, ze nemen de tijd voor je, ook tijdens de productie ('kan ik toch nog een logo wijzigen?').

Vergeleken met mijn andere motorpakken (allen confectie) valt mij vooral de bewegingsvrijheid en souplesse van Damen op. Bovendien maken ze mooie (persoonlijke) lederlogo's.

Absoluut een aanrader!

Damen Motorkleding / Top Skin Trading bv (eigenaar)
een jaar geleden
Wauw, Wat een mooie review, dank je wel!! Zo blijven we gemotiveerd. We wensen je heel veel mooie en veilige kilometers toe met je Damen pak. Nogmaals dank namens Team Damen Motorkleding

Great service, customer-oriented

Local Guide · 63 reviews · 339 foto's
★★★★★ 6 jaar geleden
Super service
Vertaling bekijken (Nederlands)

6 reviews
★★★★★ 2 maanden geleden
Uitstekend geholpen.
Maatpak laten aanmeten, zat als gegoten. Echter na eerste dag gezien dat de verf afpelde. Oplossing van Damen: Rij de zomer maar door en gooi het pak van de winter eens binnen.

Zo gezegd zo gedaan. Oplossing van Damen: Verf is niet correct afgwerkt, je krijgt een nieuw pak.

Met zo'n service voor mij niet snel een ander.

Damen Motorkleding / Top Skin Trading bv (eigenaar)
een maand geleden
Beste , dank je wel voor de review. We proberen altijd onze kwaliteit te waarborgen, als het om een of andere redenen niet lukt (fouten kunnen altijd en overal gebeuren) proberen we dit altijd zo goed mogelijk op te lossen. Fijn dat je dit waardeerd en we wensen je nogmaals hele fijne en veilige kilometers toe met je pak! Groeten Team Damen

4 reviews
★★★★★ 2 jaar geleden
Top kwaliteit en super service! Net voor de 2e keer een NSF motorpak voor mijn kinderen bij Damen geregeld, fijn dat het team zo goed meedenkt. Niet alleen qua maat en keuzes, maar ook om te kunnen passen in de truck bij Molenaar Motors. Handig, slim, service en vriendelijk

Damen Motorkleding / Top Skin Trading bv (eigenaar)
een jaar geleden
Beste , wat ontzettend fijn om te lezen! Dank je wel, we blijven ons best doen en we hopen dat jullie veel plezier hebben van het NSF pak? Mvg Team Damen

14 reviews · 10 foto's
★★★★★ 7 maanden geleden
Zeer fijne winkel met zeer fijn personeel. Klantvriendelijk, service gericht.

Zeer ruime keus aan mooie kleding.

Enorm goed geslaagd! Aanrader voor iedere (beginnende) motorrijder

Damen Motorkleding / Top Skin Trading bv (eigenaar)
7 maanden geleden
Dank je wel voor je fijne review ! Veel veilige en plezierige kilometers gewenst met je nieuwe kleding!
Gr Team Damen

Local Guide · 27 reviews · 32 foto's
★★★★★ 5 maanden geleden
Gewoon top zaak! Alles keurig op tijd, en nog belangrijker: op maat klaar!

Damen Motorkleding / Top Skin Trading bv (eigenaar)
een maand geleden
Dank je wel voor de fijne en mooie review !

Local Guide · 35 reviews · 1 foto
★★★★★ 6 jaar geleden
Wat een fantastisch zaak! Excellente dienstverlening. Topkwaliteit kleding. Kan echt niet beter.

10 reviews
★★★★★ 4 jaar geleden
Fantastische service en producten. Destijds bij de aankoop van mijn pak heel deskundig geholpen. Men laat je niet naar buiten gaan voordat het pak perfect zit. Later had ik een klein probleempje met de ritssluiting, dat wordt in alle vriendelijkheid professioneel verholpen. Ga zo door!

Local Guide · 19 reviews · 1 foto
★★★★★ 4 jaar geleden
Zeer goede, persoonlijke service.
Straight to the point de wensen van de klant bespreken en samenstellen van op maat motor kleding. Na 8 weken productie, zeer tevreden een top kwaliteit motor jas ontvangen naar eigen wens ingericht. Klein probleem met de rits, direct over geïnformeerd/ gebeld en ter plekke in de winkel kunnen verhelpen. Al met al geweldige service en top kwaliteit motor kleding.

1

Local Guide · 25 reviews · 5 foto's
★★★★★ een jaar geleden
Wat een topteam! Heb hier een pak op maat laten maken, dit was helemaal toppie! En zelf half jaar na aankoop geven hun nog altijd een mooie na-service. Dus zeker 5/5!

Damen Motorkleding / Top Skin Trading bv (eigenaar)
een jaar geleden
Beste , wat ontzettend leuk om te lezen! Hier doen we het voor en het motiveert ons nog meer om ons best te blijven doen. We wensen je heel veel mooie en veilige kilometers toe met je nieuwe pak!
MVG Team Damen

66 reviews · 13 foto's
★★★★★ 7 jaar geleden
Een paar maanden geleden een nieuwe motorbroek besteld bij Damen omdat mij Revlt (goretex) gewoon lek bleek te zijn.
Na bijna 8 weken komt de broek aan en uiteraard meteen aan...
HELAAS, de rits blijkt niet op de juiste wijze vast gezet (gulp) en de hele rits komt gewoon los.
Uiteraard contact opgenomen. Men vroeg mij de broek terug te sturen.
Na ruim 1 week komt de broek gerapareerd retour maar zag er NIET uit.
Gelukkig had Thomas van Dartel (medewerker) dat zelf ook gezien en hij bood uit zichzelf aan een nieuwe broek te leveren.
Gelukkig kon ik de gerepareerde broek blijven gebruiken totdat de nieuwe binnen was.
Inmiddels bijn 4 maanden na eerste bestelling, maar.... ik heb hem.
Mijn echter DAMEN broek. Hij zit perfect. Echt een absolute aanrader,
Wellicht een fractie duurder dan een GoreTex Revlt, maar heeeeel veel beter van kwaliteit.

Dankjewel Thomas voor het zo netjes oplossen

2

Good value for money

raadt **Damen Motorkleding** aan.
15 maart 2019 ·
Ein sehr zu empfehlender Hersteller von maßgeschneiderten Lederkombis. Super Beratung und Vermessung vor Ort in Breda. Sehr kompetente Leute, man fühlt sich sehr gut aufgehoben. Qualität ist spitzenmäßig und das Preis-Leistungsverhältnis stimmt absolut! Würde dort immer wieder meinen Anzug schneidern lassen. 👍👍👍
Vertaling weergeven
1

4 reviews
★★★★★ een jaar geleden
Inmiddels rij ik een paar maanden met een motorpak van Damen.
Voor ik een review plaats wilde ik eerst weten hoe het pak zich houdt in verschillende weerstypen. Inmiddels heb ik warm en koude, regen en stormwind meegemaakt. Met 25.000 a 30.000km per jaar mag ik mijzelf wel een frequente motorrijder noemen.
Na 1.5 jaar complete ellende met een motorpak van Dainese Antartica (loslatend stiksel van ritsen, niet waterdichte jas en broek) kwam ik bij Damen terecht.
Fantastisch geadviseerd! Motorpak met airbagvest aangeschaft. Geen moment spijt van. Inmiddels 12000km uiterst comfortabel mee gereden. Zit lekker, fijne ritsen, goede bewegingsvrijheid. Lekker warm in de winter, lekker koel door de vele ventilatie in de zomer. Superhandige magneetsluitingen.
Als je veeleisend bent, goed geadviseerd wilt worden en waar voor je geld wilt hebben beveel ik Damen 100% aan.

Damen Motorkleding / Top Skin Trading bv (eigenaar)
een jaar geleden
Beste , wat een mooie en uitgebreide review! Wat ontzettend fijn om te lezen dat je zo tevreden bent met onze kleding en het Airbag vest van Alpinestars, de beste keuze die er is! We wensen je heel veel mooie en veilige kilometers toe in het nieuwe jaar!

MVG
Team Damen Motorkleding

1 review
★★★★★ 7 maanden geleden
Als woon/ werk-rijder een lek in je pak.....broek weggebracht. Binnen 24 uur terug gestuurd gekregen met een nieuwe liner op maat gemaakt!
Ik ken geen ander motorkledingmerk die jullie dat nadoet. Dankjewel toppers!

Damen Motorkleding / Top Skin Trading bv (eigenaar)
een maand geleden
Wat fijn om te horen dat je tevreden bent over onze service, daar doen we het voor! Vriendelijke groeten, team Damen

Jullie hadden een topstand! Toen ik er was was het helaas mij te druk, had graag iets aangepast gekregen! Moet je in Breda een afspraak maken of kun je zo eens een keer binnenvallen?
3 w Leuk Beantwoorden

Auteur
Damen Motorkleding
Beste wat leuk om te horen, maar jammer dat we u daar niet hebben kunnen helpen. Het was inderdaad soms erg druk.
U bent altijd welkom bij ons in Breda en mag altijd binnenlopen. Omdat het de komende dagen ook wel druk is met afspraken adviseer ik om even een afspraak te maken, zodat we u de juiste aandacht kunnen geven.
Dat kan op 076
3 w Leuk Beantwoorden

USP: easy contact (for custom products and repairs) compared to big brands

het grootste voordeel van een maatpak van damen (en mjk ook wel alleen heb ik daar geen ervaring mee) is dat als je het pak goed kapot valt ze het weer helemaal (snel) kunnen fixen. bij een pak van oa alpinestars dainese enz is het meestal einde verhaal voor zon pak omdat het veel meer moeite kost en moeilijker communiceren is met zulke fabrikanten. bij damen en mjk breng je het pak langs en vertel je wat eraan moet gebeuren. ik heb het dan wel over hele delen vernieuwen. en geen gaatjes dichten 😀

Laatst bewerkt: 16 dec 2012

USP: One of a kind clothing. More personalisation options than other brands

30 nov 2009 #5

'k Heb inmiddels ruim 2 jaar een leren dames pak dat van Damen afkomstig is. 't Zit echt perfect op maat en ziet er stoer en vrouwelijk (en ja, ben vrouw, om de grappen even voor te zijn 😜) tegelijk uit en is helemaal naar eigen smaak samen te stellen 😊 . Daardoor heb je dus ook een pak wat je niet snel bij iemand anders tegen komt. Oftewel; ik ben er erg tevreden over, ook al kost het wel een paar centen!

25 sep 2012 #6

Ik heb een leren pak op maat laten maken van Damen. Daar heb ik wel erg lang op gewacht. Ten Kate heeft dit destijds ruimschoots gecompenseerd.

66 reviews · 13 foto's
★★★★★ 7 jaar geleden
Een paar maanden geleden een nieuwe motorbroek besteld bij Damen omdat mij Revlt (goretex) gewoon lek bleek te zijn.
Na bijna 8 weken komt de broek aan en uiteraard meteen aan...
HELAAS, de rits blijkt niet op de juiste wijze vast gezet (gulp) en de hele rits komt gewoon los.
Uiteraard contact opgenomen. Men vroeg mij de broek terug te sturen.
Na ruim 1 week komt de broek gerapareerd retour maar zag er NIET uit.
Gelukkig had Thomas van Dartel (medewerker) dat zelf ook gezien en hij bood uit zichzelf aan een nieuwe broek te leveren.
Gelukkig kon ik de gerepareerde broek blijven gebruiken totdat de nieuwe binnen was.
Inmiddels bijn 4 maanden na eerste bestelling, maar.... ik heb hem.
Mijn echter DAMEN broek. Hij zit perfect. Echt een absolute aanrader,
Wellicht een fractie duurder dan een GoreTex Revlt, maar heeeeel veel beter van kwaliteit.

Dankjewel Thomas voor het zo netjes oplossen
2

Local Guide · 235 reviews · 331 foto's
★★★★★ 2 jaar geleden
Maatwerk leren broek met bescherming, tsja wel 10 weken wachttijd...😐

Local Guide · 117 reviews · 57 foto's
★★★★★ 7 maanden geleden
Prima advies en mooie kwaliteit. Heb er 2 VKR jassen aangeschaft. 10 weken levertijd voor maatwerk en afwijkende maten. Hou daar rekening mee

Damen Motorkleding / Top Skin Trading bv (eigenaar)
6 maanden geleden
Beste ,bedankt voor de mooie revolutie. Veel succes en plezier met je nieuwe VKR jassen.
Gr Team Damen

44 reviews · 21 foto's
★★★☆☆ 2 weken geleden NIEUW
Een paar jaar geleden (jaar of 2) op aanraden van een kennis een jas gekocht. Het is een best aardige jas maar kwa kwaliteit vind ik hem persoonlijk niet beter dan een jas uit de aanbieding van de motorport, terwijl de prijs veel hoger lag.
Er werd mondeling iets beloofd over een levertermijn maar uiteindelijk werd er beroep gedaan wat er op papier stond. Terwijl als ik dat eerder had geweten ik ergens ander een jas had gekocht. Ook kwamen ze terug op een afspraak over het aanzetten van een rits, uiteindelijk hebben ze zich hier wel aan gehouden en dit als tegemoetkoming kosteloos gedaan. Ik moet wel eerlijk bekennen dat ik de aansluiting van Jas op broek van hun eigen merk erg mooi vond (helemaal rondom).

10 weeks of production time for tailored products can be a long wait for people nowadays

16 dec 2012 #7

Maatpak van damen is top. Ik heb er twee laten maken, eentje voor op de weg (combie)is nu 13 jaar jong en ziet er nog top uit en ziet ook nog goed. De andere is een overall voor op circuit en heb ik nu 4 jaar en is ook nog super. Je moet ze natuurlijk wel goed onderhouden. Als je een keertje valt en ze moeten gaan repareren dan vindt ik ze wel duur!

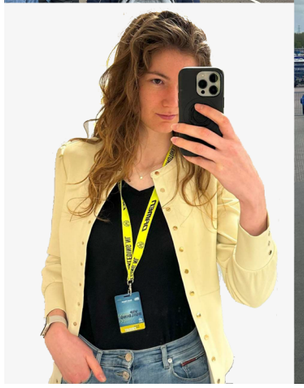
Laatst bewerkt: 16 dec 2012

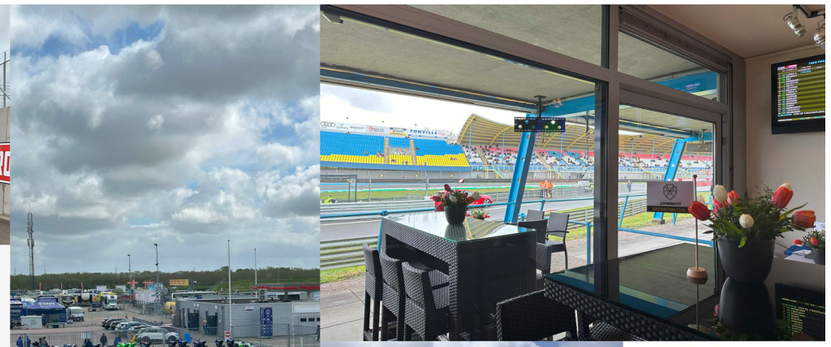
Repair can be expensive

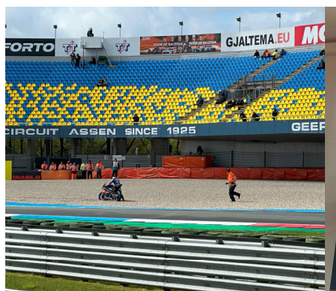
A4 - USER CONTEXT VISITS

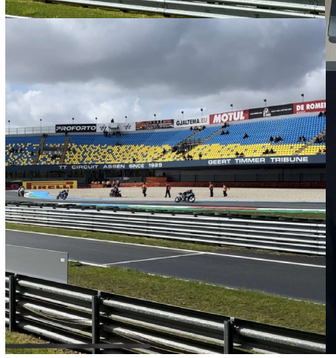
Visit to WSBK Dutch Round

Getting a better understanding of professional race weekends and conducting interviews with Damen riders.









Participating in a circuit training

Understanding and getting a feel for the body positioning and its use in practice. Gain understanding of the motorcycles' behaviour and the product (slider) use and its purposes.

Visit to MotoGP Motul TT

Getting a better understanding of professional race weekends, differences between MotoGP and WSBK and understanding the cultural consumer point of view.

A5 – RIDER INTERVIEW NOTES

1. Wat motiveert jou het meest om aan motorracen te doen?
P1: WK winnen
P2: Snelheid, het wereldje, de sfeer
P3: Van jongs af aan begonnen, dus altijd gemotiveerd geweest om te blijven doen. Altijd gaan om te winnen.

2. Wat is momenteel je grootste uitdaging op het circuit?
P1: Gewoontes afleren van het rijden bij een ander team en puntjes op de i zetten.
P2: Goede setup vinden van de motor voor de regen.
P3: Het is een grote groep, we rijden dicht bij elkaar. De uitdaging is daar het sterkst uit te komen.

3. Hoe kwam je tot het besluit om in een Damen-pak te rijden?
P1: Al eerder met Damen gereden, Nederlands merk, snelle service en reparaties.
P2: Via het team altijd met Macna, maar dat pak was te klein, dus via Damen snel reserve pak geregeld.
P3: Altijd al met Damen gereden, zeer tevreden over.

4. Wat waardeer je het meest aan je pak? (bijv. veiligheid / esthetiek / comfort / prestatie / functionaliteit) Hoeveel waarde hecht je aan je pak? Welk gevoel moet je pak je geven als je het draagt? Hoe belangrijk is de esthetiek/het uiterlijk en de uitstraling van je pak voor jou?
P1: Comfort staat voorop. Ik vertrouw de makers van het pak dat hij veiligheid biedt.
P2: Comfort is het belangrijkst, maar het pak moet natuurlijk ook wel een beetje mooi zijn.
P3: Comfort, het pak moet soepel zijn. Tijdens het rijden moet ik hem eigenlijk niet voelen. Veiligheid; het pak mag stuk gaan bij een val. Hoeft niet 100 crashes mee te gaan van mij.

5. Aan welke slider (knie/elleboog) hecht je de meeste waarde? Waarom is dat?
P1: Knie is belangrijker, is de grootste leidraad.
P2: Knie, die gebruik ik het meest.
P3: Knie is het belangrijkst, daarmee bepaal ik mijn hellingshoek, de elleboog gebruik ik weinig, meer voor bijvoorbeeld een save.

6. Hoeveel paar sliders gebruik je in een seizoen? / Wat is de levensduur van een slider voor jou (knie/elleboog)?
P1: Elleboog wordt elke sessie gecontroleerd. Die ben ik meer gaan gebruiken door mijn nieuwe rijtechniek/stijl. Slijtage is afhankelijk van het circuit en haar grip.
P2: De sliders gaan bij mij een heel race weekend mee. De elleboog gaat langer mee, die gebruik ik niet zo veel.
P3: De levensduur ligt aan de baan en het type asfalt. Nieuw asfalt slijt meer. Soms gaan sliders 1 race mee, soms een heel weekend.

7. Wanneer en waar vervang je je sliders? (knie/elleboog)
P1: De knie moet sneller vervangbaar zijn dan de elleboog.
P2: Knie: na een race weekend, niet per se ter plekke, als het regent wel. Wissel naar regensliders.
P3: Voor een wedstrijd start ik vaak met nieuwe sliders. Met warm-up en met race.

8. Ervaar je een inlooptijd van de sliders voor ze optimaal zijn? Zo ja, hoeveel? (knie/elleboog)
P1: Geen break in periode voor sliders. 10 rondes met een pak is voldoende.
P2: Geen inlooptijd voor de sliders.
P3: Er is geen inlooptijd, maar als de slider ver afsltijt verandert de hellingshoek van mijn motor. Het is eigenlijk essentieel dat de dikte gelijk blijft.

9. Voel je warmte of andere ongemakken van je sliders (knie/elleboog)?
P1: Het materiaal rolt een beetje af naar de zijkant. Als de slider slijt dan merk je dat je hellingshoek groter wordt.
P2: Als de slider te hard is blijf ik hangen. Sommige rijders raken hun slider kwijt over de Kerbs. Het klittenband op de knie van het pak slijt en wordt zwakker, daarom hadden ze bij Macna de harde kant van het klittenband op het pak zitten, en de zachte kant op de sliders.
P3: Het klittenband kan oud worden waardoor sliders beginnen los te laten. Ze worden dan vaak met ductape verstevigd.

10. Op welke manier wil je feedback krijgen van je sliders bij droog en nat weer? (Gebruik je regensliders? Hoe verandert je techniek als het regent?) En bij veschillende typen Kerbs? Wat is je favoriete slidermateriaal en waarom?
P1: Ik gebruik het liefst dunne sliders, dan weet ik waar ik zit met mijn hellingshoek. Als het regent 2cm extra op de sliders. Die zijn belangrijk als referentie voor de hellingshoek. Ik gebruik de slider om me rechtop te drukken. Bij verschillende Kerbs merk ik niks.
P2: Als het regent gebruik ik dikkere sliders. Ik duw vaak minder hard op het asfalt. Ik heb 1 rijstijl, maar soms hang ik meer ernaast of kom ik anders uit de bocht, ga ik bijvoorbeeld eerder in een andere houding zitten.
P3: De sliders moeten niet te zacht zijn, dan blijft je knie haken. Harder materiaal hapt niet. Als het regent gebruik ik dikkere sliders. Mijn knie heeft altijd een vaste positie, daarom is de dikte van de slider zo belangrijk.

11. Slijten jouw sliders altijd op dezelfde plek of merk je hier variatie in?
P1: Voor de elleboog is het altijd dezelfde plek. Bij de knie verschilt het een beetje per bocht, maar de variatie vlakt zichzelf uit op de slider.
P2: Op de knie varieert het per circuit. Bij de elleboog is er weinig variatie.
P3: Knie en elleboog slijten bij mij altijd op dezelfde plek.

12. Hoe vaak verplaats je je sliders? Doe je wel eens een testrit voor je slider positie? Wat is voor jou de belangrijkste reden om een slider te herpositioneren?
P1: Ik verplaats ze eigenlijk nooit. Plak ze altijd op dezelfde plek. Ik weet waar ze moeten zitten.
P2: Ik verplaats ze per circuit.
P3: Verplaatsen niet nodig. Raakt altijd zelfde plek dus altijd op dezelfde plek erop zetten.

13. Wat is jouw mening over de klittenband- en schroefbevestigingssystemen?
P1: Bij het gebruik van schroefjes op de elleboog is de locatie van de schroefjes erg belangrijk. Als de slider vast zit door het afslijten van de schroefjes moet ik een ander pak aantrekken.
P2: Schroefjes kunnen afslijten. Klittenband is makkelijk en snel.
P3: Schroefjes op de ellebogen slijten vaak door een crash. Snel kunnen verwisselen is belangrijk, maar bij ellebogen kun je wat langer wachten. Bij klittenband kan je niet te laat zijn/te lang wachten.

A6 – WSBK RACE WEEKEND SCHEDULE

SBK MOTUL FIM SUPERBIKE WORLD CHAMPIONSHIP

PIRELLI DUTCH ROUND

TT Circuit Assen, 19-12 April 2024

EVENT SCHEDULE

Issued | 28 February 2024 | 1730h

FRIDAY 19 April 2024

	09:00	09:25	*0:25*	Northern Talent Cup	Free Practice 1
	09:40	**10:05**	*0:25*	**WorldSSP300**	**Free Practice**
	10:20	**11:05**	*0:45*	**WorldSBK**	**Free Practice 1**
	11:20	**12:00**	*0:40*	**WorldSSP**	**Free Practice**
	12:15	12:40	*0:25*	Yamaha R3 bLU cRU FIM World Cup	Free Practice
	12:50	*13:20*	*0:30*	*Kids' Special Pit Walk*	
	13:30	13:55	*0:25*	Northern Talent Cup	Free Practice 2
	14:10	**14:35**	*0:25*	**WorldSSP300**	**Tissot Superpole**
	15:00	**15:45**	*0:45*	**WorldSBK**	**Free Practice 2**
	16:00	**16:40**	*0:40*	**WorldSSP**	**Tissot Superpole**
	16:55	17:20	*0:25*	Yamaha R3 bLU cRU FIM World Cup	Superpole
	17:35	18:05	*0:30*	Northern Talent Cup	Qualifying

SATURDAY 20 April 2024

	09:00	**09:20**	*0:20*	**WorldSBK**	**Free Practice 3**
	09:30	**09:40**	*0:10*	**WorldSSP300**	**Warm Up**
	09:50	**10:00**	*0:10*	**WorldSSP**	**Warm Up**
	10:05	*10:45*	*0:40*	*Pit Walk 1 & Safety Car Laps*	
	11:00	**11:15**	*0:15*	**WorldSBK**	**Tissot Superpole**
	11:50			**Yamaha R3 bLU cRU FIM World Cup**	**RACE 1**
	12:45			**WorldSSP300**	**RACE 1**
	13:15	*13:35*	*0:20*	*Safety Car Laps*	
	14:00			**WorldSBK**	**RACE 1**
	15:15			**WorldSSP**	**RACE 1**
	16:20			**Northern Talent Cup**	**RACE 1**
	17:00	*17:15*		*Fans' Bike Parade Lap*	

SUNDAY 21 April 2024

	09:00	**09:10**	*0:10*	**WorldSBK**	**Warm Up**
	09:20	**09:30**	*0:10*	**WorldSSP300**	**Warm Up**
	09:40	**09:50**	*0:10*	**WorldSSP**	**Warm Up**
	09:55	*10:35*	*0:40*	*Pit Walk 2 & Safety Car Laps*	
	11:00			**WorldSBK**	**TISSOT SUPERPOLE RACE**
	11:50			**Yamaha R3 bLU cRU FIM World Cup**	**RACE 2**
	12:45			**WorldSSP300**	**RACE 2**
	14:00			**WorldSBK**	**RACE 2**
	15:15			**WorldSSP**	**RACE 2**
	16:20			**Northern Talent Cup**	**RACE 2**

Time Schedule in local time. Time Zone: GMT + 2 hours.

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CIRCUIT

A7 – COMPETITOR BRANDS ANALYSIS

Counted 17-05-2024 via WorldSBK.com

	World SBK	World SSP	World SSP 300
Alpinestars	6	8	0
Ixon	6	4	0
Mass Sports	0	1	6
AWA Racing	0	1	5
Dainese	4	1	1
PSì Hubìk	0	2	2
Virus Power	0	1	3
Damen	0	1	2
Furygan	1	2	0
Rewin	1	1	1
Gimoto	0	0	2
Onex	0	0	2
REV'IT!	2	0	0
RST	1	1	0
4SR	0	1	1
Armure	0	1	0
Berik	0	0	1
Bison	0	0	1
CDREAM leathers	0	0	1
DRC Leathers UK	0	0	1
IXS	1	0	0
Shark	0	0	1
Spidi	1	0	0

Counted 17-05-2024 via motogp.com

	MotoGP	Moto2	Moto3	MotoE
Alpinestars	11	2	7	5
Dainese	4	4	5	1
Ixon	4	5	0	0
REV'IT!	1	5	3	3
Macna	0	4	2	2
Furygan	1	1	3	1
IXS	0	2	3	1
Kushitani	0	3	1	0
Spidi	0	4	0	0
Giuseppe	0	0	1	0
Mtech	0	0	1	0
SLR	0	0	0	1
DTS	0	0	0	1
Mugen Race	0	0	0	1

A8 - RIDER QUESTIONNAIRES

Participant ID: 1

14. Hoe zou je je huidige knie en elleboog sliders in het algemeen beoordelen?

1 2 3 4 5 6 7 8 9 10

15. Hoe zou je de positionering van je huidige knie en elleboog sliders beoordelen?

1 2 3 4 5 6 7 8 9 10

16. Zou je kunnen aangeven wat je belangrijk vindt voor je knie en elleboog sliders?

Gewicht	vs	Veiligheid
Esthetiek / Uiterlijk	vs	Comfort
Stroomlijn	vs	Functionaliteit
Lange Levensduur	vs	Snel vervangbaar
Nauwkeurige positie	vs	Snel verplaatsbaar
Minder grip & meer slijtage	vs	Minder slijtage & meer grip

Participant ID: 2

14. Hoe zou je je huidige knie en elleboog sliders in het algemeen beoordelen?

1 2 3 4 5 6 7 8 9 10

15. Hoe zou je de positionering van je huidige knie en elleboog sliders beoordelen?

1 2 3 4 5 6 7 8 9 10

16. Zou je kunnen aangeven wat je belangrijk vindt voor je knie en elleboog sliders?

Gewicht	vs	Veiligheid
Esthetiek / Uiterlijk	vs	Comfort
Stroomlijn	vs	Functionaliteit
Lange Levensduur	vs	Snel vervangbaar
Nauwkeurige positie	vs	Snel verplaatsbaar
Minder grip & meer slijtage	vs	Minder slijtage & meer grip

DAMEN MOTORKLEDING

Participant ID: 3

Active tarmac contact points in motorcycle racing. | Graduation project research MSc IPD at IDE - TU Delft

14. Hoe zou je je huidige knie en elleboog sliders in het algemeen beoordelen?

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	●	○	●	○	○

15. Hoe zou je de positionering van je huidige knie en elleboog sliders beoordelen?

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	●	○	○	●

16. Zou je kunnen aangeven wat je belangrijk vindt voor je knie en elleboog sliders?

Gewicht	vs	Veiligheid
Esthetiek / Uiterlijk	vs	Comfort
Stroomlijn	vs	Functionaliteit
Lange Levensduur	vs	Snel vervangbaar
Nauwkeurige positie	vs	Snel verplaatsbaar
Minder grip & meer slijtage	vs	Minder slijtage & meer grip

minder

Damen Motorkleding

A9 – FINDING A RESEARCH METHOD

Possibilities for research setup & execution

Setup requirements

- Body position should be as realistic as possible compared to actual cornering in track riding.
- The setup can be used realistically in stores, for tailoring the protection.

Moto Trainer – MotoGP Bike Simulator

Possibilities	Inabilities
- The simulator allows the rider to operate the bike realistically. - The simulator allows the use of any motorcycle, which allows tailoring not only for the rider but also based on the bike they ride.	- The simulator is too expensive to purchase for small research and small companies. - The simulator requires quite some force for the bike to be tilted. Not every user manages to reach the ground and/or stay down. - It is questionable how realistic it is for riders to come in with their GP bike for measurements.

Demo bike on paddock stand

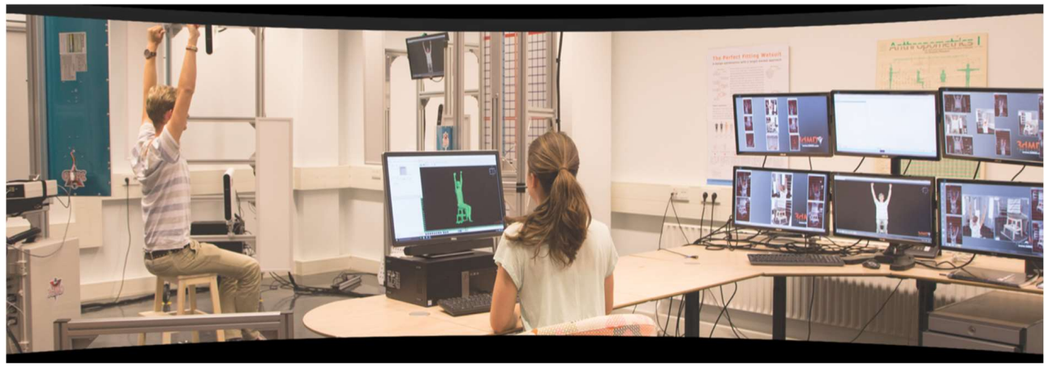
Possibilities	Inabilities
- Floor can be simulated with diagonal plate. - Riders can use their own bike.	- The bike cannot lean. - Possible inaccuracy of rider posture as a result of bike being straight up.

(Demo) bike Tilted with new setup

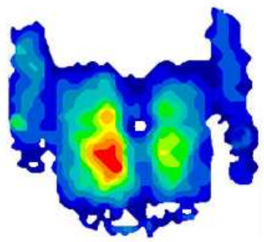
Possibilities	Inabilities
- Realistic body positioning possible. - A well-designed stand allows any bike to be used.	- Creating setup from scratch is time consuming.

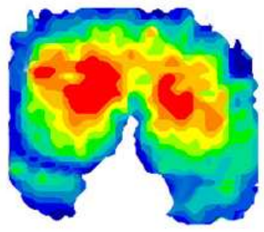
(3D) scanning possibilities

Possibilities	Inabilities
- Full body scan after marking contact points with paint.	- Cannot scan full body with motorcycle, as it does not fit in the full body scan.
- Pressure mat (Not realistic enough with static bike)	- Cannot scan contact point unless rider is raised from the floor.

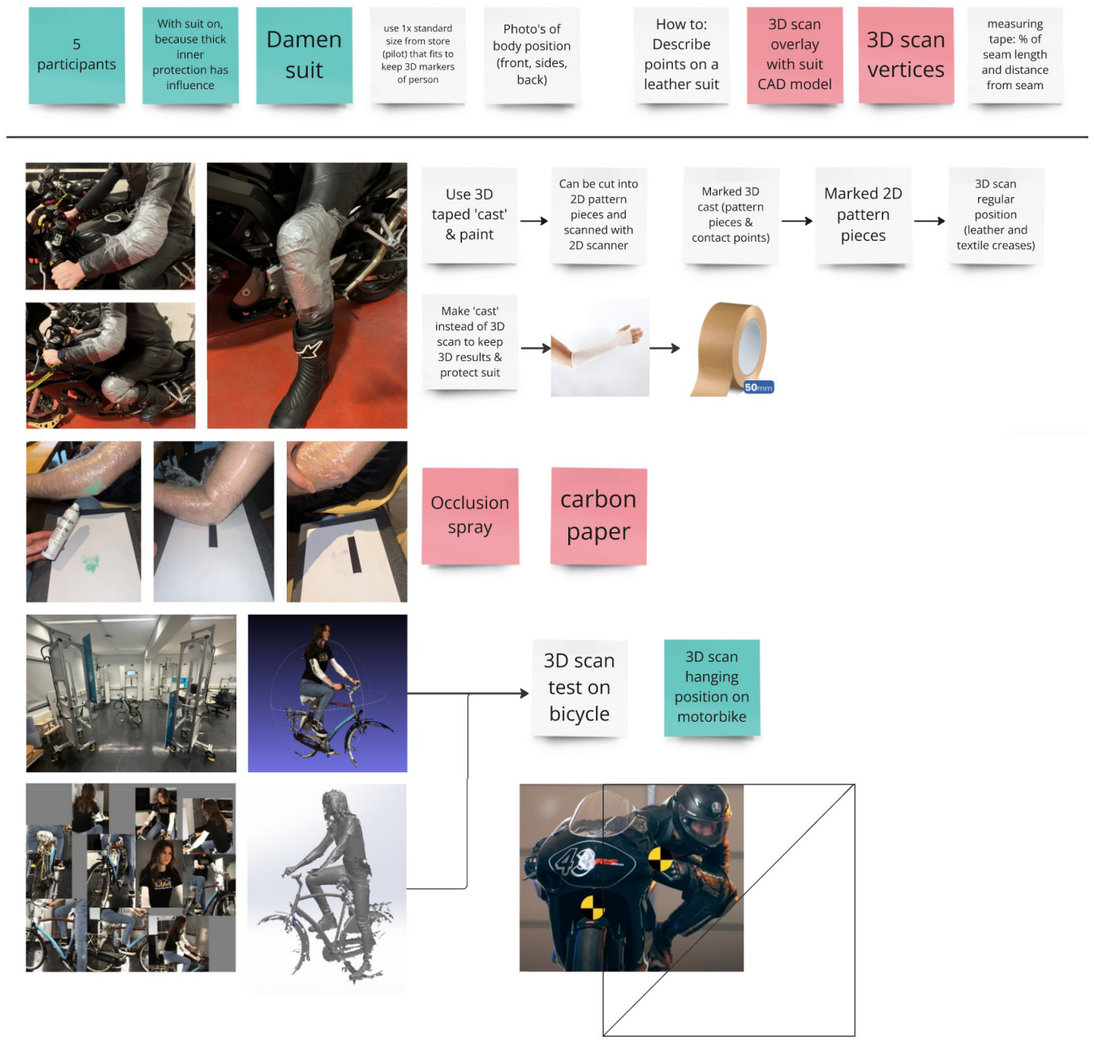


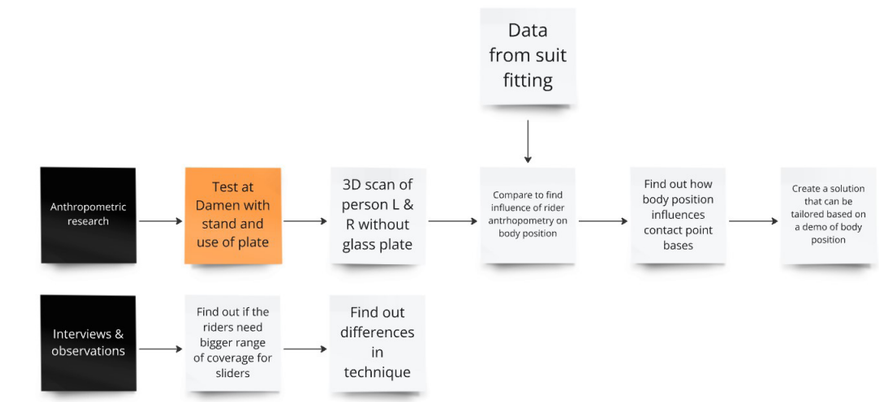
Fujifilm Prescale pressure measuring film / Pressure mat.

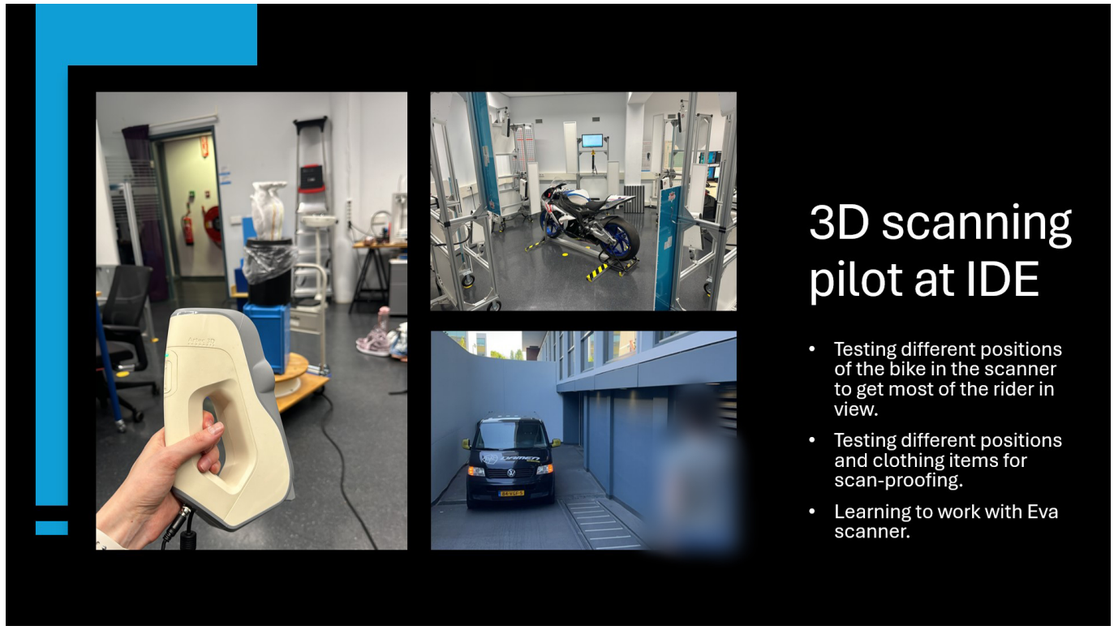


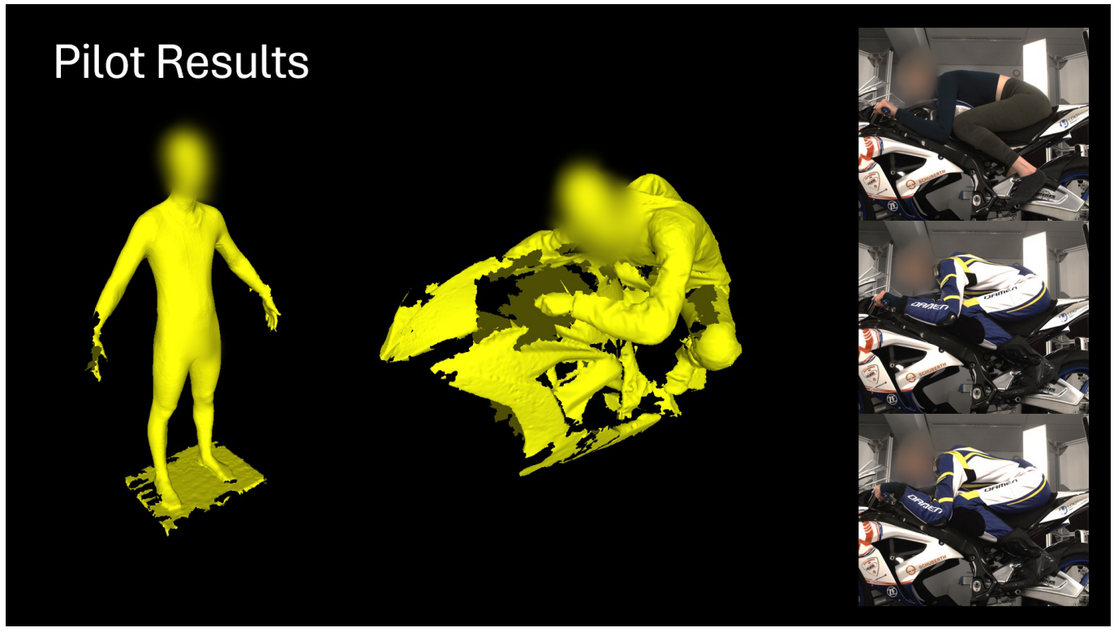


METHOD

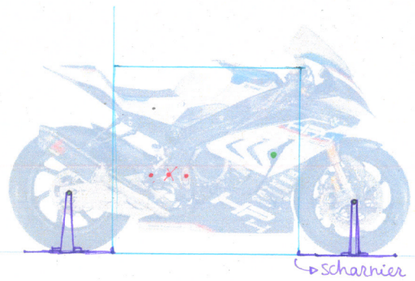


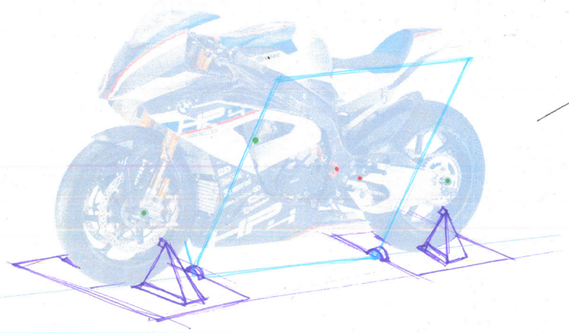


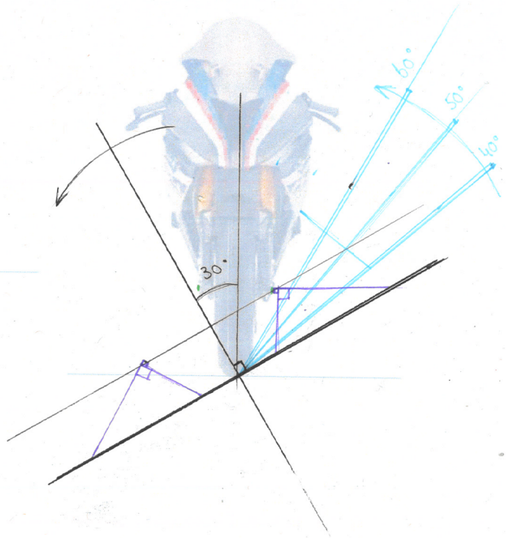




A10 – DESIGNING THE DEMO BIKE STAND



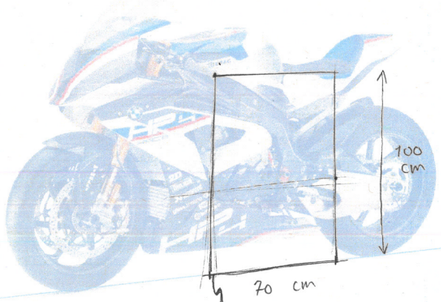




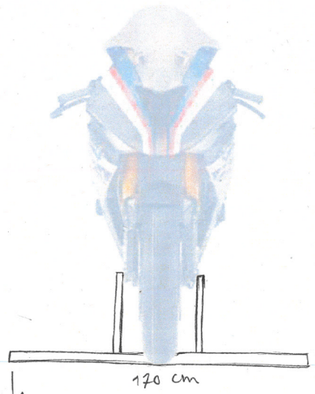
Scan 1: Bike L
Scan 2: Bike R
Scan 3: Standing

Hitting the apex

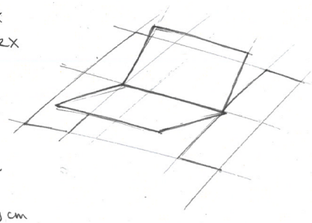
Verschillende maten sliders! (crash)
→ Maar niet voor pucks..



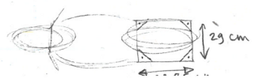
plexiglas?

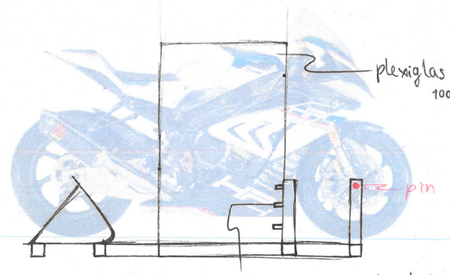


voor 1x
achter 2x

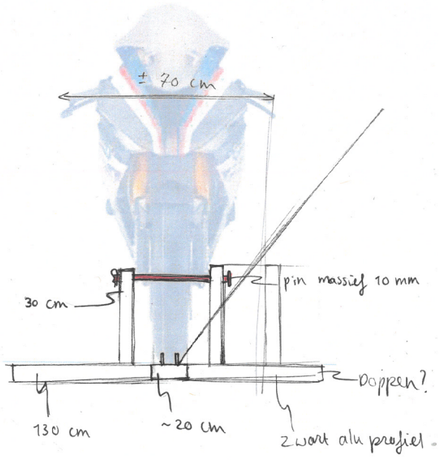


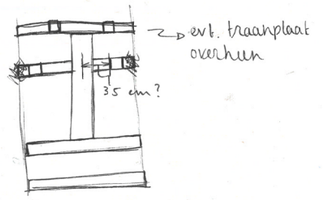
stand bike:



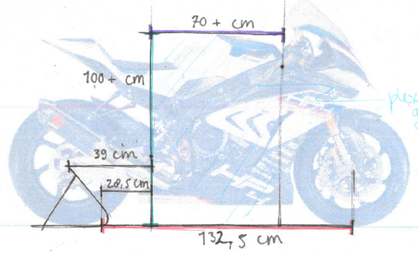


Measuring pins angle, drill one side

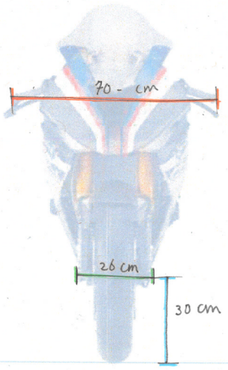


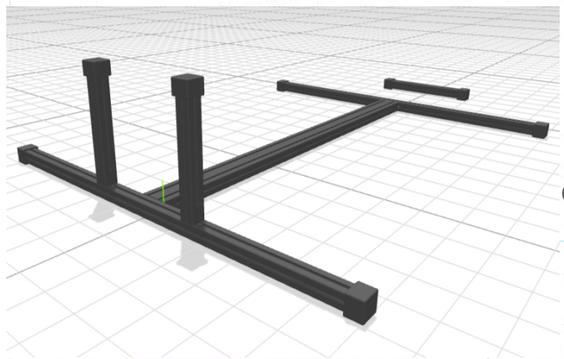


Demo bike Measurements



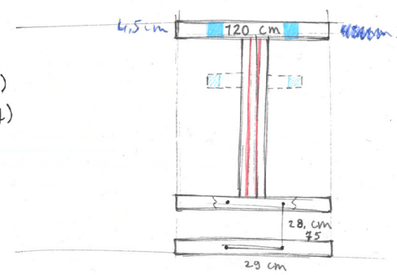
plexi glass?





- Alu profile
- Metal rods
- Fitting bolts
- plexi glass

(- Caution tape)
(- Metal flooring)



A11 - BUILDING THE DEMO BIKE STAND

A12 - DEVICE INSPECTION

Delft University of Technology
INSPECTION REPORT FOR DEVICES TO BE USED IN CONNECTION WITH HUMAN SUBJECT RESEARCH

This report should be completed for every experimental device that is to be used in interaction with humans and that is not CE certified or used in a setting where the CE certification no longer applies[1].

The first part of the report has to be completed by the researcher and/or a responsible technician.

Then, the safety officer (Heath, Security and Environment advisor) of the faculty responsible for the device has to inspect the device and fill in the second part of this form. An actual list of safety-officers is provided on this webpage.

Note that in addition to this, all experiments that involve human subjects have to be approved by the Human Research Ethics Committee of TU Delft. Information on ethics topics, including the application process, is provided on the HREC website.

Device identification (name, location): Demo motorcycle stand

Configurations inspected[2]: NA

Type of experiment to be carried out on the device:[3] Physical exercise: Sitting on a demo motorcycle, 3D scanning of riding positions.

Name(s) of applicants(s): Dr. ir. Marijke Dekker

Job title(s) of applicants(s): Lecturer

(Please note that the inspection report should be filled in by a TU Delft employee. In case of a BSc/MSc thesis project, the responsible supervisor has to fill in and sign the inspection report.)

Date: 22.04.24

Signature(s): 

1 Modified, altered, used for a purpose not reasonably foreseen in the CE certification

2 If the devices can be used in multiple configurations, otherwise insert NA

3 e.g. driving, flying, VR navigation, physical exercise, ...

Setup summary

The experimental device is a stand made to keep an empty demo motorbike standing straight up while research participants are sitting on it (engine and all other components of the motorcycle except the frame and body kit are removed). During a motorcycle road race, riders hang off the side of the bike to move their center of gravity to the inside of the curve (see example below). This body positioning technique is being researched via full body 3D scans. Participants are asked to hang off the bike like this during a 3D scan. The stand has been made of highly trustworthy aluminum profiles used in mechanical engineering. The beams have been covered in warning tape for visibility, which prevents tripping. As demonstrated below, the stand can easily hold the bike upright even when hanging on the side of the bike with the entire body weight. (See the appendix for more images of the stand.)

Risk checklist

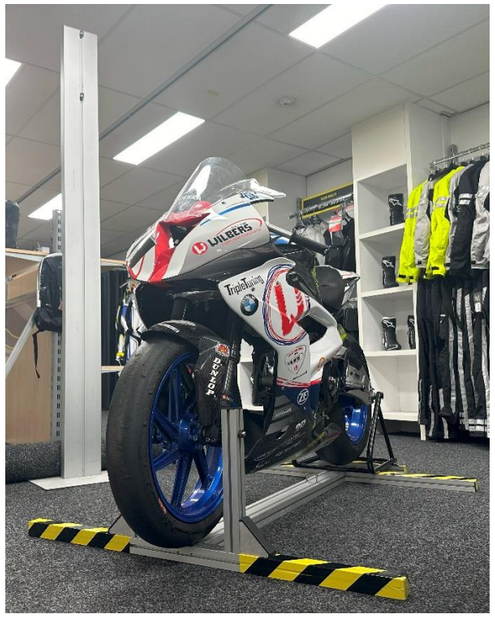
Please fill in the following checklist and consider these hazards that are typically present in many research setups. If a hazard is present, please describe how it is dealt with.

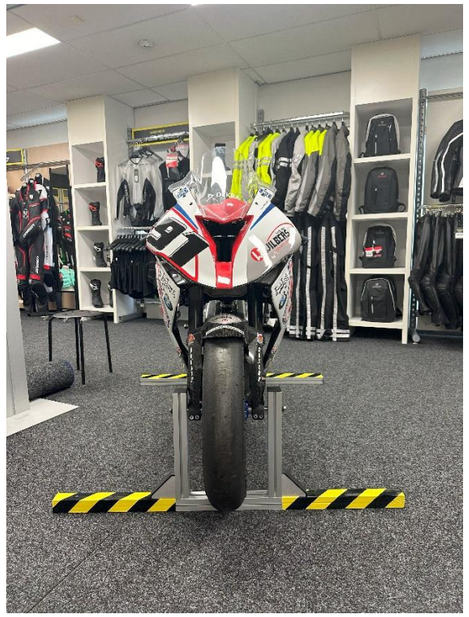
Also, mention any other hazards that are present.

Hazard type	Present	Hazard source	Mitigation measures
Mechanical (sharp edges, moving equipment, etc.)		Sawn aluminum profile.	All profile ends have been covered with firmly fitting plastic caps to cover the sharp edges.
Electrical	-	-	-
Structural failure		Setup of structure was designed and assembled in-house.	The structure is put together from a material system used in mechanical engineering, which is specifically engineered to be assembled and trusted in modular setups.
Touch Temperature	-	-	-
Electromagnetic radiation	-	-	-
Ionizing radiation	-	-	-
(Near-)optical radiation (lasers, IR-, UV-, bright visible light sources)	-	-	-
Noise exposure	-	-	-
Materials (flammability, offgassing, etc.)		Plastic caps and tape may be flammable.	The motorcycle is completely stripped, so there is no fire hazard involved with the test setup.
Chemical processes	-	-	-
Fall risk		Hanging off the bike requires the participant to hang on tightly.	Participants asked to hang off the bike are selected to be experienced in practicing the technique in the same way.
Other:			
Other:			
Other:			

Appendices

All profile ends have been topped with plastic caps. The stand has been tested by various people using the riding position and more extreme positions, under which the bike and stand remain stable.





6

Device inspection

(to be filled in by the AMA advisor of the corresponding faculty)

Name: Peter Kohne

Faculty: ID

The device and its surroundings described above have been inspected. During this inspection I could not detect any extraordinary risks.

(Briefly describe what components have been inspected and to what extent (i.e. visually, mechanical testing, measurements for electrical safety etc.)

Date: 23-04-2024

Signature:

Inspection valid until[4]:

Note: changes to the device or set-up, or use of the device for an experiment type that it was not inspected for require a renewed inspection

4 Indicate validity of the inspection, with a maximum of 3 years

A13 – HUMAN RESEARCH ETHICS CHECKLIST

Delft University of Technology
HUMAN RESEARCH ETHICS
CHECKLIST FOR HUMAN RESEARCH
(Version January 2022)

IMPORTANT NOTES ON PREPARING THIS CHECKLIST

1. An HREC application should be submitted for every research study that involves human participants (as Research Subjects) carried out by TU Delft researchers
2. Your HREC application should be submitted and approved **before** potential participants are approached to take part in your study
3. All submissions from Master's Students for their research thesis need approval from the relevant Responsible Researcher
4. The Responsible Researcher must indicate their approval of the completeness and quality of the submission by signing and dating this form OR by providing approval to the corresponding researcher via email (included as a PDF with the full HREC submission)
5. There are various aspects of human research compliance which fall outside of the remit of the HREC, but which must be in place to obtain HREC approval. These often require input from internal or external experts such as Faculty Data Stewards, Faculty HSE advisors, the TU Delft Privacy Team or external Medical research partners.
6. You can find detailed guidance on completing your HREC application here
7. Please note that incomplete submissions (whether in terms of documentation or the information provided therein) will be returned for completion **prior to any assessment**
8. If you have any feedback on any aspect of the HREC approval tools and/or process you can leave your comments here

I. Applicant Information

PROJECT TITLE:	**Active tarmac contact points in motorcycle racing**
Research period: *Over what period of time will this specific part of the research take place*	**19 April-31 August, 2024**
Faculty:	**Industrial Design Engineering**
Department:	**Applied Ergonomics & Design**
Type of the research project: *(Bachelor's, Master's, DreamTeam, PhD, PostDoc, Senior Researcher, Organisational etc.)*	**Master thesis**
Funder of research: *(EU, NWO, TUD, other – in which case please elaborate)*	**Damen motorkleding, client of the master thesis, will fund required research setups.**
Name of Corresponding Researcher: *(If different from the Responsible Researcher)*	**Nola Houtepen**
E-mail Corresponding Researcher: *(If different from the Responsible Researcher)*	**.nl**
Position of Corresponding Researcher: *(Masters, DreamTeam, PhD, PostDoc, Assistant/ Associate/ Full Professor)*	**Master student**
Name of Responsible Researcher: ***Note:*** *all student work must have a named Responsible Researcher to approve, sign and submit this application*	**Dr. ir. Marijke Dekker**
E-mail of Responsible Researcher: *Please ensure that an institutional email address (**no Gmail, Yahoo, etc.**) is used for all project documentation/ communications including Informed Consent materials*	**.nl**
Position of Responsible Researcher : *(PhD, PostDoc, Associate/ Assistant/ Full Professor)*	**Lecturer**

II. Research Overview

NOTE: *You can find more guidance on completing this checklist here*

a) Please summarise your research very briefly (100-200 words)

What are you looking into, who is involved, how many participants there will be, how they will be recruited and what are they expected to do?

Add your text here – (please avoid jargon and abbrevations)
This study is aimed at gaining insight in differences between the users of leather motorcycle suits and their needs in terms of external protection (positioning). The data will be used for designing and developing a new external protection system in leather motorcycle suits used in track racing. 5-15 motorcyclists will be recruited via purposive sampling. During the research, participants will be asked to answer some interview questions about their motorcycling experience and about motorcycle gear. In addition, 5 participants are asked to take place on a demo motorcycle in a 3D scanner, followed by taking on their riding positions as they would when driving on a race track.

b) **If your application is an additional project** related to an existing approved HREC submission, please provide a brief explanation including the existing relevant HREC submission number/s.

Add your text here – (please avoid jargon and abbrevations)

c) **If your application is a simple extension of, or amendment to,** an existing approved HREC submission, you can simply submit an HREC Amendment Form as a submission through LabServant.

III. Risk Assessment and Mitigation Plan

NOTE: *You can find more guidance on completing this checklist here*

Please complete the following table in full for all points to which your answer is "yes". Bear in mind that the vast majority of projects involving human participants as Research Subjects also involve the collection of **Personally Identifiable Information (PII)** and/or **Personally Identifiable Research Data (PIRD)** which may pose potential risks to participants as detailed in Section G: Data Processing and Privacy below.

To ensure alighment between your risk assessment, data management and what you agree with your Research Subjects you can use the last two columns in the table below to refer to specific points in your Data Management Plan (DMP) and Informed Consent Form (ICF) – **but this is not compulsory**.

It's worth noting that **you're much more likely to need to resubmit your application if you neglect to identify potential risks**, than if you identify a potential risk and demonstrate how you will mitigate it. If necessary, the HREC will always work with you and colleagues in the Privacy Team and Data Management Services to see how, if at all possible, your research can be conducted.

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
A: Partners and collaboration						
1. Will the research be carried out in collaboration with additional organisational partners such as: • One or more collaborating research and/or commercial organisations • Either a research, or a work experience internship provider[1] [1] *If yes, please include the graduation agreement in this application*	■		The collaborating organization (Damen motorkleding) does not want to use their acquintaces as participants.	The owner of Damen acts as the company mentor to the researching student and is fully on board to help recruit the particpants needed for the research. The student will use her own resources as a backup to recruit participants when necessary.		
2. Is this research dependent on a Data Transfer or Processing Agreement with a collaborating partner or third party supplier? *If yes please provide a copy of the signed DTA/DPA*		■				
3. Has this research been approved by another (external) research ethics committee (e.g.: HREC and/or MREC/METC)? *If yes, please provide a copy of the approval (if possible) and summarise any key points in your Risk Management section below*		■				
B: Location						
4. Will the research take place in a country or countries, other than the Netherlands, within the EU?		■				
5. Will the research take place in a country or countries outside the EU?		■				
6. Will the research take place in a place/region or of higher risk – including known dangerous locations (in any country) or locations with non-democratic regimes?		■				
C: Participants						
7. Will the study involve participants who **may** be vulnerable and possibly (legally) unable to give informed consent? (e.g., children below the legal age for giving consent, people with learning difficulties, people living in care or nursing homes,).		■				
8. Will the study involve participants who **may** be vulnerable under specific circumstances and in specific contexts, such as victims and witnesses of violence, including domestic violence; sex workers; members of minority groups, refugees, irregular migrants or dissidents?		■				
9. Are the participants, outside the context of the research, in a dependent or subordinate position to the investigator (such as own children, own students or employees of either TU Delft and/or a collaborating partner organisation)? *It is essential that you safeguard against possible adverse consequences of this situation (such as allowing a student's failure to participate to your satisfaction to affect your evaluation of their coursework).*	■		Participants may be customers of Damen, which may influence their answers to some of the interview questions about the product they currently own.	Participants will be encouraged to critique their suit even if it is a Damen garment, as the purpose of the research is to improve it.		
10. Is there a high possibility of re-identification for your participants? (e.g., do they have a very specialist job of which there are only a small number in a given country, are they members of a small community, or employees from a partner company collaborating in the research? Or are they one of only a handful of (expert) participants in the study?	■		Professional motorcyclists may participate in the research, who can be re-identified.	All participants will be informed about the possibility of re-identification. They will be asked wether or not they wish to participate anonymously, meaning that their re-identifiable data will be processed as anonymous as possible, to limit the possibilities of re-identification. If participants do not feel comfortable with the risk of re-identification they will be asked to discontinue their participation.		7,8,13
D: Recruiting Participants						
11. Will your participants be recruited through your own, professional, channels such as conference attendance lists, or through specific network/s such as self-help groups	■		Some participants will be recruited through the channels of Damen, which gives a less randomized selection of participants.	As the research aims to improve the product of Damen, recruiting through their own channels will be most beneficial for the research, as they have loyal customers who trust them, helping them feel comfotoble when participating, and they have long-term experience in using their products, which offers the most valuable insights for improvements.		
12. Will the participants be recruited or accessed in the longer term by a (legal or customary) gatekeeper? (e.g., an adult professional working with children; a community leader or family member who has this customary role – within or outside the EU; the data producer of a long-term cohort study)		■				
13. Will you be recruiting your participants through a crowd-sourcing service and/or involve a third party data-gathering service, such as a survey platform?	■		An online survey platform may be used to gather data. Re-identifiable data could end up online.	When an online survey platform is used, the researcher will make sure the form content is anonymous and/or required contact information and other re-identifiable data is collected separately. Participants will be informed about the risks of data-breach via the physical consent form of the research.		8
14. Will you be offering any financial, or other, remuneration to participants, and might this induce or bias participation?	■		Participants may consent to participating based on being rewarded, instead of their full willingness and motivation to help the research purposes.	In case a reward is offered, participants will not be informed of the small reward (e.g. taking home their 3D scan) before the start of the research. They will be offered the reward after completing their participation.		
E: Subject Matter *Research related to medical questions/health may require special attention. See also the website of the CCMO before contacting the HREC.*						
15. Will your research involve any of the following: • Medical research and/or clinical trials • Invasive sampling and/or medical imaging • Medical and *In Vitro Diagnostic Medical* Devices Research		■				
16. Will drugs, placebos, or other substances (e.g., drinks, foods, food or drink constituents, dietary supplements) be administered to the study participants? *If yes see here to determine whether medical ethical approval is required*		■				
17. Will blood or tissue samples be obtained from participants? *If yes see here to determine whether medical ethical approval is required*		■				
18. Does the study risk causing psychological stress or anxiety beyond that normally encountered by the participants in their life outside research?		■				
19. Will the study involve discussion of personal sensitive data which could put participants at increased legal, financial, reputational, security or other risk? (e.g., financial data, location data, data relating to children or other vulnerable groups) *Definitions of sensitive personal data, and special cases are provided on the TUD Privacy Team website.*		■				
20. Will the study involve disclosing commercially or professionally sensitive, or confidential information? (e.g., relating to decision-making processes or business strategies which might, for example, be of interest to competitors)		■				
21. Has your study been identified by the TU Delft Privacy Team as requiring a Data Processing Impact Assessment (DPIA)? *If yes please attach the advice/ approval from the Privacy Team to this application*		■				
22. Does your research investigate causes or areas of conflict? *If yes please confirm that your fieldwork has been discussed with the appropriate safety/security advisors and approved by your Department/Faculty.*		■				
23. Does your research involve observing illegal activities or data processed or provided by authorities responsible for preventing, investigating, detecting or prosecuting criminal offences *If so please confirm that your work has been discussed with the appropriate legal advisors and approved by your Department/Faculty.*		■				
F: Research Methods						
24. Will it be necessary for participants to take part in the study without their knowledge and consent at the time? (e.g., covert observation of people in non-public places).		■				
25. Will the study involve actively deceiving the participants? (For example, will participants be deliberately falsely informed, will information be withheld from them or will they be misled in such a way that they are likely to object or show unease when debriefed about the study).		■				
26. Is pain or more than mild discomfort likely to result from the study? And/or could your research activity cause an accident involving (non-) participants?	■		Participants are asked to sit on a demo motorcycle and hanging off to the side in their riding position. There is a very minor chance for participants to fall off the bike.	The demo bike is static and low to the ground and participants are recruited to be experienced in taking on the riding positions that are researched. The task they do in terms of body position will be similar to regular body positioning training on track days and regular rides. Participants may revoke their participation if they are not comfortable.		6
27. Will the experiment involve the use of devices that are not 'CE' certified? *Only, if 'yes': continue with the following questions:*	■					
• Was the device built in-house?	■		The device that keeps the demo motorcycle up straight was built in-house, which involves the risk of failure of the device.	The device was be built using an existing modular system used in mechanical engineering, with the help of experienced users of the system, to ensure the quality and strength of the device.		*6*
• Was it inspected by a safety expert at TU Delft? *If yes, please provide a signed device report*	■			The device has been tested by the researcher and inspected by a safety expert at TU Delft (See device report).		6
• If it was not built in-house and not CE-certified, was it inspected by some other, qualified authority in safety and approved? *If yes, please provide records of the inspection*		■				
28. Will your research involve face-to-face encounters with your participants and if so how will you assess and address Covid considerations?	■		Researcher and/or participants might be ill.	Though there are currently no Covid measurements, but in case of serious sickness, the researcher will postpone the research. Seriously ill participants will be asked to come back when they feel better or to cancel their participation.		
29. Will your research involve **either:** a) "big data", combined datasets, new data-gathering or new data-merging techniques which might lead to re-identification of your participants **and/or** b) artificial intelligence or algorithm training where, for example biased datasets could lead to biased outcomes?		■				
G: Data Processing and Privacy						
30. Will the research involve collecting, processing and/or storing any directly identifiable PII (Personally Identifiable Information) including name or email address that will be used for administrative purposes only? (eg: obtaining Informed Consent or disbursing remuneration)	■		Name, (contact info) and signature will be collected for informed consent and further research.	Informed consent will be stored safely with other physical confidential documents at Damen and remain untouched to prevent it from getting lost or accidentally spread.	IV.17	
31. Will the research involve collecting, processing and/or storing any directly or indirectly identifiable PIRD (Personally Identifiable Research Data) including videos, pictures, IP address, gender, age etc and **what other Personal Research Data** (including personal or professional views) will you be collecting?	■		Body measurement data will be collected from existing sources. Participants will be asked open questions and opinions that disclose who they are and what they value as a person. 3D scans of body positioning will be gathered.	All PIRD data will be processed anonymously unless the participant has consented otherwise. The researcher will ask consent for the collection of PIRD. The PIRD information will be stored confidentially together with the informed consent forms until the end of the project and are processed as un-identifiable as possible. Participants are allowed to wear a full face helmet with a tinted visor during 3D scans. The suits of the participants will be represented in a single colour / assilhouettes to prevent re-identification via the suit design.		4,7,8
32. Will this research involve collecting data from the internet, social media and/or publicly available datasets which have been originally contributed by human participants	■		Data gathered during the measuring appointment of the suit fittings of participants from Damen may be re-used in this research.	Particpants will be asked for consent for re-use of the data (body measurements) that was previously gathered by Damen.		
33. Will your research findings be published in one or more forms in the public domain, as e.g., Masters thesis, journal publication, conference presentation or wider public dissemination?	■		The master thesis will include research results and will be published to the repository.	Data of participants who wish to stay anonymous will be processed in results as anonymous. Confidential appendices wil not be published to the repository and only read by those authorised to do so. Participants who are not comfortable with the risk of re-identification will be asked not to participate.	IV.18, IV.22, IV.25, IV.27	11
34. Will your research data be archived for re-use and/or teaching in an open, private or semi-open archive?	■		Data may be archived for a maximum of 2 years for further development of the product design resulting from this research and/or learning. Re-use can lead to publication of data.	Data will only be accessible for the graduation team when re-used for product development. Participants will be asked for consent in case of re-use for learning.		15,16

H: More on Informed Consent and Data Management

NOTE: You can find guidance and templates for preparing your Informed Consent materials) here

Your research involves human participants as Research Subjects if you are recruiting them or actively involving or influencing, manipulating or directing them in any way in your research activities. This means you must seek informed consent and agree/ implement appropriate safeguards regardless of whether you are collecting any PIRD.

Where you are also collecting PIRD, and using Informed Consent as the legal basis for your research, you need to also make sure that your IC materials are clear on any related risks and the mitigating measures you will take – including through responsible data management.

Got a comment on this checklist or the HREC process? You can leave your comments here

IV. Signature/s

Please note that by signing this checklist list as the sole, or Responsible, researcher you are providing approval of the completeness and quality of the submission, as well as confirming alignment between GDPR, Data Management and Informed Consent requirements.

Nola Houtepen

Signature of Corresponding Researcher: 

Date: 25-04-2024

Marijke Dekker

Signature (or upload consent by mail) Responsible Researcher: 

Date: 25.04.2024

V. Completing your HREC application

Please use the following list to check that you have provided all relevant documentation

Required:

- **Always:** This completed HREC checklist
- **Always:** A data management plan (reviewed, where necessary, by a data-steward)
- **Usually:** A complete Informed Consent form (including Participant Information) and/or Opening Statement (for online consent)

Please also attach any of the following, if relevant to your research:

Document or approval	Contact/s
Full Research Ethics Application	After the assessment of your initial application **HREC will let you know if and when you need to submit additional information**
Signed, valid Device Report	Your Faculty HSE advisor
Ethics approval from an external Medical Committee	TU Delft Policy Advisor, Medical (Devices) Research
Ethics approval from an external Research Ethics Committee	Please append, if possible, with your submission
Approved Data Transfer or Data Processing Agreement	Your Faculty Data Steward and/or TU Delft Privacy Team
Approved Graduation Agreement	Your Master's thesis supervisor
Data Processing Impact Assessment (DPIA)	TU Delft Privacy Team
Other specific requirement	Please reference/explain in your checklist and append with your submission

A14 – INFORMED CONSENT

Participant ID: _____

Active tarmac contact points in motorcycle racing.

You are being invited to participate in a research study titled “Active tarmac contact points in motorcycle racing”. This study is conducted by Nola Houtepen, as part of her MSc graduation project for the study Industrial Design Engineering at TU Delft. The study and project are executed in collaboration with Damen Motorkleding, who aims to improve the external protection in their leather suits.

The purpose of this research study is to gain insight in differences between the users of leather motorcycle suits and their needs in terms of external protection (positioning), and will take you approximately **60 minutes** to complete. The data will be used for designing and evaluating a new external protection system in leather motorcycle suits used in track racing. The processed research results will be published in the final graduation report, which will be accessible online to the public via the TU Delft repository.

The research consists of the following activities:

- Answering interview questions about your track racing experience and gear.
- Completing a survey questionnaire.
- Taking place on the demo motorcycle in your leather suit.
- Taking on your track riding position for a 3D scan.

The demo bike stand has been built in-house. The risk of structural failure or physical harm from falling off the bike has been mitigated by involving an experienced technician and executing a safety inspection.

As with any research the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. Your personally identifiable information / data (PII/PIRD) will be stored confidentially with similar data at Damen and may be reused solely for this project and the potential development of a product at Damen. Your personal data will be inaccessible to anyone who is not involved in this project and will be guarded for a retention period of up to 2 years after the completion of the project.

Data including that is processed into results may be published in the final presentation and report of the graduation project. If you wish to stay anonymous, we will minimize any risks of re-identification from processed results by de-identifying your data.

No financial compensation will be provided for participation in this research.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions. If you wish to remove your data from this research, contact the researcher within 24 hours after participating.

In case you have any questions or remarks please contact Nola Houtepen at _____ *:nl.*

Participant ID: _____

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated *16/04/2024*, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves:	☐	☐
• *Answering interview questions about my track racing experience and gear. (Researcher writes notes)* • *Completing a survey questionnaire.* • *Taking place on the demo motorcycle in your leather suit.* • *Taking on your track riding position for a 3D scan.*		
4. I consent for the researcher to use the body measurements that were previously gathered by Damen during the fitting of my suit.	☐	☐
5. I understand that the study will end after the researching student has graduated.	☐	☐
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
6. I understand that taking part in the study involves the following risks. I understand that these will be mitigated by	☐	☐
• *The demo bike stand has been built in-house. The risk of structural failure or physical harm from falling off the bike has been mitigated by involving an experienced technician and executing a safety inspection.*		
7. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) and associated personally identifiable research data (PIRD) with the potential risk of my identity being revealed.	☐	☐
• *I may be re-identified by PII such as my name.* • *I may be re-identified by PIRD such as answers given during the interview and questionnaire, body measurements or 3D scan.*		
8. I understand that the following steps will be taken to minimise the threat of a data breach, and protect my identity in the event of such a breach:	☐	☐
• *The use of combinations of your personal data that can lead to re-identification will be avoided.* • *Data will be processed using pseudo-anonymisation and aggregation.* • *Access to the data will be limited to the graduation team connected to this research and data will be stored confidentially.* • *3D scans will be anonymised by allowing you to wear a helmet and saving the scan without colouring on the model.*		
9. I understand that personal information collected about me that can identify me, such as my name, will not be shared beyond the study team unless permitted by me.	☐	☐

Participant ID: _____

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
10. I understand that the (identifiable) personal data I provide will be destroyed at maximum 2 years after the researching student has graduated.	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
11. I understand that after the research study the de-identified information I provide will be used for:	☐	☐
• *Designing and potentially developing a new external protection system for the leather race suits of Damen Motorkleding.* • *Reporting and presenting research outcomes and publishing the graduation report in the TU Delft repository.* • *Visual material like 3D scans and photos and quotes from answers to research questions may be used in the presentation and published in the research report.*		
12. I agree that my responses, views or other input can be quoted anonymously in research outputs (choice).	☐	☐
13. I agree that my real name can be used for quotes in research outputs (choice).	☐	☐
14. I give the researcher permission to use scans from today in the graduation report and presentation.	☐	☐
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		
15. I give permission for the de-identified 3D scans that I provide to be archived in the TU Delft repository so it can be used for further research and learning.	☐	☐
16. I understand that access to this repository is restricted to allow access only to the graduation team.	☐	☐

Signatures

_____ _____ _____

Name of participant Signature Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Nola Houtepen

_____ _____ _____

Researcher name Signature Date

Study contact details for further information: Nola Houtepen, +31 ,
_____.nl

A15 – DATA MANAGEMENT PLAN

Plan Overview

A Data Management Plan created using DMPonline

Title: Active tarmac contact points in motorcycle racing.

Creator: Nola Houtepen

Principal Investigator: Nola Houtepen

Data Manager: Nola Houtepen

Project Administrator: Nola Houtepen

Affiliation: Delft University of Technology

Template: TU Delft Data Management Plan template (2021)

Project abstract:

This research is executed in collaboration with Damen motorkleding and consists of interviews, testing, 3D scanning, surveys and observations. The company aims to improve their product with the help of this research. The data gathered during this research will be used for designing and developing a new external protection system in leather motorcycle suits used in track racing.

5-15 motorcyclists will be recruited via purposive sampling and snowball sampling.

During the research, participants will be asked to answer some interview questions about their motorcycling experience and about motorcycle gear. In addition, 5 participants are asked to take place on a demo motorcycle, followed by taking on their riding positions as they would when driving on a race track.

Data gathered will consist of consent, body measurements, interview / questionnaire answers, observations,3D scans body positioning and photo's of observations.

ID: 148701

Start date: 19-04-2024

End date: 31-08-2024

Last modified: 26-04-2024

Active tarmac contact points in motorcycle racing.

0. Administrative questions

1. Name of data management support staff consulted during the preparation of this plan.

My faculty data steward, Jeff Love, is out of office and asks graduating students to fill out this online template for their HREC application.

2. Date of consultation with support staff.

2024-04-25

I. Data description and collection or re-use of existing data

3. Provide a general description of the type of data you will be working with, including any re-used data:

Type of data	File format(s)	How will data be collected (for re-used data: source and terms of use)?	Purpose of processing	Storage location	Who will have access to the data
Body measurements	.xlsx	Re-use of existing data from Damen. (Data available for use in this research with consent from participants and company mentor)	Understand the influence of anthropometrics on body positioning.	Project storage drive	The Graduation project team (Client mentor: Maarten Alewijn, Chair: Marijke Dekker, Mentor: Anna Ruiter and student: Nola Houtepen)
Body positioning 3D scan	.obj	Full body scanner in 3D body scanning lab at IDE	Find differences in body positioning and understand their influence on contact point position.	Project storage drive	Graduation project team
Qualitative interview data	.docx	Collected through physical conversation as notes.	Understand the user and their needs and wishes and evaluate design solutions.	Project storage drive	Graduation project team
Quantitative interview data	.csv	Online survey	Rank the importance of design aspects and evaluate design solutions.	Project storage drive	Graduation project team
Interview data including consent forms with names.	Physical notes	Physical interview and questionnaire	Understand the user and their needs and wishes and evaluate design solutions.	Confidential archive of physical documents at Damen.	Graduation project team

4. How much data storage will you require during the project lifetime?

- < 250 GB

II. Documentation and data quality

5. What documentation will accompany data?

- Methodology of data collection
- Other - explain below

The data will not be re-used by anyone outside the graduation project team. The members of the graduation project team are familiar with the methodology of data collection and the contents, therefore the graduation report will be sufficient as metadata.

III. Storage and backup during research process

6. Where will the data (and code, if applicable) be stored and backed-up during the project lifetime?

- Project Storage at TU Delft

IV. Legal and ethical requirements, codes of conduct

7. Does your research involve human subjects or 3rd party datasets collected from human participants?

- Yes

8A. Will you work with personal data? (information about an identified or identifiable natural person)

If you are not sure which option to select, first ask your Faculty Data Steward for advice. You can also check with the privacy website . If you would like to contact the privacy team: privacy-tud@tudelft.nl, please bring your DMP.

- Yes

Data including names, body measurements and 3D scans will be stored. Names are used solely for collecting consent and scans will be anonymized according to the preference of the participants. A participant identification number will be used to store the data anonymously. Identification numbers are written in the physical consent form. The stored data is digital, separate from the physical consent forms, to prevent re-identification.

8B. Will you work with any other types of confidential or classified data or code as listed below? (tick all that apply)

If you are not sure which option to select, ask your Faculty Data Steward for advice.

- Yes, I work with other types of confidential or classified data (or code) - please explain below

I will be working with confidential data consisting of documents such as European standards licensed to the company and filled out order temlates of their customers. The company mentor is directly involved in the research project as the client and the researching student will only use confidential data with permission of the client. The digital data will be stored safely in the TU Delft project storage drive and physical files will remain at their storage location at Damen.

9. How will ownership of the data and intellectual property rights to the data be managed?

For projects involving commercially-sensitive research or research involving third parties, seek advice of your Faculty Contract Manager when answering this question. If this is not the case, you can use the example below.

The dataset will not be publicly released. The rights to the confidential data will remain at Damen. The confidential data will not be shared in the report and final presentation of the graduating student. A confidential appendix will be shared with the graduation

team solely.

10. Which personal data will you process? Tick all that apply

- Data collected in Informed Consent form (names and email addresses)
- Signed consent forms
- Photographs, video materials, performance appraisals or student results
- Special categories of personal data (specify which): race, ethnicity, criminal offence data, political beliefs, union membership, religion, sex life, health data, biometric or genetic data

Body measurements
3D scans

11. Please list the categories of data subjects

motorcycle road racers

12. Will you be sharing personal data with individuals/organisations outside of the EEA (European Economic Area)?

- No

15. What is the legal ground for personal data processing?

- Informed consent

16. Please describe the informed consent procedure you will follow:

All study participants will be asked for their verbal and written consent for taking part in the study and for data processing before the start of the interview, questionnaire or test.

17. Where will you store the signed consent forms?

- Same storage solutions as explained in question 6

The files will be stored physically with other confidential documents at Damen.

18. Does the processing of the personal data result in a high risk to the data subjects?

If the processing of the personal data results in a high risk to the data subjects, it is required to perform a Data Protection Impact Assessment (DPIA). In order to determine if there is a high risk for the data subjects, please check if any of the options below that are applicable to the processing of the personal data during your research (check all that apply).
If two or more of the options listed below apply, you will have to complete the DPIA. Please get in touch with the privacy team: privacy-tud@tudelft.nl to receive support with DPIA.
If only one of the options listed below applies, your project might need a DPIA. Please get in touch with the privacy team: privacy-tud@tudelft.nl to get advice as to whether DPIA is necessary.
If you have any additional comments, please add them in the box below.

- Sensitive personal data

3D scans of participants will be processed anonymously. The riders will be scanned with a helmet and leather suit on. The scans will

be saved without colours on the 3D model, which makes the participants unrecognizable.

19. Did the privacy team advise you to perform a DPIA?

- No

22. What will happen with personal research data after the end of the research project?

- Other - please explain below

The data will be processed into a graduation report. Bits of anonymised data may be shown in the research report. The report will be shared in the TU Delft repository. Participants will be asked for their consent with regards to the publicity of the graduation report.

23. How long will (pseudonymised) personal data be stored for?

- Other - please state the duration and explain the rationale below

The data will be deleted when the client chooses not to continue developing research results.
The data will be stored for 2 years maximum to give the company time to develop a product related to the research.

24. What is the purpose of sharing personal data?

- For research purposes, which are in-line with the original research purpose for which data have been collected

25. Will your study participants be asked for their consent for data sharing?

- Yes, in consent form - please explain below what you will do with data from participants who did not consent to data sharing

Study participants who do not consent for their data to be shared in the form of processed results in the graduation report will be asked not to participate.

V. Data sharing and long-term preservation

27. Apart from personal data mentioned in question 22, will any other data be publicly shared?

- All other non-personal data (and code) produced in the project

Results in the form of non-personal data (such as questionnaire results) will be shared anonymously in the graduation report.

29. How will you share research data (and code), including the one mentioned in question 22?

- My data will be shared in a different way - please explain below

Any data that is shared has been processed to become public in the graduation report, which is shared in the repository.

30. How much of your data will be shared in a research data repository?

- < 100 GB

31. When will the data (or code) be shared?

- At the end of the research project

32. Under what licence will be the data/code released?

- Other - Please explain

The raw data is not released.

VI. Data management responsibilities and resources

33. Is TU Delft the lead institution for this project?

- Yes, leading the collaboration - please provide details of the type of collaboration and the involved parties below

TU Delft is the lead institution for this graduation project. Damen Motorkleding is involved as the client of the design project.

34. If you leave TU Delft (or are unavailable), who is going to be responsible for the data resulting from this project?

Marijke Dekker (_____) is the chair of the graduating student and Lecturer at the faculty of IDE at the TU Delft. Therefore, she will be responsible for data left at the TU Delft after the student graduates.

35. What resources (for example financial and time) will be dedicated to data management and ensuring that data will be FAIR (Findable, Accessible, Interoperable, Re-usable)?

4TU.ResearchData is able to archive 1TB of data per researcher per year free of charge for all TU Delft researchers. We do not expect to exceed this and therefore there are no additional costs of long term preservation.

A16 – ETHICS APPROVAL

Date 25-Jun-2024
Correspondence hrec@tudelft.nl

Human Research Ethics
Committee TU Delft
(http://hrec.tudelft.nl)

Visiting address
Jaffalaan 5 (building 31)
2628 BX Delft

Postal address
P.O. Box 5015 2600 GA Delft
The Netherlands

Sincerely,

Dr. Ir. U. Pesch
Chair HREC
Faculty of Technology, Policy and Management

Ethics Approval Application: Active tarmac contact points in motorcycle racing.
Applicant: Houtepen, Nola

Dear Nola Houtepen,

It is a pleasure to inform you that your application mentioned above has been approved.

Thanks very much for your submission to the HREC which has been conditionally approved. Please note that this approval is subject to your ensuring that the following condition/s is/are fulfilled:

Please address the issue of sharing so much data with Damen. In some instances this may be argued (e.g. anonymized 3D-scanner data for product development seems plausible), but others certainly not (Informed Consent forms do not need to be shared with Damen). Currently, there is insufficient separation on this front (see the IC forms), meaning principles of data (sharing) minimization are breached.

In addition to any specific conditions or notes, the HREC provides the following standard advice to all applicants:
• In light of recent tax changes, we advise that you confirm any proposed remuneration of research subjects with your faculty contract manager before going ahead.
• Please make sure when you carry out your research that you confirm contemporary covid protocols with your faculty HSE advisor, and that ongoing covid risks and precautions are flagged in the informed consent - with particular attention to this where there are physically vulnerable (eg: elderly or with underlying conditions) participants involved.
• Our default advice is not to publish transcripts or transcript summaries, but to retain these privately for specific purposes/checking; and if they are to be made public then only if fully anonymised and the transcript/summary itself approved by participants for specific purpose.
• Where there are collaborating (including funding) partners, appropriate formal agreements including clarity on responsibilities, including data ownership, responsibilities and access, should be in place and that relevant aspects of such agreements (such as access to raw or other data) are clear in the Informed Consent.

Good luck with your research!

Note: The approval underlines the condition that consent forms are not shared with Damen by storing them at their office. The researcher has ensured that consent forms have been stored separately from Damen during the entirety of the project and will remain private between participant and researcher. Thus, no principles were breached and the approval is fulfilled.

A17 – MJF TPU 3D PRINTING LEG PLATES

Xometry

Xometry Europe GmbH
Ada-Lovelace-Str. 9
85521, Ottobrunn
T: +49 893 803 4818
F: +49 89 93 960 142
E: info@xometry.eu
www.xometry.de

UST-id.Nr.: DE318027176
Steuer-Nr.: 143/194/00231
Handelsregister: Amtsgericht München / HRB 256172
Bank: J.P. Morgan AG
IBAN: DE38 5011 0800 6161 5322 02
BIC: CHASDEFX

Director / Geschäftsführer: Dmitry Kafidov

ORDER CONFIRMATION / AUFTRAGSBESTÄTIGUNG

Bill to:

VAT ID:

Ship to: Top Skin Trading B.V., Nola Houtepen

Document # / Dokumentnummer:
Issue date / Datum: **19.07.2024**
Shipment date / Versandbereit: 01.08.2024

Your order date / Ihre Bestelldatum: 17.07.2024

Pos.	**Article No** / Artikel	**Quantity** Menge	**Price per 1** Preis pro 1	**Total** Betrag
1	Leg_Plate_TPU_V3_RL.STL Process: 3D Printing (MJF) Material: TPU Polyurethane Gray / Black (MJF) Finish:	2	€16.93	€33.86
2	Leg_Plate_TPU_V3_LL.STL Process: 3D Printing (MJF) Material: TPU Polyurethane Gray / Black (MJF) Finish:	2	€16.93	€33.86
	Price net, EUR / Preis, Netto, EUR: Applicable VAT rate / Anwendbarer MwSt-Satz: VAT, EUR / MWSt, EUR: **Gross price, EUR / Preis, Brutto, EUR:**			€67.72 0 % 0.00 **€67.72**

Packaging / Verpackung: included / inklusive

Expected transportation time / Erwartete Lieferzeit:
Box-deliveries / Paketsendung – 2-5 business days / Werktage;
Pallet deliveries, non-standart deliveries / Palettenlieferungen und Sperrgutlieferungen – 3-8 business days / Werktage
Shipping costs / Transportkosten: not included / nicht inbegriffen

Payment conditions / Zahlungsbedingungen: 30 days netto / 30 Tage netto

Delivery of the order is carried out during the working hours of the transport companies (from Monday to Friday, from 8 to 17 hours or from 9 to 18 hours), if your working hours differ from those indicated or you have planned business holidays at the time of the expected delivery, please let us know in advance, we will inform the shipping company and schedule the delivery accordingly.
All costs for storing the order in case of not timely informing about the impossibility of delivering within the standard terms will be re-charged to the client.

Die Zustellung der Bestellung erfolgt während der Arbeitszeiten der Transportunternehmen (von Montag bis Freitag, von 8 bis 17 Uhr oder von 9 bis 18 Uhr). Wenn Ihre Arbeitszeiten von den angegebenen abweichen oder Sie zum Zeitpunkt der erwarteten Zustellung geschlossen haben, informieren Sie uns bitte im Voraus. Wir werden das Transportunternehmen informieren und die Zustellung entsprechend umplanen.
Alle Kosten für die Lagerung der Bestellung im Falle einer nicht rechtzeitigen Benachrichtigung, über die fehlenden Liefermöglichkeiten innerhalb der Standardfristen, werden dem Kunden in Rechnung gestellt.

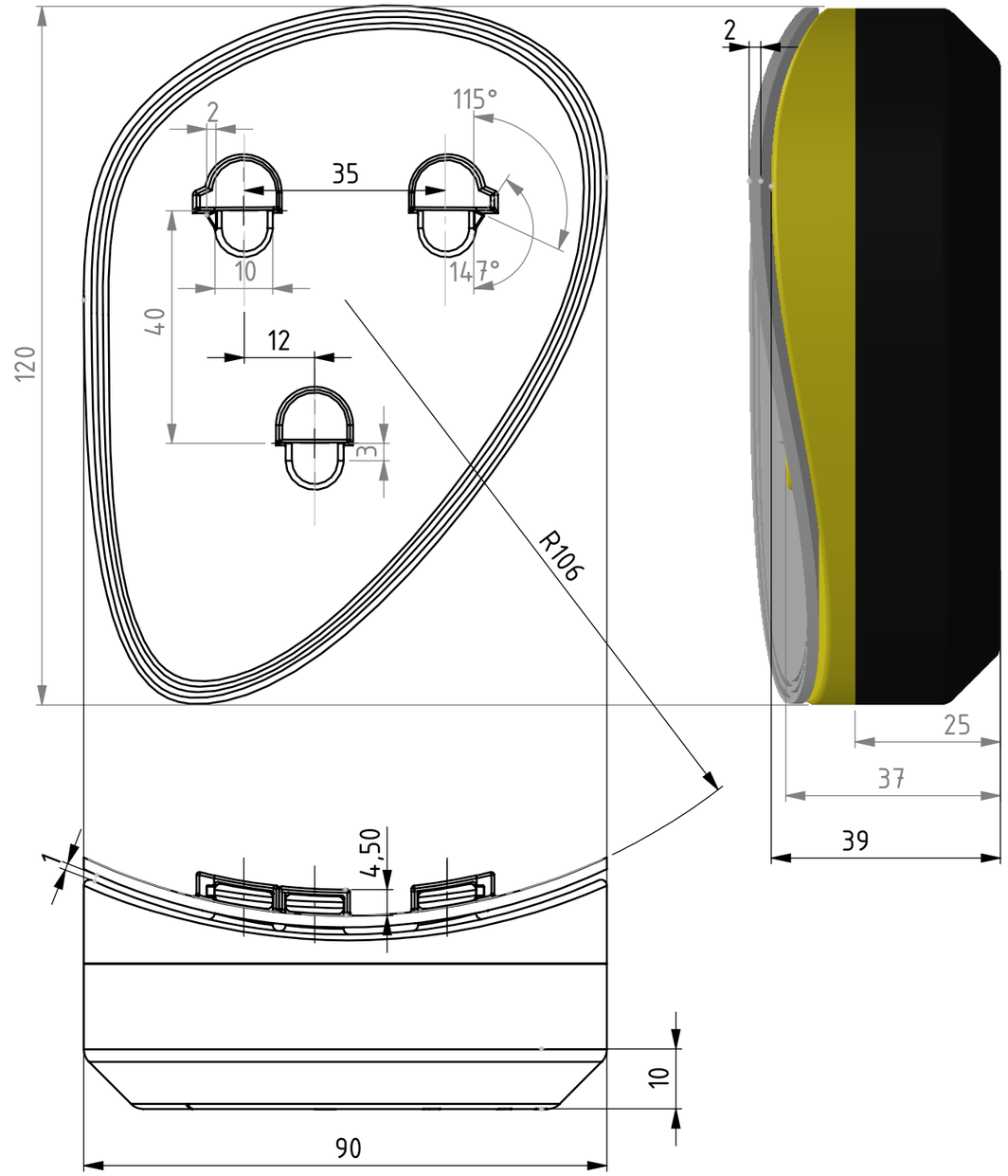
Unless specified otherwise, Terms and Conditions of Xometry Europe GmbH apply.
Wenn nicht anders spezifiziert, gelten die AGB der Xometry Europe GmbH

For the next quotation please visit our website and get an instant quote.
If you have any questions about your order contact our support team.

Für das nächste Angebot besuchen Sie bitte unsere Website und erhalten Sie sofort ein Angebot.Wenn Sie Fragen zu Ihrer Bestellung haben, wenden Sie sich an unser Support-Team.

Web: **get.xometry.eu**
Support: **help@xometry.de**
Phone: **+ 49 89 3803 4818**

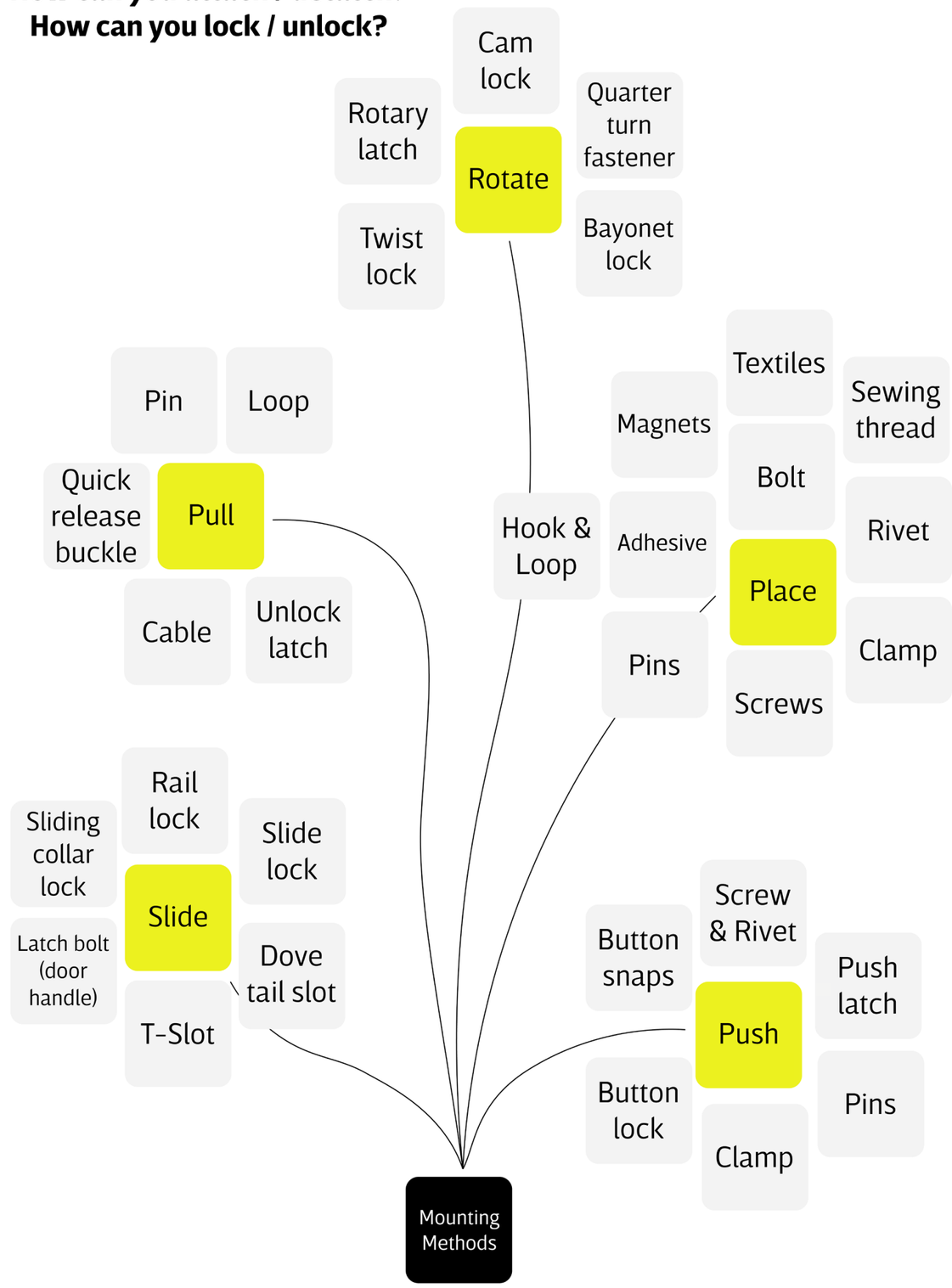
A1S - DESIGN DIMENSIONS

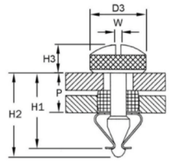


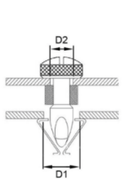
	units mm	scale 1:1	quantity 1	date 24-8-2024	remark -
material TPU				mass gr	TU Delft Delft University of Technology
author Nola Houtepen- 5016347				group -	
name Final_Assembly				format A4	drawing no. 1

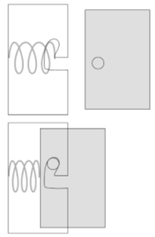
A19 - IDEATION

How can you attach / detatch?
How can you lock / unlock?



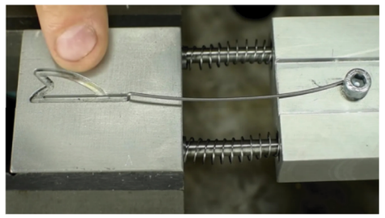


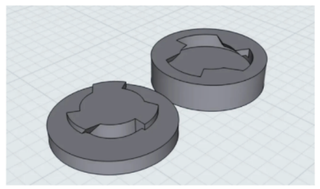




Camlock

Quick-Release





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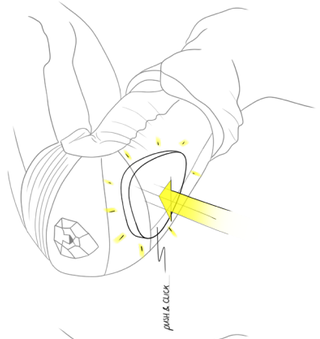
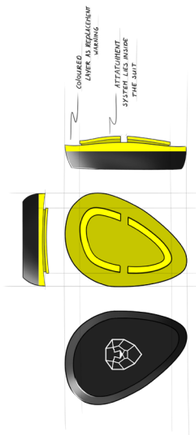
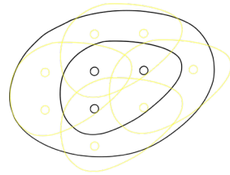
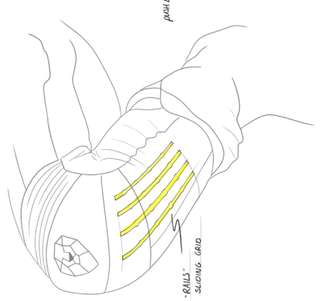
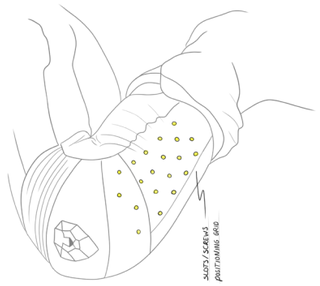
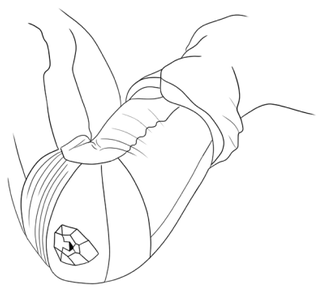


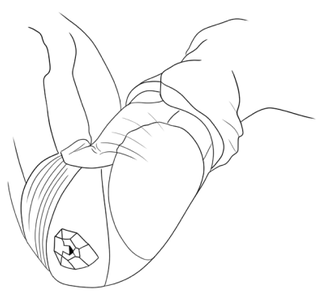


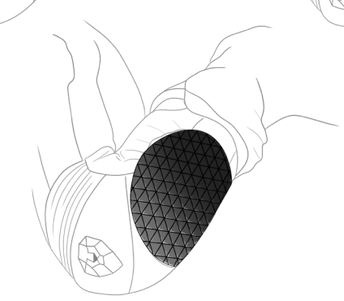








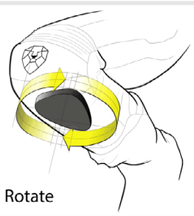
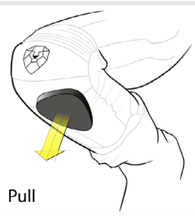
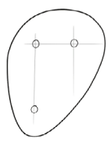
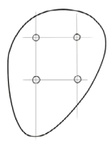
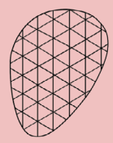
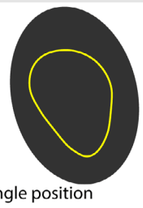
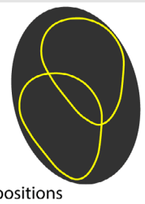
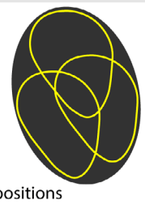
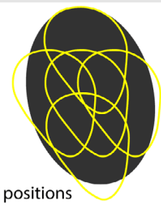
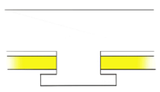
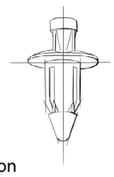
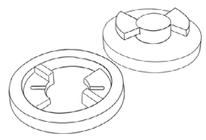
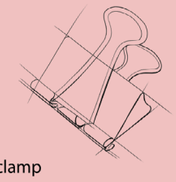
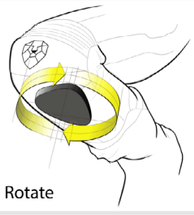
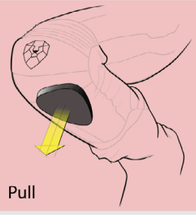
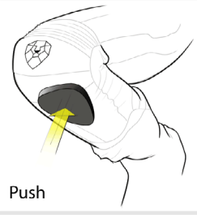




ATTACHMENT MOTION	place	Rotate	Slide	Pull	Push
ATTACHMENT BASE	3 pins	4 pins	contour	grid pattern	center pin
NUMBER OF POSITONS	single position	2 positions	3 positions	5 positions	9 positions
LOCK / UNLOCK	latch	button	twist lock	bolts	clamp
DETATCHMENT MOTION	pick	Rotate	Slide	Pull	Push

ATTACHMENT MOTION	place	Rotate	Slide	Pull	Push
ATTACHMENT BASE	3 pins	4 pins	contour	grid pattern	center pin
NUMBER OF POSITONS	single position	2 positions	3 positions	5 positions	9 positions
LOCK / UNLOCK	latch	button	twist lock	bolts	clamp
DETATCHMENT MOTION	pick	Rotate	Slide	Pull	Push

ATTACHMENT MOTION	place	Rotate	Slide	Pull	Push
ATTACHMENT BASE	3 pins	4 pins	contour	grid pattern	center pin
NUMBER OF POSITONS	single position	2 positions	3 positions	5 positions	9 positions
LOCK / UNLOCK	latch	button	twist lock	bolts	clamp
DETATCHMENT MOTION	pick	Rotate	Slide	Pull	Push

ATTACHMENT MOTION	 place	 Rotate	 Slide	 Pull	 Push
ATTACHMENT BASE	 3 pins	 4 pins	 contour	 grid pattern	 center pin
NUMBER OF POSITONS	 single position	 2 positions	 3 positions	 5 positions	 9 positions
LOCK / UNLOCK	 latch	 button	 twist lock	 bolts	 clamp
DETATCHMENT MOTION	 pick	 Rotate	 Slide	 Pull	 Push

ATTACHMENT MOTION	place	Rotate	Slide	Pull	Push
ATTACHMENT BASE	3 pins	4 pins	contour	grid pattern	center pin
NUMBER OF POSITONS	single position	2 positions	3 positions	5 positions	9 positions
LOCK / UNLOCK	latch	button	twist lock	bolts	clamp
DETATCHMENT MOTION	pick	Rotate	Slide	Pull	Push

A20 – COST ESTIMATION INJECTION MOULDING

BASE PLATE

HIER IS JOUW VRIJBLIJVENDE OFFERTE

Materiaal: TPU
Aantal: 500

Lengte	Breedte	Hoogte	Gewicht
90,03 mm	120,17 mm	12,03 mm	18,67 gr

Enkel- of meer-voudigmatrijs	Matrijsprijs	Product prijs (per stuk)	Totale kosten (incl. in stelkosten)	Totale kosten (per stuk)
1 BEST PRICE	€ 3.349,42	€ 0,67	€ 3.879,01	€ 7,76
2	€ 5.122,93	€ 0,53	€ 5.583,61	€ 11,17
4	€ 8.014,03	€ 0,46	€ 8.440,25	€ 16,88

DISCLAIMER De prijsberekening op deze pagina is een schatting en geen gegarandeerde prijs voor onze diensten en producten. De indicatie is gebaseerd op de waarden die u in het formulier heeft ingevuld. De werkelijke kosten kunnen afwijken na overleg met ons of op basis van uw 3D-model. U kunt geen rechten ontlenen aan deze pagina of de informatie op deze website. Alle genoemde prijzen zijn exclusief BTW. Is er iets onduidelijk? Neem dan gerust contact met ons op. We helpen je graag verder!

OVERZICHT

Maten
90,03 x 120,17 x 12,03 mm
Materiaal
TPU
Gewicht
18,67 gr
Aantal
500

Productie prijs
€ 3.879,01

Instelkosten € 195,00

HIER IS JOUW VRIJBLIJVENDE OFFERTE

Materiaal: PA6
Aantal: 500

Lengte	Breedte	Hoogte	Gewicht
90,03 mm	120,17 mm	12,03 mm	18,67 gr

Enkel- of meer-voudigmatrijs	Matrijsprijs	Product prijs (per stuk)	Totale kosten (incl. in stelkosten)	Totale kosten (per stuk)
1 BEST PRICE	€ 3.349,42	€ 0,54	€ 3.812,21	€ 7,62
2	€ 5.122,93	€ 0,40	€ 5.516,81	€ 11,03
4	€ 8.014,03	€ 0,33	€ 8.373,46	€ 16,75

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OVERZICHT

Maten
90,03 x 120,17 x 12,03 mm
Materiaal
PA6
Gewicht
18,67 gr
Aantal
500

Productie prijs
€ 3.812,21

Instelkosten € 195,00

(QDP, 2023)

SLIDER / PUCK

HIER IS JOUW VRIJBLIJVENDE OFFERTE

Materiaal: TPU
Aantal: 500

Lengte	Breedte	Hoogte	Gewicht
90,03 mm	120,17 mm	39,44 mm	283,43 gr

Enkel- of meer-voudigmatrijs	Matrijsprijs	Product prijs (per stuk)	Totale kosten (incl. in stelkosten)	Totale kosten (per stuk)
1 BEST PRICE	€ 3.716,48	€ 4,32	€ 6.072,07	€ 12,14
2	€ 5.702,01	€ 4,18	€ 7.988,70	€ 15,98
4	€ 8.983,98	€ 4,11	€ 11.236,21	€ 22,47

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OVERZICHT

Maten
90,03 x 120,17 x 39,44 mm
Materiaal
TPU
Gewicht
283,43 gr
Aantal
500

Productie prijs
€ 6.072,07

Instelkosten € 195,00

HIER IS JOUW VRIJBLIJVENDE OFFERTE

Materiaal: PA6
Aantal: 500

Lengte	Breedte	Hoogte	Gewicht
90,03 mm	120,17 mm	39,44 mm	283,43 gr

Enkel- of meer-voudigmatrijs	Matrijsprijs	Product prijs (per stuk)	Totale kosten (incl. in stelkosten)	Totale kosten (per stuk)
1 BEST PRICE	€ 3.716,48	€ 2,59	€ 5.206,40	€ 10,41
2	€ 5.702,01	€ 2,45	€ 7.123,02	€ 14,25
4	€ 8.983,98	€ 2,38	€ 10.370,54	€ 20,74

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OVERZICHT

Maten
90,03 x 120,17 x 39,44 mm
Materiaal
PA6
Gewicht
283,43 gr
Aantal
500

Productie prijs
€ 5.206,40

Instelkosten € 195,00

(QDP, 2023)