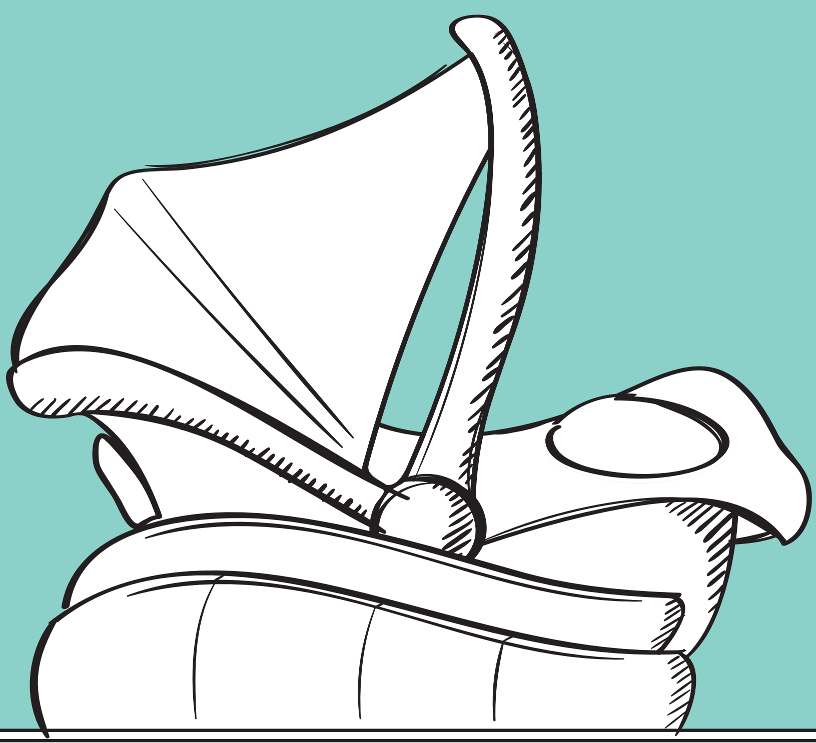
Appendices

Bart van Driessche
Master Thesis Report
Integrated Product Design
Delft Univeristy of Technology



CON
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Appendix 1

Email conversations

The design scope 'cycling with infants' was shared with three experts. This appendix provides e-mail conversations (in Dutch) with these three experts and their concerns about the transmitted vibrations.

Name
Joseph Giacomin

Company
Human Centred Design Institute (HCDI), Brunel University London

Date
31-05-2018

Message
Bart,

In response:

(...)

(4) Regarding the question of whether we "are really shaking babies that bad", the simple answer is "yes we are shaking babies that bad". Common sense would suggest that there is something ethically problematic about a society which is happy to provide better vibration protection to adults than it does to small children. Nevertheless, such is the current situation. There is however a big intellectual question at the heart of the current situation. The fact that the vibration is big does not necessarily mean that it does harm. The problem with vibro0acoustic data is that only the very largest stimuli are guaranteed to cause harm. Once a stimulus is low enough to be considered as part of "normal everyday life" then it becomes exceedingly difficult to decide exactly what level of the stimulus is to be considered acceptable. Common sense suggests that the levels which you have measured would be harmful if maintained 24 hours a day for weeks at a time. But it becomes very difficult to establish scientifically and medically whether a few hours of such vibration, occurring a few days a week, is actually harmful.

I trust that the above will go some way towards assisting your work.

Best regards.

Joseph Giacomin

Name
Ria Nijhuis (Hoogleraar Paramedische Wetenschappen)

Company
Radboud University medical center

Date
02-01-2018

Message
Beste Bart,

Deze mail kwam bij mij terecht via de NVFK.

Ik denk dat in de bijlage al helder gemaakt is welke factoren een rol spelen bij het transport van jonge baby's: nl het blootstellen aan krachten die ze niet kunnen hanteren of dat nu in een auto een fiets of in het dagelijks gebruik is.

Zie bv de instructies van de Mayo kliniek https://www.mayoclinic.org/healthy-lifestyle/infant-and-toddler-health/in-depth/car-seat-safety/art-20043939

Dat betekent volgens mij dat je dit moet vertalen in je ontwerp: nu wordt echt afgeraden door consultatie bureaus etc om een kind op de fiets te vervoeren voordat het zelf kan gaan zitten (en dit is nl een signaal dat hij de krachten kan hanteren). De krachten op een fiets zijn nl vele malen groter dan in een auto die toch wel wat vering heeft).DE krachten worden ook bepaald door de snelheid natuurlijk.

https://www.nhtsa.gov/research-data/child-seat-research dit is nog een site met research data maar een korte zoektocht laat weinig onderzoek zien.

Mi is het dus zaak dat je in je ontwerp een oplossing zoekt voor twee dingen; 1 hoe zorg je dat er weinig krachten op de baby worden uitgeoefend (denk bv aan de kinderwagens waar de vering zo is aangebracht dat de krachten gedempt worden, want ook het transport in een kinderwagen vraagt om dit soort oplossingen) en hoe zorg je er voor dat er bij botsingen een val etc beveiliging is… (je kunt een zuigeling geen helmpje op doen). Dan is voor de zit positie wel onderzoek aanwezig in de auto industrie. Inderdaad is liggend optimaal maar niet vanuit het opvangen van krachten gezien

PS ik gebruik voor kinderen met een ernstige aandoening waardoor er geen spierkracht is vaak een : bolletjesonderlaag in het autostoeltje (in een hoes op mat gemaakt met bolletjes van kunststof ethyreen), die de trillingen dempen waardoor het kind beter de positie kan handhaven. Het kind mag daarin echter nooit alleen gelaten worden vanwege gevaar op verstikking

Het lijkt me dat je dus als ontwerper moet onderzoeken of je de problemen tav de krachten kunt oplossen. Dan blijft het zaak dit slechts te gebruiken voor korte ritten maar ja de richtlijn is dat jonge zuigelingen niet langer dan een half uur in het autostoeltje mogen maar of dit ook gevolgd wordt?

Kortom: beter niet mits…. Je een oplossing vindt…

EN voor zover ik weet is in Delft ook de gewoonte je oplossingen voor te leggen aan experts…

En tja dan kan een onderzoek uitlopen op de conclusie dat het niet haalbaar is… maar wie weet ben je zo inventief dat het lukt, het lost wel een bestaande vraag op van ouders die nu of moeten lopen of de auto moeten nemen.

Groet Ria Nijhuis

Appendix 2
Popal the brand

Popal fietsen Nederland B.V. (abbreviated as Popal) is a Dutch bicycle supplier and wholesaler founded in the Netherlands in 1999. This appendix provides a detailed profile of the brand Popal, including Business Model Canvas.

2.1 The story of a bike brand

In 1999 the Dutch bike market consisted mainly of either expensive luxury models or cheap disposable ones. A good bike for a fair price: it didn't actually exist. The Popal brothers felt that there was room for improvement, and decided to produce good quality bikes themselves, for a reasonable price.
With more than 300 models in the collection, and more than 250 dealers in the Netherlands and abroad, Popal has an extensive product portfolio and network channel. Popal's contemporary bicycles are manufactured and produced in China. The graphic appearance (e.g. color and logo placement) is composed internally at Popal. At the moment, Popal does not have an internal design (engineering) team that is able to fully design (and engineer) bicycles until manufacturing.

The majority of Popal's bicycles can be segmented as 'low-cost' or 'entry-level' bicycles. These utilitarian products basically satisfy one basic need: the ability to transport something – a person – safely. Popal's 'mid-priced' bicycles, however, have added an emotional component to the mix: e.g. excitement of cycling, performance or styling.

2.2 To be part of the family

2.2.1 The Popal family tree

Since the founding of Popal in 1999 by Mr. Popal, the 'Popal family tree' has grown enormously, both in annual turnover as well as employees. Popal has 30 FTE employees and an annual turnover of approximately 10 million euros. The organizational structure of the company – 'the Popal family tree' – can be found in appendix X. Popal remains a family business, and that is the basis of its philosophy. To be part of the family, that's Popal's ambition. A Popal bike in every shed in the Netherlands, for young and old.

2.2.2 Finding the ideal bicycle - vision

It is noteworthy that Popal's vision not only draws emphasis on their bicycles, but also on their e-commerce approach:

"We are constantly striving to find the ideal bicycle. That's why you can only find bicycles in our product portfolio where quality and affordability unite into trendy, contemporary and innovative models. We also find it important to make online shopping for consumers as enjoyable as possible. For example, our wide range of products can be viewed clearly and the bicycles can be delivered to the consumer within 48 hours."

2.2.3 Turn consumers into fans - mission

Popal is not satisfied with satisfied consumers, they "like to turn consumers into fans". Popal's mission is to be the specialist in the field of cycling and cycling equipment.

2.3 Business model canvas

Popal's main business aspects are visually mapped in a Business Model Canvas that can be found in Figure 1. Three business aspects are described in more detail, due to their possible influence on future sections of the design process.

Please note, the Business Model Canvas is derived prior to the graduation project. The outcome of the graduation project can possibly change parts of the Business Model Canvas.

2.3.1 Customer segments

Popal's key customers

Popal's regular customers are B2B customers, which can be divided into 4 types:

- Dealers with a physical store only, mainly traditional bicycle mechanics.

"The Dutch like to keep abreast of the newest trends, but are smart enough not to pay too much for them. Which is why Popal produces affordable good-quality bikes with a contemporary design. Hip to look at, sturdy quality, but at a price to suit everyone!"

- Dealers with a web shop only. In most cases, these dealers, simply 'drop ship' orders at Popal (resell).
- Dealers with both a physical store and a web shop. The minority of these dealers hold their own stock, but the majority of the dealers make use of Popal's drop shipment service.
- Companies. Besides dealers, Popal also has companies as customer. These are especially interested in marketing bikes, or large quantities of regular bicycles that can be used as sales drivers.

Popal's end users

Popal's end customers are subdivided into four target groups:

- (Parents of) children between 3 to 12 years old
- (Parents of) teenagers between 12 years to 18 years.
- (Young) adults starting at the age of 18
- Parents

Popal's key resources

Popal has several strong key resources. Both the employee who is responsible for acquisition and purchase and the director speak fluent Chinese, which has resulted in good relations with Chinese suppliers. In addition, Popal purchases predominantly in large quantities and has a warehouse in Utrecht to maintain this large stock. Therefore, Popal is able to guarantee short delivery times. Moreover, due to the fact that Popal purchases in large purchase quantities, selling prices can stay low.

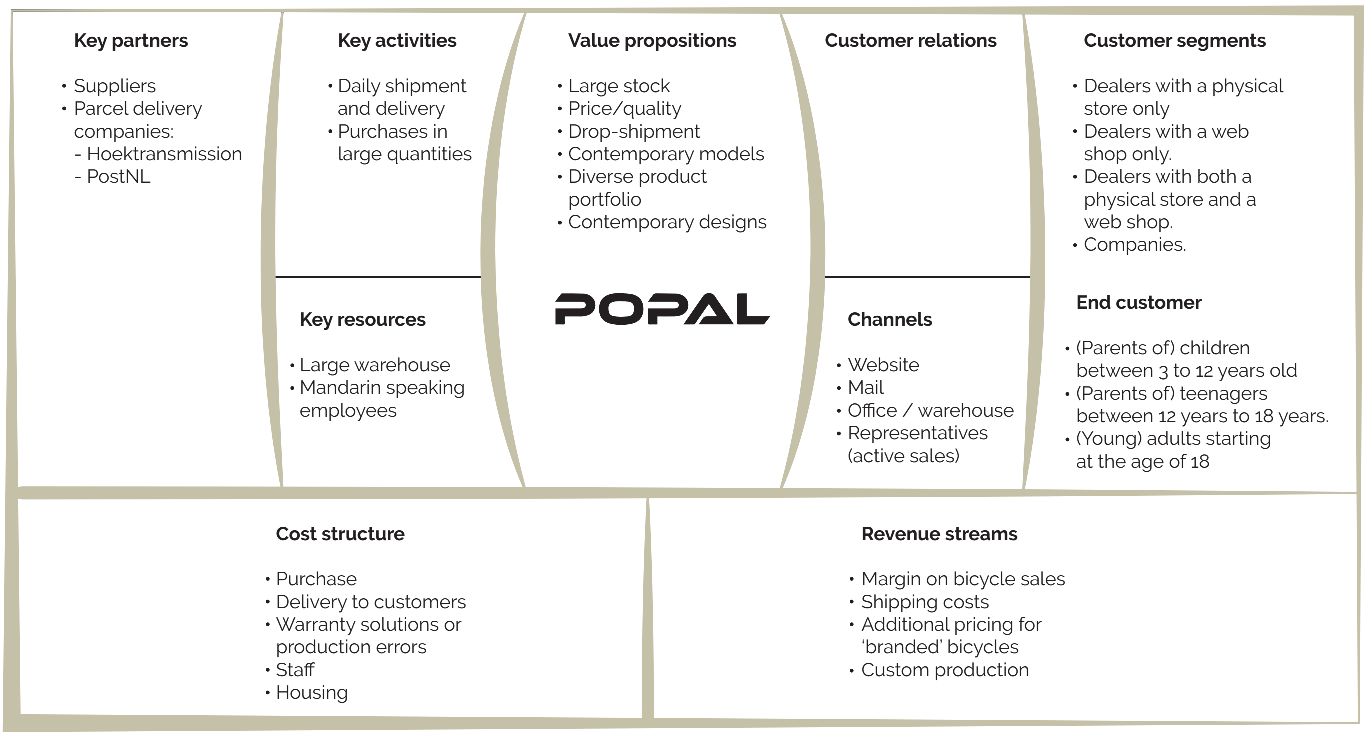


Figure 1: Popal's Business Model Canvas

Appendix 3

Changes in the **urban environment**

The world is changing fast, faster than ever before. It is, therefore, of utmost importance to understand the main factors underlying this change. Not only the use of innovative technologies has effect on the urban environment. Also how urban planners, designers and communities have been organizing and arranging (inner) city areas due to the continuing trend of urbanization. This section discusses several key factors that influence the urban environment.

3.1 Taking on density

While urban growth (defined by towns and cities of a given size) may be slowing, the drift to suburbanisation continues apace. In many countries relatively small, quite widely dispersed urban centers, are gradually integrating into large urban agglomerations as centers expand, and transport and other infrastructures tie them ever more closely together.

On the other side, greater demand for core urban sites will increase urban density, leading to the need to create additional residential and commercial space. This housing need further highlights the advantages of mid- to high-rise buildings as places to live and work.

As a consequence of high-rise buildings, most people buy or rent smaller apartments comparing to the ones they would have in towns and villages, so they need smarter solutions to store goods and arrange goods to accommodate various occasions.

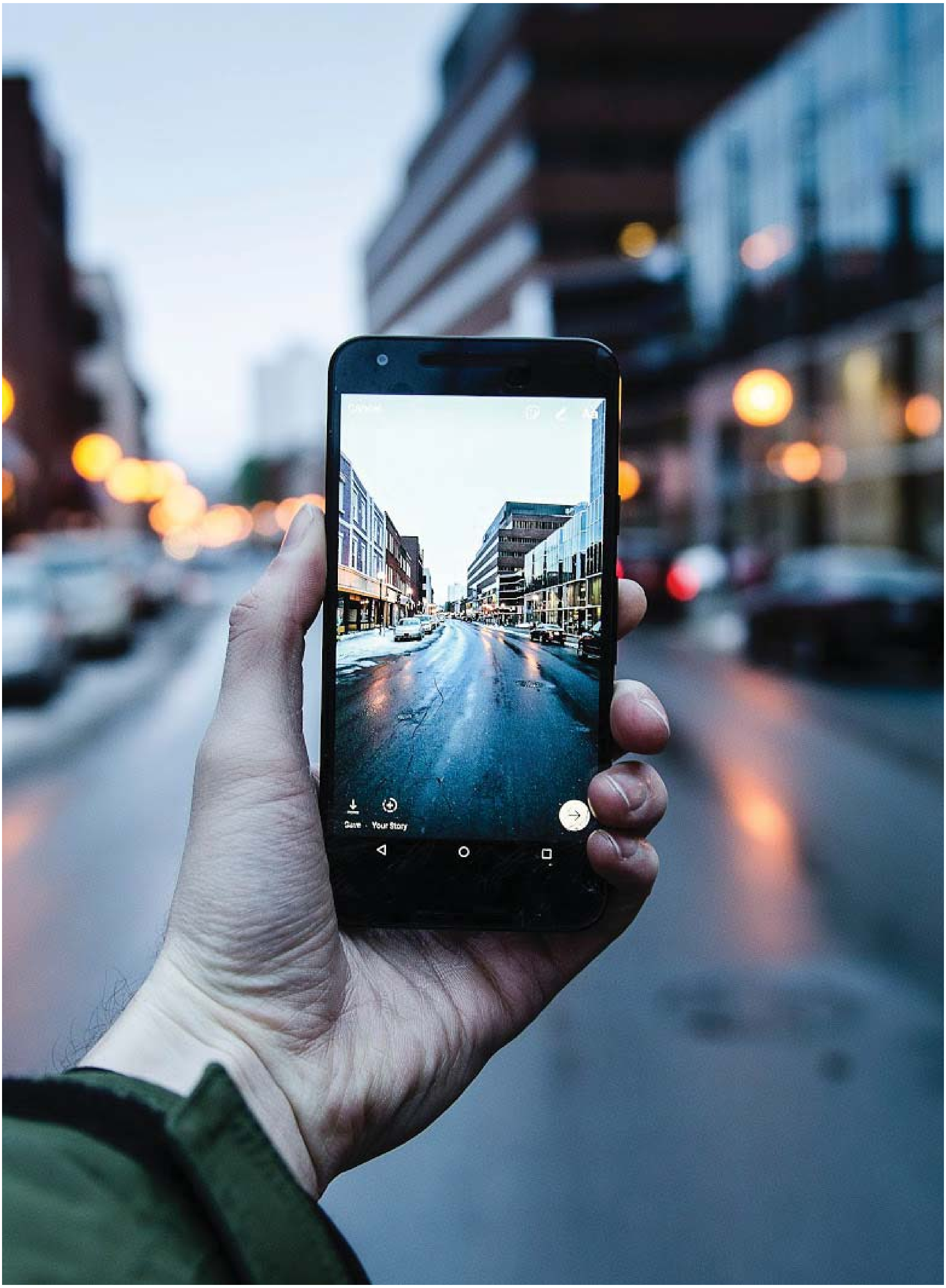
3.2 Image-driven culture

According to a report released in the Business Insider (Edwards, 2014), we currently upload and share 1.8 billion images every single day. Images reflect, communicate, and even shape cultural meaning (Boustany et al, 2015). Smartphones and the internet that enables them can be considered as the modern-day equivalent to movable type, and these tools are still very new (Briggs, 2017).

Visual literacy (the ability to read, write and create visual images) helps us to translate complex or subjective information into easily digestible images, bringing together the practical need to communicate with an aesthetic sensibility. Visual literacy creates also awareness about important urban behaviors, patterns and conditions, such as bike use, traffic and safety.

▶ Figure 2: We upload and share many images every single day. This new way of communication can considered to be one of the main contributing factors of the image-driven culture.

▼ Figure 3: The skyline of Rotterdam (the Netherlands), highlighting one of Netherlands's most densily populated city.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Social design reminds designers of their responsibility toward society.

3.3 Climate Change

There is serious debate about the current and future repercussions of climate change. These effects may be ultimately irreversible and are largely due to an increase in carbon dioxide levels—the highest levels of which are produced in cities (BMW Guggenheim Lab, 2011). Through large-scale intergovernmental guidelines and individual initiatives, urban planners and citizens are becoming more aware of these issues, resulting in more responsible design and lifestyle choices that can lead to urgently needed reductions in emissions.

3.4 Design for social impact

Social design reminds designers of their responsibility toward society. Since we live in a social world defined by interaction, it is natural that our actions have an impact on other people's lifes. Design can be seen, therefore, as a tool to promote and facilitate social change. The development of projects engaged with communities, governments, and other organizations challenges designers to create solutions for social issues and commit to its important role in society.

3.5 Dynamic Personalization

In the past, people recognized the limitations of time, production and manufacturing capabilities. But today we're faced with a consumer expectation that they can have exactly what they want at any moment in time. This has been driven by the democratization of knowledge, global connectivity (Valerie Jacobs, 2016), always-on lifestyles (always being connected to a network), and strong return to consumerism after an era of austerity. It has manifested in the disruption of all types of products, services and even business models. Not only do we see it in the startup, entrepreneurial, maker culture, but also in the level of customization being offered to consumers today.

Figure 4: (upper) The Brisbane River banks broke on the 11th of January 2011 and river levels peaked on the 13th at 4.46 metres, the sixth highest in the city's long history. The cause: climate change.

Figure 5: (middle) Solutions for the homeless. Project: The Homeless Studio. Exploring the role that architects have as part of the solution to the problem of homelessness

Figure 6: (lower) A bicycle being personalised with name stickers.

Appendix 4

Leading or upcoming **mobility companies**

4.1 Amber mobility

Amber is a car sharing platform for business users that makes use of an application and specifically adjusted BMW i3's. By using the app business users can order, unlock, start, park and charge an Amber BMW i3.

Founded in 2016, they now have more than 1500 business users and 122 BMW i3's that are daily available for their users in the six biggest cities in the Netherlands (a.o. Amsterdam, Utrecht and Rotterdam). In October 2018 Amber was awarded with the title Most Disruptive Innovator of the 2018 Deloitte Technology Fast 50 (Drive Amber, 2018). Moreover, currently they are developing their own EV car.

4.2 Uber

Uber was founded in San Francisco, California in 2009. It started as a transportation network company that utilized licensed taxi drivers for its ridesharing services. The idea behind the business was to integrate a mobile application into its practices to connect passengers with drivers of vehicles for hire. Users are able to reserve vehicles by sending text messages or through the use of the application on their mobile devices. The customer can also track the vehicle as it makes its way to their location.

Uber's yearly revenue is around $10 billion.

4.3 Swapfiets

Swapfiets is a bicycle sharing company founded in 2015. For 15 euros per month (12 euros for students) users can lease a bicycle. In the event of damages. such as a flat tire, the Swapfiets team will personally visit the user to repair the bicycle.

Swapfiets was awarded with the title Marketing Start-up of the Year at the 2018 Dutch Marketing Awards. In October 2018 they had more than 600 employees, divided over 170 FTE and more than 50.000 daily users.

4.4 Lime and Bird

Lime, like Bird, lets people reserve a local scooter on their phone, ride for a small fee, and at the end of the journey, leave the scooter wherever to be claimed by the next rider (Business Insider, 2018). Investor are pouring millions into these start-ups since they believe electric scooters can get you to a location faster than any other form of transportation. Lime was valued at about $1 billion and Bird reportedly raising money at twice that valuation (CNBC, 2018).

Electric scooters are fast becoming the new transportation mode of choice (CTech, 2018). This modest and light weighted vehicle is steadily becoming an alternative to both bicycles and motorcycles.

Figure 7: More than 120 specifically adjusted BMW i3's are available every day for Amber's business user's.

Figure 8: (upper) The Swapfiets team will personally visit the user to repair the bicycle, in the event of damages. such as a flat tire.

Figure 9: (lower) Lime (white/green), like Bird (black), lets people reserve a local scooter on their phone, ride for a small fee, and at the end of the journey, leave the scooter wherever to be claimed by the next rider (Business Insider, 2018).

Appendix 5

Research **travelling behavior**

A quantitative research, by means of an online questionnaire, was executed to map the travelling behavior of parents travelling with children. The online questionnaire was distributed on three Facebook pages: bakfietservaringen (1200 followers), Ouder van Nu (165.000 followers) and Vreugdevol Ouderschap - voor écht contact met je kind (3000 followers).

5.1 Purpose of the research

Children's travel behaviour varies from that of adults in several ways: they have less choice about where they go and often they are not allowed to travel unescorted by an older person. The factors that influence children's travel behaviour have changed in recent years, with the development of car-oriented lifestyles, increased numbers of mothers in employment and changes in attitudes towards children's independent mobility (Mackett, 2013). The purpose of this research was to examine young children's travel behaviour (0 to 6 years of age) and to identify factors that influence it. Moreover, challenges when travelling with these young children were discussed.

5.2 Participants

In total, 175 participants have started the online questionnaire. 111 Participants (63%) completed the questionnaire. The high number of unfinished questionnaires might be caused by its length. 38 Of the 111 participants, which accounts for 34%, lived in 1) cities, 2) municipalities that show a strong population grow according to the Dutch Regional Population and Household Forecast (2015) or 3) municipalities that have more than 100.000 inhabitants. The results of these 38 participants were used for the data analysis. This appendix provides the online questionnaire that was used in the research.

Pagina 1

Fijn dat je wilt meewerken aan mijn korte onderzoek! Het onderzoek duurt ongeveer 10 minuten, afhankelijk van het aantal ingevulde vragen. Alle ingevulde data zal vertrouwelijk worden behandeld en wordt alleen voor het doel van het onderzoek gebruikt.

Dit onderzoek, naar het gezamenlijke reisgedrag van ouders en kinderen 0 - 6 jaar oud, doe ik, Bart van Driessche, voor mijn afstudeeropdracht aan de faculteit Industrial Design Engineering aan de Technische Universiteit Delft.

Het onderzoek bestaat uit drie delen:
- Het eerste deel bevat algemene vragen over de persoonlijke situatie zoals leeftijd etc;
- Het tweede deel bevat vragen m.b.t. gezinssamenstelling (zoals aantal kinderen en leeftijd);
- Het derde deel richt zich op het gezamenlijke reisgedrag van ouders en kinderen in de leeftijd 0 - 6 jaar oud.

Als bedankje verloot ik, in samenwerking met Bigline (http://www.bigline.nl/), twee tegoedbonnen t.w.v. €25,00. Deze kortingsbonnen zijn vrij te besteden op het gehele assortiment van fiets tot kinderwagen. Wil je meedoen? Laat dan aan het eind van de vragenlijst jouw e-mailadres achter. De winnaars krijgen begin november bericht. Alleen volledig ingevulde vragenlijsten dingen mee voor de prijs.

Heb je naar aanleiding van het invullen van het onderzoek vragen? Of wil je meer inhoudelijke informatie over het onderzoek? Neem dan contact met mij op via info@bartvandriessche.nl.

Nogmaals hartelijk dank voor de deelname.

Pagina 2

De volgende vragen hebben betrekking op je persoonlijke (demografische) kenmerken.

1.1. Wat is je leeftijd?

- ◯ 15 - 24 jaar
- ◯ 25 - 34 jaar
- ◯ 35 - 44 jaar
- ◯ 45 jaar en ouder

1.2. Wat is de postcode van het woonadres (1234AA)?

[ ]

1.3. Wat is je leefsituatie?

- ◯ Alleenstaand
- ◯ Samenwonend of getrouwd
- ◯ Inwonend bij ouders/familie

1.4. Wat is de hoogst voltooide opleiding?

- ◯ Master (WO of HBO) / post-doctoraal hieronder valt ook: doctoraal
- ◯ Bachelor (WO of HBO) hieronder valt ook: hbo, hts, heao, kandidaatsopleiding
- ◯ Havo/VWO eindexamen hieronder valt ook: mms, hbs, gymnasium, lyceum, atheneum
- ◯ MBO-1 / MBO-2 / MBO-3 / MBO-4 / MBO vóór 1998, hieronder valt ook: mts, meao, mhno, inas, mis, e.d.
- ◯ VMBO (theoretisch / gemengd) hieronder valt ook: mavo, ulo, mulo, ivo, vglo
- ◯ VMBO (beroepsgericht) / MBO-1 (assistentenopleiding) hieronder valt ook: lts, ito, leao, lhno, huishoudschool, lavo, e.d.
- ◯ Basisschool hieronder valt ook: lagere school
- ◯ Anders, namelijk: [ ]

1.5. Wat is op dit moment voor jou van toepassing (meerdere antwoorden mogelijk)?

Indien je niet werkzaam bent, kun je na het invullen van deze vraag verder gaan naar vraag 1.9.

- ☐ Ik ben zelfstandig ondernemer
- ☐ Ik werk in loondienst (full-time)
- ☐ Ik werk in loondienst (part-time)
- ☐ Ik ben werkloos, werkzoekend, in de bijstand
- ☐ Ik studeer / ik ga naar school
- ☐ Ik ben huisman, huisvrouw
- ☐ Ik doe vrijwilligerswerk
- ☐ Anders, namelijk: ________

1.6. Hoe veel uur werk je gemiddeld per week?

____

1.7. Met welke vervoerwijze leg je de langste afstand af als je naar je werk gaat?

- ○ Lopen
- ○ Fietsen
- ○ Auto
- ○ Openbaar vervoer
- ○ Motor/bromfiets/scooter
- ○ Anders, namelijk ________

1.8. Wat is de gemiddelde woon-werk afstand in kilometers?

Tip! Je kunt je locatie van je werk ingeven bij Google Maps en op basis van je vervoerwijze kijken wat de totale afstand is.

____

1.9. Heb je de beschikking over een auto?

- ◯ Beide ouders kunnen over een eigen auto beschikken
- ◯ Een van de ouders kan over een eigen auto beschikken
- ◯ Beide ouders kunnen over een deel auto beschikken (particulier (b.v. vrienden of collega's) of via een organisatie)
- ◯ Een van de ouders kan over een deel auto beschikken (particulier (b.v. vrienden of collega's) of via een organisatie)
- ◯ Geen van beide ouders beschikt over een eigen auto
- ◯ Geen van beide ouders beschikt over een deel auto
- ◯ anders, namelijk __________

Pagina 3

De volgende vragen hebben betrekking op de samenstelling van het gezin.

2.1. Wat is de leeftijd van kind 1?

____

2.2. Wat is het geslacht van kind 1?

- ◯ Jongen
- ◯ Meisje

2.3. Wat is de leeftijd van kind 2?

Indien van toepassing

____

2.4. Wat is het geslacht van kind 2?

Indien van toepassing

- ◯ Jongen
- ◯ Meisje

2.5. Wat is de leeftijd van kind 3?

Indien van toepassing

____

2.6. Wat is het geslacht van kind 3?

Indien van toepassing

- ◯ Jongen
- ◯ Meisje

2.7. Wat is de leeftijd van kind 4?

Indien van toepassing

____

2.8. Wat is het geslacht van kind 4?

Indien van toepassing

- ◯ Jongen
- ◯ Meisje

2.9. Wat is de leeftijd van kind 5?

Indien van toepassing

[ ]

2.10. Wat is het geslacht van kind 5?

Indien van toepassing

◯ Jongen

◯ Meisje

Pagina 4

Het volgende deel heeft betrekking op het gezamenlijke reisgedrag van ouders en kinderen in de leeftijd 0 tot en met 6 jaar.

Een literatuurstudie heeft aangetoond dat er onvoldoende volledige en betrouwbare gegevens bestaan over het gezamenlijke reisgedrag van ouders en kinderen in de leeftijd van 0 – 6 jaar oud. Het gezamenlijke reisgedrag hangt namelijk af van vele factoren, zoals afstand, beschikbaarheid van vervoerwijzen (trein, tram, auto, etc.), zelfstandig of onder begeleiding reizen of de bezettingsgraad (hoe veel en welke personen reizen er mee).

Ik heb reizen ingedeeld op basis van afstand:

1. Reizen met een afstand minder dan 1000 meter;
2. Reizen met een afstand van 1000 meter tot 3 km;
3. Reizen met een afstand van 3 km tot 5 km;
4. Reizen met een afstand van meer dan 5 km

Per afstand (bovengenoemd, 1 t/m 4) worden er 7 vragen gesteld. Dit onderzoek richt zich op het gezamenlijke reisgedrag van ouders (jezelf) met kind(eren) in de leeftijd van 0 tot en met 6 jaar. In andere woorden, het gaat om de reizen die je samen maakt met je kind(eren) en dus niet de reizen die je alleen maakt of waar je kinderen niet bij zijn.

Pagina 5

De volgende vragen hebben betrekking op reizen van minder dan 1000 meter die je samen maakt met je kind(eren).

3.1. Welke vervoerwijze gebruik je het vaakst bij reizen met een afstand minder dan 1000 meter?

- ◯ Lopen
- ◯ Begeleidend fietsen
- ◯ Samen op een (bak)fiets
- ◯ Samen op een elektrische (bak)fiets
- ◯ Met de auto
- ◯ Met de brommer/motorfiets/scooter
- ◯ Met het openbaar vervoer
- ◯ Anders, namelijk: ____________

3.2. Wat is (in de meeste gevallen) de bezettingsgraad?

Bezettingsgraad betekent wie en hoe veel mensen er in de meeste gevallen op of in de vervoerwijze aanwezig zijn

Gelieve dit zo specifiek mogelijk te noemen. Bijvoorbeeld: jezelf, je kind, één leeftijdsgenootje (vriendje of vriendinnetje), één ouder kind (zoon of dochter)

____

3.3. Wat is de reden dat je voor deze vervoerwijze kiest (meerdere antwoorden mogelijk)?

- ☐ omdat het kind te jong is om zelfstandig te gaan
- ☐ omdat de route niet verkeersveilig is voor jonge kinderen
- ☐ omdat het gezellig is om samen deel te nemen aan het verkeer
- ☐ omdat ik / andere volwassene(n) toch al meeging(en) om een ander kind te begeleiden
- ☐ omdat deze bestemming(en) op de route naar de eindbestemming ligt/liggen (zoals werk, sport, winkelcentrum, etc.)
- ☐ omdat ik / andere volwassene(n) na het wegbrengen direct iets anders gingen doen
- ☐ omdat de route niet sociaal veilig is
- ☐ omdat ik / andere volwassene(n) niet de hele dag thuis wilde zitten
- ☐ omdat de afstand te ver is om gebruik te maken van een ander vervoersmiddel
- ☐ Met een ander vervoerwijze kan ik niet zo veel personen vervoeren
- ☐ Anders, namelijk: ____________

3.4. Welke vorm van verkeershinder of knelpunten kom je (regelmatig) tegen bij reizen met een afstand minder dan 1000 meter (meerdere antwoorden mogelijk)?

- ☐ Gevaarlijk of lastig geparkeerde auto's, waardoor er weinig zicht is op de weg.
- ☐ Verkeersgedrag van anderen
- ☐ Slordig geparkeerde auto's rondom locatie
- ☐ Te hard rijdende auto's
- ☐ Geen of onveilige fietspaden/stroken
- ☐ Het oversteken van drukke wegen
- ☐ Onoverzichtelijke zebrapaden
- ☐ Wegversmalling
- ☐ Slecht verlichte tunnels en viaducten
- ☐ Wegwerkzaamheden
- ☐ Gebrek aan parkeermogelijkheden
- ☐ Anders, namelijk: ____________

3.5. Kies je wel eens voor een alternatieve vervoerwijze bij reizen met een afstand minder dan 1000 meter?

- ○ Nooit
- ○ Bijna nooit
- ○ Soms
- ○ Niet van toepassing

3.6. Wat is de reden waarom je dan voor dit alternatieve vervoerwijze kiest?

3.7. Welke activiteiten bevinden zich binnen reizen met afstanden minder dan 1000 meter (meerdere antwoorden mogelijk)?

- [ ] School, buitenschoolse opvang (BSO) of kinderdagverblijf (hieronder vallen ook oma's of opa's of andere personen wanneer zij op vaste dagen voor de opvang van het kind zorgen)
- [ ] Bezoek aan familie / vrienden / kennissen
- [ ] Buitenrecreatie (boswandelingen, speeltuinen – en plaatsen, parken)
- [ ] Uitgaan (uit eten, lunchen, op het terras)
- [ ] Winkelen voor plezier (boodschappen doen, kleding, lichaamsverzorging)
- [ ] Bezoek aan attracties (kindertheater, educatie & musea, zwembad, binnen speeltuin, kinderboerderij)
- [ ] Anders, namelijk: ____________

Pagina 6

De volgende vragen hebben betrekking op reizen met een afstand van 1000 meter tot 3 km die je samen maakt met je kind(eren).

3.8. Welke vervoerwijze gebruik je het vaakst bij reizen met een afstand van 1000 meter tot 3 km?

- ○ Lopen
- ○ Begeleidend fietsen
- ○ Samen op een (bak)fiets
- ○ Samen op een elektrische (bak)fiets
- ○ Met de auto
- ○ Met de brommer/motorfiets/scooter
- ○ Met het openbaar vervoer
- ○ Anders, namelijk: ____________

3.9. Wat is (in de meeste gevallen) de bezettingsgraad?

Bezettingsgraad betekent wie en hoe veel mensen er in de meeste gevallen op of in de vervoerwijze aanwezig zijn

Gelieve dit zo specifiek mogelijk te noemen. Bijvoorbeeld: jezelf, je kind, één leeftijdsgenootje (vriendje of vriendinnetje), één ouder kind (zoon of dochter)

____

3.10. Wat is de reden dat je voor deze vervoerwijze kiest (meerdere antwoorden mogelijk)?

- ☐ omdat het kind te jong is om zelfstandig te gaan
- ☐ omdat de route niet verkeersveilig is voor jonge kinderen
- ☐ omdat het gezellig is om samen deel te nemen aan het verkeer
- ☐ omdat ik / andere volwassene(n) toch al meeging(en) om een ander kind te begeleiden
- ☐ omdat deze bestemming(en) op de route naar de eindbestemming ligt/liggen (zoals werk, sport, winkelcentrum, etc.)
- ☐ omdat ik / andere volwassene(n) na het wegbrengen direct iets anders gingen doen
- ☐ omdat de route niet sociaal veilig is
- ☐ omdat ik / andere volwassene(n) niet de hele dag thuis wilde zitten
- ☐ omdat de afstand te ver is om gebruik te maken van een ander vervoersmiddel
- ☐ Met een ander vervoerwijze kan ik niet zo veel personen vervoeren
- ☐ Anders, namelijk: ____________________

3.11. Welke vorm van verkeershinder of knelpunten kom je (regelmatig) tegen bij reizen met een afstand van 1000 meter tot 3 km (meerdere antwoorden mogelijk)?

- ☐ Gevaarlijk of lastig geparkeerde auto's, waardoor er weinig zicht is op de weg.
- ☐ Verkeersgedrag van anderen
- ☐ Slordig geparkeerde auto's rondom locatie
- ☐ Te hard rijdende auto's
- ☐ Geen of onveilige fietspaden/stroken
- ☐ Het oversteken van drukke wegen
- ☐ Onoverzichtelijke zebrapaden
- ☐ Wegversmalling
- ☐ Slecht verlichte tunnels en viaducten
- ☐ Wegwerkzaamheden
- ☐ Gebrek aan parkeermogelijkheden
- ☐ Anders, namelijk: ____________________

3.12. Kies je wel eens voor een alternatieve vervoerwijze bij reizen met een afstand van 1000 meter tot 3 km?

- ◯ Nooit
- ◯ Bijna nooit
- ◯ Soms
- ◯ Niet van toepassing

3.13. Wat is de reden waarom je dan voor dit alternatieve vervoerwijze kiest?

3.14. Welke activiteiten bevinden zich binnen reizen met een afstand van 1000 meter tot 3 km (meerdere antwoorden mogelijk)?

- ☐ School, buitenschoolse opvang (BSO) of kinderdagverblijf (hieronder vallen ook oma's of opa's of andere personen wanneer zij op vaste dagen voor de opvang van het kind zorgen)
- ☐ Bezoek aan familie / vrienden / kennissen
- ☐ Buitenrecreatie (boswandelingen, speeltuinen – en plaatsen, parken)
- ☐ Uitgaan (uit eten, lunchen, op het terras)
- ☐ Winkelen voor plezier (boodschappen doen, kleding, electronica)
- ☐ Bezoek aan attracties (kindertheater, educatie & musea, zwembad, binnen speeltuin, kinderboerderij)
- ☐ Anders, namelijk:

Pagina 7

De volgende vragen hebben betrekking op reizen met een afstand van 3 km tot 5 km die je samen maakt met je kind(eren).

3.15. Welke vervoerwijze gebruik je het vaakst bij reizen met een afstand van 3 km tot 5 km?

- ◯ Lopen
- ◯ Begeleidend fietsen
- ◯ Samen op een (bak)fiets
- ◯ Samen op een elektrische (bak)fiets
- ◯ Met de brommer/motorfiets/scooter
- ◯ Met de auto
- ◯ Met het openbaar vervoer
- ◯ Anders, namelijk: ____________

3.16. Wat is (in de meeste gevallen) de bezettingsgraad?

Bezettingsgraad betekent wie en hoe veel mensen er in de meeste gevallen op of in de vervoerwijze aanwezig zijn

Gelieve dit zo specifiek mogelijk te noemen. Bijvoorbeeld: jezelf, je kind, één leeftijdsgenootje (vriendje of vriendinnetje), één ouder kind (zoon of dochter)

____

3.17. Wat is de reden dat je voor deze vervoerwijze kiest (meerdere antwoorden mogelijk)?

- ☐ omdat het kind te jong is om zelfstandig te gaan
- ☐ omdat de route niet verkeersveilig is voor jonge kinderen
- ☐ omdat het gezellig is om samen deel te nemen aan het verkeer
- ☐ omdat ik / andere volwassene(n) toch al meeging(en) om een ander kind te begeleiden
- ☐ omdat deze bestemming(en) op de route naar de eindbestemming ligt/liggen (zoals werk, sport, winkelcentrum, etc.)
- ☐ omdat ik / andere volwassene(n) na het wegbrengen direct iets anders gingen doen
- ☐ omdat de route niet sociaal veilig is
- ☐ omdat ik / andere volwassene(n) niet de hele dag thuis wilde zitten
- ☐ omdat de afstand te ver is om gebruik te maken van een ander vervoersmiddel
- ☐ Met een ander vervoerwijze kan ik niet zo veel personen vervoeren
- ☐ Anders, namelijk: ____________

3.18. Welke vorm van verkeershinder of knelpunten kom je (regelmatig) tegen bij reizen met een afstand van 3 km tot 5 km (meerdere antwoorden mogelijk)?

- ☐ Gevaarlijk of lastig geparkeerde auto's, waardoor er weinig zicht is op de weg.
- ☐ Verkeersgedrag van anderen
- ☐ Slordig geparkeerde auto's rondom locatie
- ☐ Te hard rijdende auto's
- ☐ Geen of onveilige fietspaden/stroken
- ☐ Het oversteken van drukke wegen
- ☐ Onoverzichtelijke zebrapaden
- ☐ Wegversmalling
- ☐ Slecht verlichte tunnels en viaducten
- ☐ Wegwerkzaamheden
- ☐ Gebrek aan parkeermogelijkheden
- ☐ Anders, namelijk: __________

3.19. Kies je wel eens voor een alternatieve vervoerwijze bij reizen met een afstand van 3 km tot 5 km?

- ◯ Nooit
- ◯ Bijna nooit
- ◯ Soms
- ◯ Niet van toepassing

3.20. Wat is de reden waarom je dan voor dit alternatieve vervoerwijze kiest?

3.21. Welke activiteiten bevinden zich binnen reizen met een afstand van 3 km tot 5 km (meerdere antwoorden mogelijk)?

- ☐ School, buitenschoolse opvang (BSO) of kinderdagverblijf (hieronder vallen ook oma's of opa's of andere personen wanneer zij op vaste dagen voor de opvang van het kind zorgen)
- ☐ Bezoek aan familie / vrienden / kennissen
- ☐ Buitenrecreatie (boswandelingen, speeltuinen – en plaatsen, parken)
- ☐ Uitgaan (uit eten, lunchen, op het terras)
- ☐ Winkelen voor plezier (boodschappen doen, kleding, electronica)
- ☐ Bezoek aan attracties (kindertheater, educatie & musea, zwembad, binnen speeltuin, kinderboerderij)
- ☐ Anders, namelijk: ____________

Pagina 8

De volgende vragen hebben betrekking op reizen van meer dan 5 km die je samen maakt met je kind(eren).

3.22. Welke vervoerwijze gebruik je het vaakst bij reizen van meer dan 5 km?

- ○ Lopen
- ○ Begeleidend fietsen
- ○ Samen op een (bak)fiets
- ○ Samen op een elektrische (bak)fiets
- ○ Met de auto
- ○ Met de brommer/motorfiets/scooter
- ○ Met het openbaar vervoer
- ○ Anders, namelijk: ____________

3.23. Wat is (in de meeste gevallen) de bezettingsgraad?

Bezettingsgraad betekent wie en hoe veel mensen er in de meeste gevallen op of in de vervoerwijze aanwezig zijn

Gelieve dit zo specifiek mogelijk te noemen. Bijvoorbeeld: jezelf, je kind, één leeftijdsgenootje (vriendje of vriendinnetje), één ouder kind (zoon of dochter)

____

3.24. Wat is de reden dat je voor deze vervoerwijze kiest (meerdere antwoorden mogelijk)?

- ☐ omdat het kind te jong is om zelfstandig te gaan
- ☐ omdat de route niet verkeersveilig is voor jonge kinderen
- ☐ omdat het gezellig is om samen deel te nemen aan het verkeer
- ☐ omdat ik / andere volwassene(n) toch al meeging(en) om een ander kind te begeleiden
- ☐ omdat deze bestemming(en) op de route naar de eindbestemming ligt/liggen (zoals werk, sport, winkelcentrum, etc.)
- ☐ omdat ik / andere volwassene(n) na het wegbrengen direct iets anders gingen doen
- ☐ omdat de route niet sociaal veilig is
- ☐ omdat ik / andere volwassene(n) niet de hele dag thuis wilde zitten
- ☐ omdat de afstand te ver is om gebruik te maken van een ander vervoersmiddel
- ☐ Met een ander vervoerwijze kan ik niet zo veel personen vervoeren
- ☐ Anders, namelijk: ____________

3.25. Welke vorm van verkeershinder of knelpunten kom je (regelmatig) tegen bij reizen van meer dan 5 km (meerdere antwoorden mogelijk)?

- ☐ Gevaarlijk of lastig geparkeerde auto's, waardoor er weinig zicht is op de weg.
- ☐ Verkeersgedrag van anderen
- ☐ Slordig geparkeerde auto's rondom locatie
- ☐ Te hard rijdende auto's
- ☐ Geen of onveilige fietspaden/stroken
- ☐ Het oversteken van drukke wegen
- ☐ Onoverzichtelijke zebrapaden
- ☐ Wegversmalling
- ☐ Slecht verlichte tunnels en viaducten
- ☐ Wegwerkzaamheden
- ☐ Gebrek aan parkeermogelijkheden
- ☐ Anders, namelijk: ____________

3.26. Kies je wel eens voor een alternatieve vervoerwijze bij reizen van meer dan 5 km?

- ◯ Nooit
- ◯ Bijna nooit
- ◯ Soms
- ◯ Niet van toepassing

3.27. Wat is de reden waarom je dan voor dit alternatieve vervoerwijze kiest?

3.28. Welke activiteiten bevinden zich binnen reizen van meer dan 5 km (meerdere antwoorden mogelijk)?

- ☐ School, buitenschoolse opvang (BSO) of kinderdagverblijf (hieronder vallen ook oma's of opa's of andere personen wanneer zij op vaste dagen voor de opvang van het kind zorgen)
- ☐ Bezoek aan familie / vrienden / kennissen
- ☐ Buitenrecreatie (boswandelingen, speeltuinen – en plaatsen, parken)
- ☐ Uitgaan (uit eten, lunchen, op het terras)
- ☐ Winkelen voor plezier (boodschappen doen, kleding, electronica)
- ☐ Bezoek aan attracties (kindertheater, educatie & musea, zwembad, binnen speeltuin, kinderboerderij)
- ☐ Anders, namelijk:

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Nog één laatste belangrijke vraag: Je hebt mij zojuist een goed beeld gegeven van jouw reisgedrag. Maar wat is nou hét grootste/meest onhandige/hinderlijke/logistieke probleem dat je ervaart als je reist met je kind(eren) van 0 tot 6 jaar oud en waar je graag een oplossing voor zou willen zien?

Hartelijk dank voor het invullen van de vragenlijst. Wil je meedingen naar een van de twee tegoedbonnen t.w.v. €25,00, te besteden op het gehele assortiment van Bigline (http://www.bigline.nl/) van fiets tot kinderwagen? Vul dan hieronder je email-adres in. De winnaars zullen begin november bericht krijgen.

Uw email-adres:

» Redirection to final page of Enquêtes Maken

Appendix 6

Current **transportation solutions**

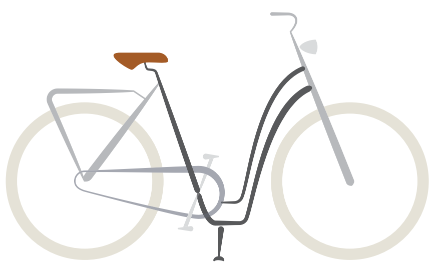
Nowadays, a lot of different 'active transportation' systems enable safe and efficient transport with babies, toddlers and young children. This section will provide an overview of the different systems available. Three systems can be identified:

- **A system in which the child takes passively part in traffic. Meaning the child does not control the mode of transportation.**
- **A system in which the child takes actively part in traffic. Meaning independently controlling his or her mode of transportation.**
- **A system in which the child takes part in traffic, but not independently. Meaning the parent or any other person controls the mode of transportation and the child assists.**

6.1 Passively part in traffic

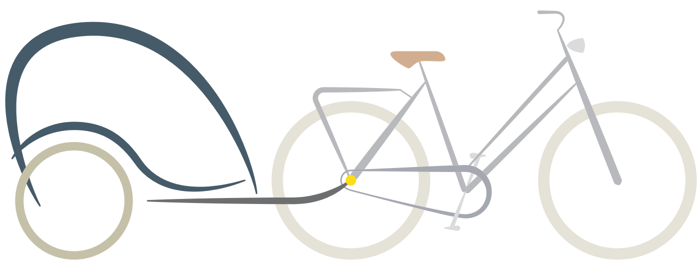
6.1.1 Mother bicycle

This bicycle differentiates in comparison to a normal bicycle due to its enlarged space between handlebar and seat, double stand and lower and easier boarding.



6.1.2 Bicycle trailer

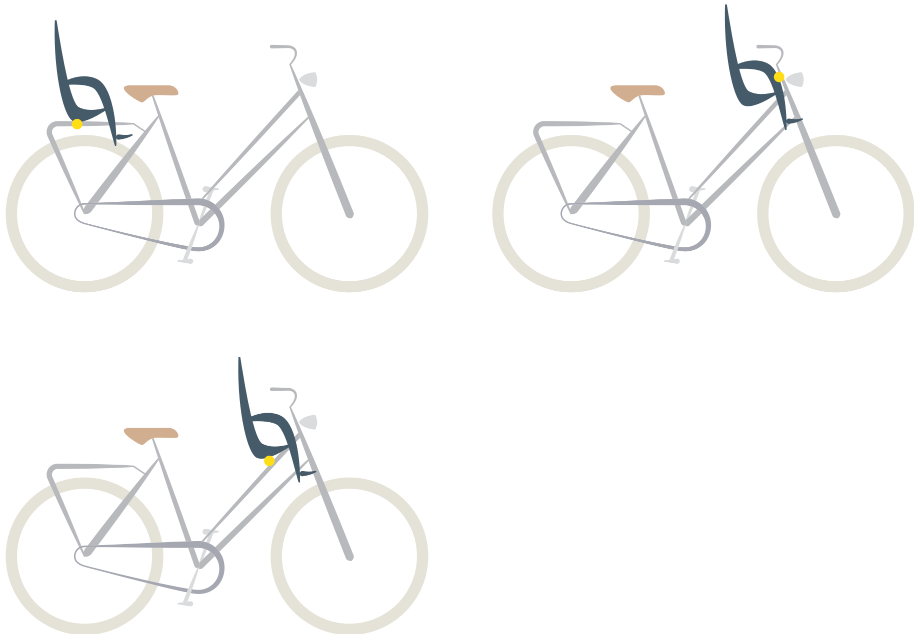
A bicycle trailer is a wheeled frame with a protective cage construction for transporting children and is hitched onto the rear wheel of a bicycle. In addition, it offers more stability in case of a collision.



6.1.3 Child seats

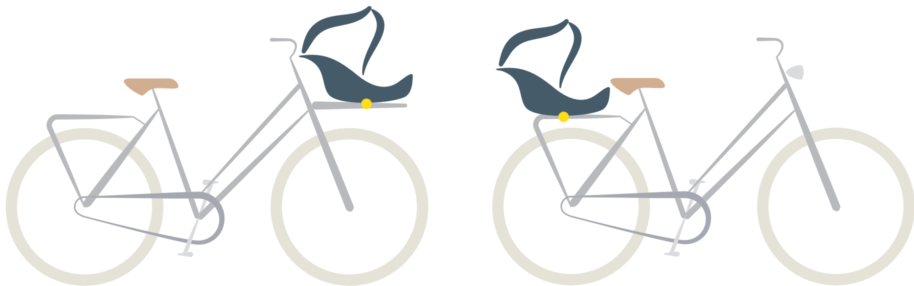
6.1.3.1 The child bicycle seat

The bicycle child seat can be placed at different locations on a bicycle: 1) at the back, 2) at the front, attached to the handlebars and bicycle or 3) at the front, attached between handlebar and cyclist.



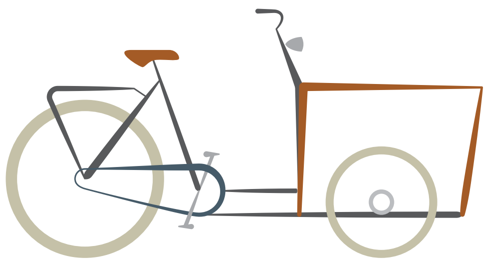
6.1.3.2 The infant safety seat

A special carrier makes it possible to either attach a child car seat (maxi-cosi) at the front of the bicycle or at the back..



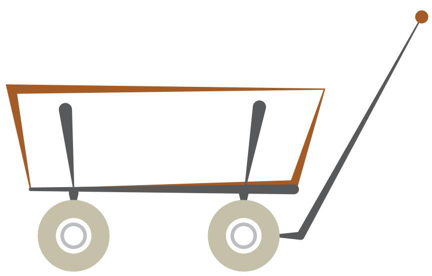
6.1.4 Cargo bike

A cargo bike is suitable for both transporting children and goods, such as small parcels and groceries. Children are positioned in front of the cyclist, resulting in more interaction between cyclist and child.



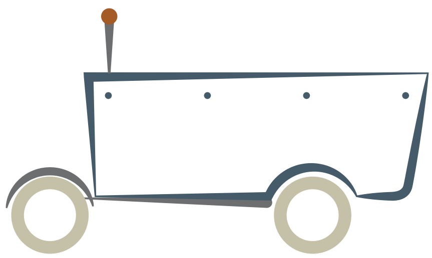
6.1.5 Pull along wagon

The pull along wagon is a four-wheeled cart that is pulled by means of a front handle. A bolderkar is often used for transporting young children to child care or school or to bring groceries home by foot.



6.1.6 The Stint

The Stint is a transportation solution for a group of children between 4 and 12 years old. The Stint can be considered as an electrical pull along wagon and can be controlled by anyone older than 16 years old.



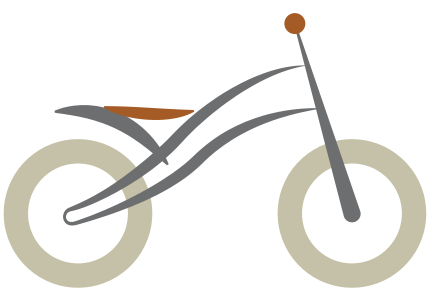
6.1.7 Stroller

A stroller is a four-wheeled, often collapsible, chair-like carriage in which small children are pushed. A side-by-side stroller is a specially designed stroller for two small children.

6.2 Actively part in traffic

6.2.1 Balance bike

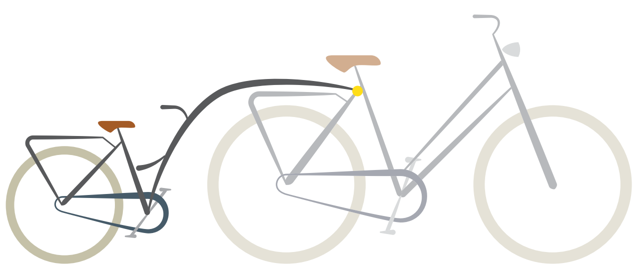
A balance bike is a two-wheeled pedal-less bike that teaches kids as young as 18-months to balance on two wheels.



6.3 Assist

6.3.1 Trailer cycles

Trailer cycles are a great option for riding with older kids (from the age of 4). A trailer cycle consists of handlebars, a seat, pedals, and a wheel that attaches to the back of a standard adult bike.



Appendix 7

Transportation **comparison**

This appendix offers a complete comparison chart between the child bicycle seat, the bicycle trailer and family cargo bike. All three solutions are compared on eight main topics: safety, handling, maneuverability, social, price, utility, comfort and maintenance. Within this chart, disadvantages, advantages and possibilities of each solution are indicated visually (respectively in red, green and blue).

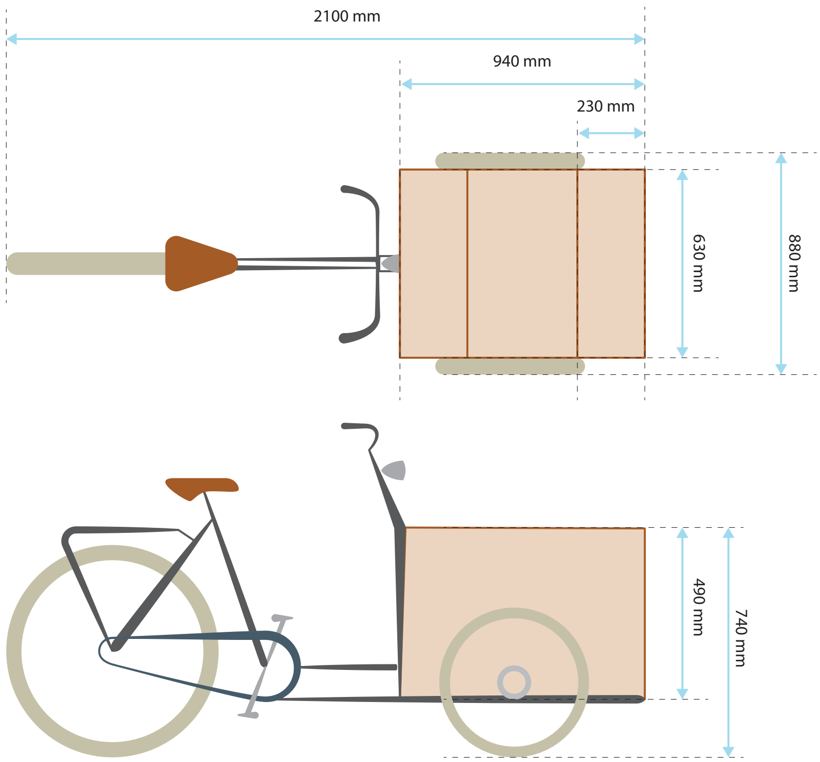
		Child seat	Bicycle trailer	Cargo tricycle	Bakfiets
Safety	unilateral accident - falling	High downward travel before child hits the ground. Arms and legs can get trapped under the bicycle.	Will stay upright.	Will stay upright	Minimal injury risk.
	unilateral accident – bicycle spoke injuries	Greater risk of getting feet or other body parts caught in the wheel.	Little risk of getting feet or other body parts caught in the wheel.	Medium risk of getting feet or other body parts caught in the wheel.	Medium risk of getting feet or other body parts caught in the wheel.
	Protection (e.g. flank collision)	Little protection.	Roller cage surrounds the child completely and the layer of fabric offers some protection.	'Box' offers side and front protection.	'Box' offers side and front protection.
	Visibility	Difficult for other road users to notice in the distance.	Clearly visible.	Clearly visible.	Clearly visible.
	Tipping over	May reduce the tendency to flip just slightly, however a flip may still occur. Front child seats are more risky, as the seat may hit the ground or object while you still have your weight behind the child.	Weight is located at the back, and prevents the bike from completely flipping over.	Little tendency to tip over.	Little tendency to tip over.
Handling	Center of gravity	Weight high up can make the bike feel a bit more unbalanced	Low center of gravity	Sloping roads create the feeling of tilting	Children sit down a little bit, lowering the center of gravity.
	Turning	Medium effect on turning, especially with two child seats	Can tip over if you turn abruptly or turn when one wheel is going over a bump.	Handles almost like a normal bike.	Heavier turning
	Seating location	Seating on the rear of the bike, requires more steering.	Seating behind the rear wheel makes tipping occur faster.	Seating in front of the bike makes steering more sensitive	Seating in front of the bike makes steering more sensitive
Maneuverability	Width	No effect on width	Usually a bit wider, takes up more of the road.	Usually a bit wider, takes up more of the road.	Much wider, takes up more of the road.
	U-turning	No effect on U-turning	Difficult to make a u-turn.	U-turning is less easy	Difficult to make a u-turn.
	Length	No effect on length	Much longer than normal bicycle.	Longer than normal bicycle	Much longer than normal bicycle

Social	Interaction	Closer to your child, so you can talk to them easily.	Harder to keep an eye on your child or communicate with them.	Easy to communicate with children.	Easy to communicate with children
	Acceptance	Accepted by all road users	Relatively well accepted	Causes irritation for other road users	Causes irritation for other road users
	Fun	Less fun, since parent and child sit behind each other.	Less fun, since parent and child are separated far away from one other.	Children have more fun, due to direct interaction	Children have more fun, due to direct interaction
Price		Less expensive	Medium expensive	Very expensive	Very expensive
Utility	Weather	more exposed to the vagaries of weather	Provide almost complete shelter from wind, rain, and sun.	Provide some shelter from wind.	Provide some shelter from wind.
	Installation	Installing only once.	Attaching and detaching might take some time	No installation required	No installation required
	Store and park	Little effect on storing and parking.	More difficult to store. Though, can collapse flat or have detachable wheels	Impractical to store	Impractical to store
	Storage space	No storage space after bicycle seat is placed.	Offers additional storage space	Much higher carrying capacity.	Much higher carrying capacity.
	Number of children	One	Two	Easily up to four	Two to three
	Lifespan	Can only be used for a limited age range	Wider age range from about eight weeks up to six years.	Wider age range from about eight weeks up to six years.	Wider age range from about eight weeks up to six years.
	Multi-purpose	Only serves one purpose	Many often work as joggers and strollers in addition to trailers.	Can carry children as well as goods	Can carry children as well as goods
Comfort	Physical	Upright backrest: if your kid falls asleep, their head may slump forward, and might be uncomfortable over an extended period of time.	More comfortable and inclined backrest and ability to attach a child car seat.	In most cases, not much extra comfort than a standard wooden bench	In most cases, not much extra comfort than a standard wooden bench
	Loading children	Loading the child onto the bike before you get on yourself, makes the bicycle very unstable.	Slightly uncomfortable due to its low position	Very easy due to its stability	More difficult to keep balance.
	Psychological	No real effect	Regarded as less safe: children "sticking out" into traffic	Having overview of your children contributes to psychological comfort	Having overview of your children contributes to psychological comfort
Maintenance		Little to none maintenance	Decoupling requires a more complex design and, therefore, more maintenance.	More maintenance compared to a normal bicycle.	More maintenance compared to a normal bicycle.

Appendix 8
Cargo bike **benchmark**

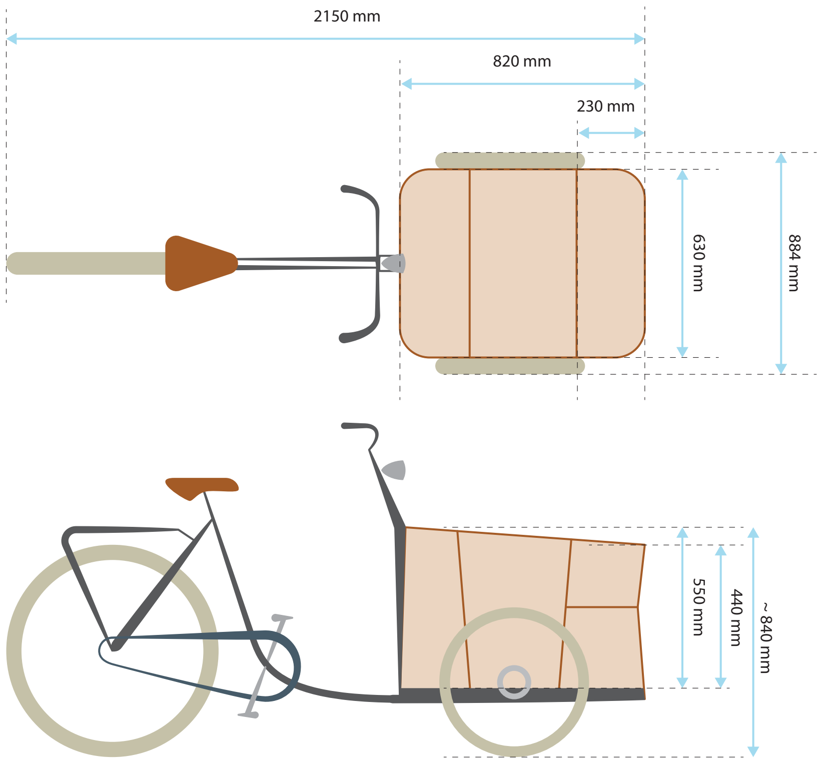
8.1 Cangoo Groovy Elektrisch
This is Cangoo's bestseller and offers space for up to four children. The simple 'block' shape (of the box), made out of four wooden panels, is considered to be the archetype shape for three-wheeled cargo bikes.

Figure 10: Cangoo Groovy Elektrisch



8.2 Babboe Curvy E
Babboe is the market leader in the industry of cargo bikes. Moreover, they have patented their curved wooden box.

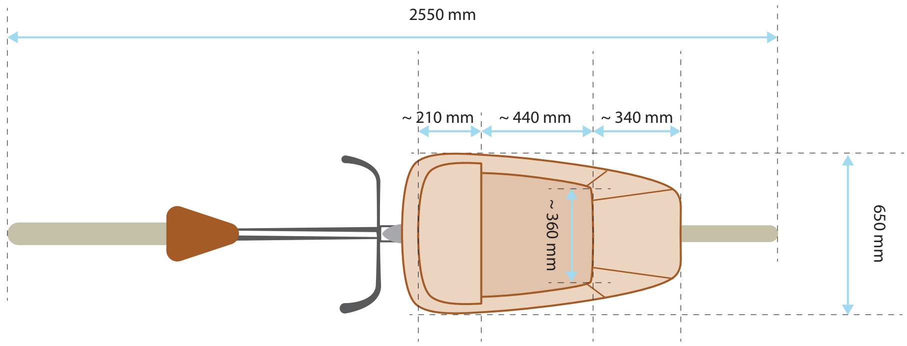
Figure 11: Babboe Curvy E

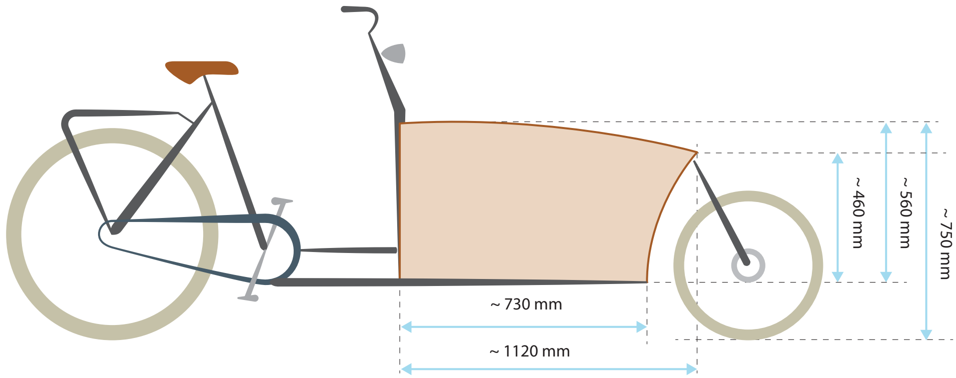


8.3 Dolly cargo bike

This cargo bike is unique because of its double-walled plastic box.

Figure 13: Dolly cargo bike

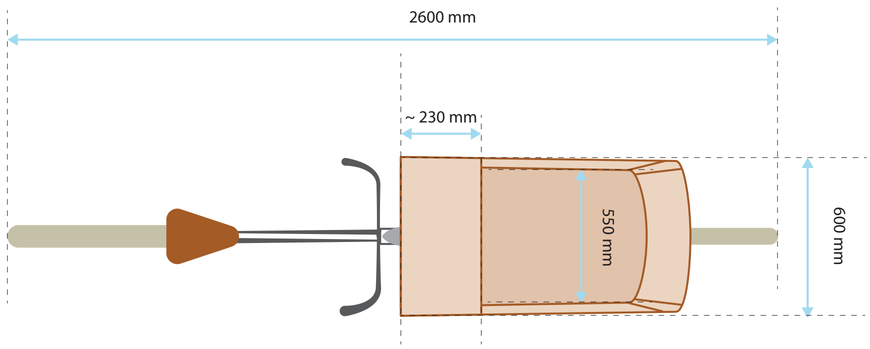


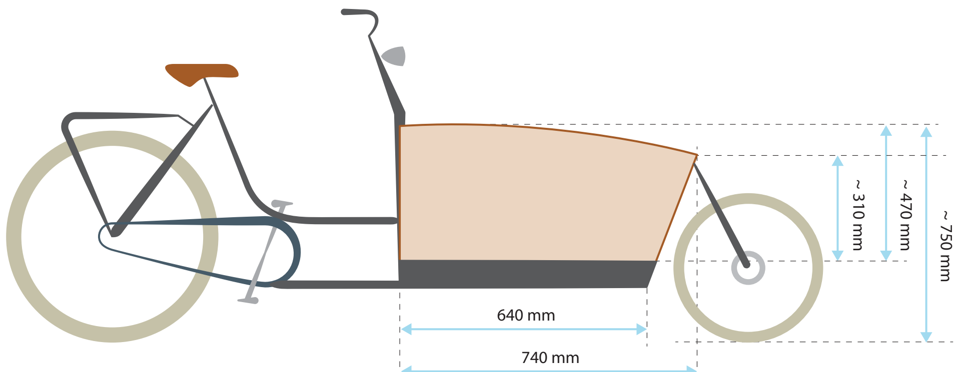


8.4 Urban Arrow Family

This cargo bike has a EPS (expended PolyStyrene) box. This cargo bike is considered to be one of the best cargo bikes available today.

Figure 12: Urban Arrow Family





Appendix 9
Privacy declaration

Privacyverklaring Onderzoek Bakfiets Gebruik

Versie 1.0

Deze pagina is voor het laatst aangepast op 14-11-2017.

Ik ben ervan bewust dat u vertrouwen stelt in mij en mijn onderzoek. Ik zie het dan ook als mijn verantwoordelijkheid om uw privacy en daarmee de privacy van uw kind(eren) te beschermen. In deze privacyverklaring laat ik u weten welke gegevens ik verzamel als u meewerkt met dit onderzoek en waarom ik deze gegevens verzamel. Zo snapt u precies hoe ik te werk ga tijdens mijn onderzoek.

1. Standaard gegevens

Naam van de onderzoeker:	Bart van Driessche
Onderzoeksperiode:	november 2017 – december 2017
E-mail contactpersoon:	info@bartvandriessche.nl
Universiteit:	Technische Universiteit Delft
Faculteit:	Industrieel Ontwerpen (Industrial Design Engineering)
Master richting:	Integrated Product Design

2. Uw persoonlijke gegevens

Ik zal uw persoonlijke gegevens zonder uw toestemming niet ter beschikking stellen aan derden. Het persoonlijke beeldmateriaal en de geluidsopnames worden enkel en alleen gebruikt voor interne analyse van het onderzoek waarvoor u deze aan mij toevertrouwd. Alleen in overeenstemming met de ouder(s) mag het beeldmateriaal en/of de geluidsopnames gebruikt worden voor rapporten en/of presentaties. De ouder(s) dien(t)(en) in dit geval aan te geven of de kind(eren) onherkenbaar gemaakt dienen te worden.

3. Eigendom van de gegevens

Al het beeldmateriaal en de geluidsopnames zijn eigendom van de ouder(s) en worden na interne analyse verstrekt aan de ouder(s).

4. Doeleinden

Ik verzamel of gebruik geen beeldmateriaal of geluidsopnames voor andere doeleinden dan de doeleinden die worden beschreven in deze privacyverklaring, tenzij ik van tevoren uw toestemming hiervoor heb verkregen.

Het doel van de afstudeeropdracht is het ontwerpen van een gebruiksvriendelijk en veilig vervoersmiddel voor ouders en jonge kind(eren) en/of peuter(s) in stedelijke gebieden. Het doel van het onderzoek 'Bakfiets Gebruik' is om inzicht te krijgen in:

- De interactie tussen (jonge) kinderen onderling in de bakfiets
- De interactie tussen (jonge) kinderen in de bakfiets en ouder(s)
- De interactie tussen (jonge) kinderen in de bakfiets, ouders en de verkeerssituatie(s) waarin zij zich bevinden.
- De interactie tussen (hulp)middelen, die geplaatst worden in de bakfiets (zoals een maxi-cosi, babyschaal of buggy) en (jonge) kinderen in de bakfiets en/of ouder(s)

5. Gebruik van het beeldmateriaal en geluidsopnames

Het beeldmateriaal en geluidsopnames worden gebruikt om het onderzoek uit te kunnen voeren. De gegevens worden opgeslagen op een persoonlijke laptop welke aangeschaft is bij de TU Delft. Door mij een e-mail te sturen kunt u het persoonlijke beeldmateriaal en de geluidsopnames laten verwijderen. Dit is echter pas mogelijk nadat de beelden geanalyseerd zijn en de resultaten schriftelijk bekend zijn (medio december 2017).

6. Bewaartermijn van de gegevens

Al het beeldmateriaal en de geluidsopnames zullen gedurende de gehele afstudeerperiode van de student (tot en met maart 2018) beschikbaar blijven op een persoonlijke laptop. Na deze bewaartermijn zal al het beeldmateriaal en de geluidsopnames vernietigd worden, tenzij anders overlegd met de ouder(s). Het beeldmateriaal en de geluidsopnames waarvoor eerder (onder voorwaarde(s)) toestemming is gegeven van de ouder(s) om deze gegevens te mogen gebruiken in rapporten en/of presentaties vallen buiten deze termijn en blijven daardoor in het bezit van de student. De ouder(s) heeft/hebben de mogelijkheid al het beeldmateriaal en de geluidsopnames vroegtijdig te laten verwijderen. Hiervoor dienen zij een e-mail te sturen.

Indien akkoord:

Onderzoeker	Ouder
Naam:	Naam: ....
Datum:	Datum: ....
Handtekening	Handtekening

Appendix 10 Child care poster

fietsen zoals je normaal ook doet?

Cameraatje (GoPro) + bevestiging aan stuur wordt geregeld vanuit mij. Installatie en uitleg van de camera zal bij de ouder(s) thuis plaatsvinden.

En je mag al het gefilmde materiaal ook nog eens zelf houden! Dit is natuurlijk enorm leuk/grappig voor het familiealbum!

Er is een privacyverklaring opgesteld waarin de privacy van de gesprekken en beelden die gemaakt worden van de ouder(s) + kinderen gewaarborgd worden.

Lijkt dit je leuk? Of wil je meer informatie? Stuur me een mailtje of geef me even een belletje. Mijn gegevens zijn:

Bart van Driessche
info@bartvandriessche.nl
+31 6 28092242

Appendix 11
Kut YUP!
Social acceptance of the cargo bike

Due to the growing challenges of urban mobility, cargo bikes are experiencing a renaissance. And although they can be a handy solution for moving children around the city, the social acceptance of these bicycles is rather debatable.

You either love them or you hate them. Short messages such as "Kut YUP" ("Fucking YUP") or "Die verdome perfecte bakfietsmoeders van twee straten verderop" ("Those goddamn perfect cargo bike mothers from two blocks away") are not only circulating on social media such as Twitter, but even complete Facebook pages (e.g. 'Fak de bakfiets') are fully dedicated to express their dissatisfaction with cargo bikes.

People on the street of Utrecht were asked how they thought about cargo bikes. The same as was found on social media was visible here, annoyances were either caused by its cumbersome size or by the parent(s) who drove them. However, still many people did not experience any annoyances at all and valued the practicality of a cargo bike.

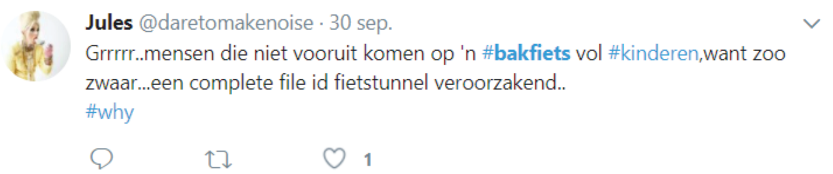
Several parents who owned a cargo bike said: "It's a utility vehicle. Not a bicycle."

Urban infrastructure (cumbersome size)
Urban areas are in need of a radical mobility transition. A cargo bike has proven its practicality in densely populated cities, both when transporting goods and children, and can be considered as a worthy alternative for a car. I believe that not the product, but rather the context can be considered as the main driver why people get annoyed by the size of a cargo bike. Current urban infrastructure is not yet fully built for the size of a cargo bike. If cycle paths and pavements would be wider and special parking places for cargo bikes would be the standard, everyone would acknowledge its practicality and no one would ever bother a cargo bike again.

Too expensive (social elite group)
Moreover, the high purchase price of a cargo bike might be one of the underlying psychological causes why people, who blame the 'Yuppie parent(s)', are annoyed by the cargo bike users. For many people with a lower income, a cargo bike might be a very expensive solution. They cannot identify themselves with the social group of people who cycle a cargo bike nowadays and regard a cargo bike solely as a bicycle, rather than as a replacement for the car.

"Niet de hond, maar het baasje."
(Not the dog, but its owner)

*YUP (Yuppie) is an English abbreviation for Young Urban Professional and name for a young twenty or thirty year old from the higher middle class. Although this term was already circulating around the early 80's of the twentieth century in the United-States, recent years a lot of people use this word to describe – according to their opinion - arrogant and supercilious people.



Our World @OW_OurWorld · 22 aug.
Check de column over #jong en niet #burnout #stress #prestatiedruk #ondernemers #startup #**bakfiets** #moeder ow-ourworld.nl/jong-en-niet-b...

1 1

Jos Sluijsmans @JosSluijsmans · 22 sep.
'Ik wil dan ook kunnen afdwingen dat ontwikkelaars grotere fietsenstallingen bouwen die geschikt zijn voor bakfietsen' #**bakfiets** #cargobike

> **Lot van Hooijdonk** @lotvanhooijdonk
> In @vng_magazine : groeiende steden hebben ingrijpende transitie van hun mobiliteit nodig vng.nl/wethouder-lot-...

Haitske van de Linde @haitskevdlinde · 16 mei
Tja, dat verbaast me dus niets. #**bakfiets**

> **Rutger de Quay** @rutger_
> Jesse Klaver rijdt op een BAKFIETS!1!2!2 Waarom zijn er nog geen wordende menigtes op straat? #kutyup

1 1

Ria_Bierman @Ligniet · 2 apr.
Allemaal #arrogante #hipsters #bakfietsterreur #**bakfiets** #oosterpark #igersamsterdam #instagram... instagram.com/p/BSYWL13gGLy/

Kaf @kafBlog · 1 mei
Met een ruk werd ik uit m'n overpeinzingen de realiteit in geslingerd. Op de grond. Getackeld door Mevr. #**Bakfiets**

> **Rij Tuig - Kaf**
> Met een ruk werd ik uit m'n overpeinzingen de realiteit in geslingerd. Op de grond. Getackeld door Mevr. #Bakfiets
> kaf.online

Appendix 12

Having children **in front or behind you?**

12.1 Purpose
The aim of the field research was to investigate whether parents with young children would prefer to have their children seated in front of them or behind them when cycling.

12.2 Method
The research consisted out of four questions. In the first two questions, the two configurations - in front and behind the parent - were showed as standalone products without being placed in a context scenario. First parents were asked which configuration they liked the most and why. Secondly, they were asked which configuration they regarded safest and why. Thereafter, the two configurations were placed in two unclear traffic situations and they were asked again which configuration they regarded safest and why. Two unclear traffic situations:

1. Trying to get on the road behind a parked car (while a car is approaching from the other direction);
2. Pressing the button of a cyclist traffic light (that is situated relatively close to the road)

Lastly, they were asked which configuration they would buy after having judged the two configurations and the two unclear traffic situations.

12.3 Results
Showing the two configurations as standalone products, 11 out of 13 participants (85%) preferred having their children seated in front of them. All those participants (100%) gave having overview of your children, better direct interaction between parent and child and the ability to correct their children as main reason. 2 Out of 13 participants preferred having their children seated behind them, because in case of a collision it would be more likely that the parent would be hit first and not their children.
When asking which configuration would be safest, the results were almost equally distributed: 54% regarded having children in front as safest, 46% regarded having children behind as safest. The reasons why participants regarded having children in front as safest were: no overview when turning, because you don't know how wide you are exactly and the fact that you cannot see and participate to what is happening behind you.
When showing the two unclear traffic situations, only 3 out of 13 participants regarded having children in front as safest. Overview of your children was still the main reason for their decision. 9 Out of 12 participants regarded having children behind you as safest. The reasons were: in case of a collision the parent would be hit first and you do not push your children on the road before having fully assessed whether the traffic conditions are safe.

Nevertheless, when participants were asked for a final judgement, 8 out of 13 participants (62%) still preferred having their children in front of them. For those 8 participants, overview of your children was still the most important factor. One participant answered as following: "You have to adjust your cycling behavior, because you know that you have your children in front of you. You have to keep this in mind. You don't have to cycle all the way until you pass the parked car completely. You could lean forward for example".

The fact that participants preferred having children in front, confirmed the disadvantages of the bicycle trailer.

Figure 14: (top left) Unclear traffic situation; pressing the button of a cyclist traffic light (that is situated relatively close to the road), the box is positioned in front of the cyclist.

Figure 15: (top right) Unclear traffic situation; pressing the button of a cyclist traffic light (that is situated relatively close to the road), the box is positioned in behind the cyclist.

Figure 16: (bottom right) Unclear traffic situation; trying to get on the road behind a parked car (while a car is approaching from the other direction), the box is placed behind the cyclist.

Figure 17: (bottom left) Unclear traffic situation; trying to get on the road behind a parked car (while a car is approaching from the other direction), the box is placed in front of the cyclist.

Figure 18: The two configurations - the box placed in front of (right) and behind (left) the cyclist, showed as standalone products without being placed in a context scenario.

Appendix 13

Column Brecht Daams

COLUMN

I'm pickin' up good vibrations (1)

Door Brecht Daams
www.ergonomie.nl, TU Delft,
faculteit Industrieel Ontwerpen

“Ooo, bop-bop, good vibrations”, zongen de Beach Boys in 1966. Het woord ‘vibratie’ heeft een hele positieve klank. Wie wil er nu geen goede vibes hebben? Zeg ‘trilling’ en het klinkt ineens heel anders, hoewel er precies hetzelfde mee bedoeld wordt. Wie aan te sterke trillingen wordt blootgesteld kan een breed scala aan gezondheidsproblemen krijgen. Wanneer zijn trillingen goed en vibraties slecht? Pick up the vibe!

Trillingen, pardon vibraties, voor baby’s zijn in de mode, gezien de volgende vier trends. Er komen steeds meer producten op de markt die actief bewegen en vibreren ten behoeve van het veronderstelde comfort van het kind. Autorijden met jonge baby’s, die daarbij continu aan trillingen worden blootgesteld, lijkt steeds meer geaccepteerd te zijn. Er zijn tegenwoordig veel kinderwagens zonder vering, dat geeft behoorlijke vibraties als je ermee over straat rijdt. En er worden steeds meer kinderen vanaf hun geboorte vervoerd per fiets, bakfiets of fietskar. De trillingsbelasting voor het kind zal daarbij groter zijn dan bij een kinderwagen, aangezien trilling aanzienlijk toeneemt bij hogere snelheden.

Zoals gezegd, er zijn goede en slechte trillingen. Het zachtjes en langzaam wiegen van een kind is een voorbeeld van een uitstekende trilling! Over het algemeen geldt: hoe sneller en heftiger de trilling, des te minder gezond. Welke trillingen ongezond zijn kunnen we vinden in de NEN-ISO norm *Trillingen op de arbeidsplaats.* Daarin staat dat werknemers nimmer mogen worden blootgesteld aan een trillingsterkte boven de aangegeven grenswaarden. Worden die overschreden dan kan dat leiden tot zeer diverse gezondheidsproblemen op korte en lange termijn: vaatziekten, bot- en gewrichtsaandoeningen, bloedingen, neurologische problemen, spieraandoeningen, problemen met waarnemen, en nog veel meer. Het effect kan cumulatief zijn, dat wil zeggen dat er tussen de blootstellingen aan hevige trilling geen volledig herstel optreedt en de schade zich opstapelt. De grenswaarden in die norm en de effecten bij overschrijding gelden voor gezonde volwassenen. Over het effect van trillingen op baby’s is onvoldoende bekend. De NEN-richtlijnen voor trillingen op volwassenen kunnen niet toegepast worden op baby’s, omdat baby’s veel kwetsbaarder zijn. Ze zijn ook kleiner en lichter, waardoor een in trilling gebracht babylichaam eerder mee zal gaan trillen, terwijl een volwassen lichaam trillingen eerder zal dempen. Het is moeilijk om de gevolgen van trilling op baby’s te bepalen, omdat sommige effecten, àls ze optreden, niet zullen opvallen (zoals buikpijn, problemen met zien, gedrags- en leerproblemen). De trillingen in transportsituaties zijn waarschijnlijk minder heftig dan bij extreme arbeidssituaties, maar gezien bovenstaande informatie staat het nog niet vast dat die trillingen geen effect hebben op baby’s.

Wat weten we wel? Het *Handbook of Human Vibration* (Griffin, 2004) raadt af om kinderen onder de 18 en zwangere vrouwen aan trillingen bloot te stellen. Hoe kleiner en lichter de persoon, des te meer zal hij in een voertuig last hebben van trillingen. Als er trilling wordt uitgeoefend op de buik van een zwangere vrouw, dan versnelt de hartslag van de foetus.

Het rijden in auto’s is wat trillingsbelasting betreft voor kleine kinderen veel oncomfortabeler dan voor volwassenen, dat heeft een Engelse wetenschapper onderzocht (Giacomin, 2002). Giacomin berekende de trillingen, maar vertelde me dat hij niet weet wat het effect daarvan op baby’s is. Wel weet hij dat trillingen die kinderen ervaren in een auto, voor volwassenen problematisch zijn, gegeven de trillingslimieten.

Oproep voor kleine enquête

Nu ben ik benieuwd wat de lezers van BabyWereld hiervan vinden. Een kleine enquête: Vindt u deze informatie aanleiding geven om voorzichtig te zijn met trillingen voor baby’s? Of ziet u geen enkel probleem? Wat is uw mening?
Mail naar: babywereld@ergonomie.nl
In de volgende column een verslag van deze enquête.

LITERATUUR

GIACOMIN, J., 2002. AN EXPERIMENTAL INVESTIGATION OF THE VIBRATIONAL COMFORT OF CHILD SAFETY SEATS. PROEFSCHRIFT (PHD THESIS), UNIVERSITY SHEFFIELD. GRIFFIN, M.J., 2004. HANDBOOK OF HUMAN VIBRATION. LONDON: ELSEVIER. NEN-ISO 2631-1 EN ISO 3549. TRILLINGEN OP DE ARBEIDSPLAATS.

COLUMN

I'm pickin' up good vibrations (2)

Door Brecht Daams
www.ergonomie.nl, TU Delft,
faculteit Industrieel Ontwerpen

Over het effect van trillingen op kinderen, bijvoorbeeld in kinderwagen, (bak)fiets en auto, is weinig bekend. Dat was het onderwerp van mijn vorige column in BabyWereld (mei 2011). Wiegen is een gezonde trilling en te sterke trillingen kunnen een breed scala aan gezondheidsproblemen tot gevolg hebben. Over het algemeen geldt: hoe sneller en heftiger de trilling is, des te minder gezond. Maar waar ligt de grens? Ik stelde lezers van BabyWereld de vraag of zij deze informatie aanleiding vonden om voorzichtig te zijn met trillingen voor baby's. Hierop kwamen zes reacties.

Een **leverancier van kinderwagens** en aanverwante producten meent dat er na kritiek op de loopstoel, de autostoel en BPA in flesjes nu de wipstoelen en schommels met trilfunctie aan de beurt zijn. 'We kunnen net zo goed stoppen met de verkoop van babyartikelen alleen omdat er mensen zijn die tijd te veel hebben om dit soort onderzoeken te doen.'

Een **fabrikant van babyfietsstoeltjes** is ervan overtuigd dat zijn geveerde stoeltje om baby's mee op de fiets te vervoeren geen enkel gezondheidsrisico oplevert voor de kinderen. Dat het fietsen met baby's misschien wel eens slecht zou kunnen zijn voor baby's in verband met trillingen, zoals door TNO gesuggereerd werd, is volgens hem een volstrekt imaginair spookbeeld.

Een **ontwerpster van kinderspeelgoed** schreef: 'Als moeder word je op heel veel gezondheidsrisico's gewezen voor je kinderen, maar niemand zegt ooit iets over trillingen. Ik zou graag willen weten wat de gevolgen van rijden in een bakfiets zijn en hoe je dat goed kan doen voor je baby.'

Een **ontwerper van kinderwagens** zei: 'Het lijkt mij een goede wake-up-call. Kinderwagenvering is in de meeste gevallen nou niet echt ontwikkeld door raketgeleerden en Joost mag weten of die veel te hard of misschien juist veel te zacht is. Verder is het echt altijd vering en nooit demping. Ik denk dat veel moderne kinderwagens met beroerde of ontbrekende vering een behoorlijk irritant trillingspatroon door kunnen geven aan een kind. Stof tot nadenken dus! Ik zit toevallig net de nieuwste NEN norm over kinderwagens door te ploeteren en het zal je niet verbazen dat er niets gezegd wordt over ergonomische eisen waaraan eventuele vering moet voldoen.'

Een **ontwerpster van kinderwagens** heeft het altijd al bijzonder gevonden dat de duurste kinderwagen (Stokke Xplory) geen vering en ook geen luchtbanden heeft. 'Ik ben het volledig met je eens dat er veel te weinig wordt gekeken naar wat nu echt goed is voor een kind; de producten in de babymarkt worden steeds meer gezien als een soort lifestyle producten. Alles moet gewoon kunnen; en inderdaad, inclusief je pasgeboren baby vastsnoeren in een autostoeltje en die weer vastzetten in je bakfiets. En dan met de banden flink opgepompt over de Utrechtse/Amsterdamse klinkertjes. Kan niet goed zijn naar mijn idee.'

Een **hoogleraar ontwikkelingsneurologie** liet weten: 'Over het effect bij trillingen bij baby's is weinig bekend. Ik zou me echter nog niet direct zo ongerust maken. Ik begrijp je ongerustheid. Maar we weten in de verste verte niet wat op het gebied van trilling goed of slecht is voor de kinderlijke ontwikkeling. We weten het niet.'
De conclusie is dat er uiteenlopende meningen zijn. Een wetenschappelijk artikel zou hier afsluiten met 'meer onderzoek is nodig'. Laten we het daar maar op houden.

Appendix 14

Vibrational comfort: a matter of concern or not?

After receiving a letter from a concerned parent, K. Broer (2017), editor of the Fietsersbond, investigated whether bicycle child seat manufacturers knew about the aspects of vibrational comfort. The results were found below:

- Sven Willems, marketing manager at Thule: “we never had have this question before. We test our bicycle child seat according to the NEN-standard. However, this standard does not include vibrational comfort tests.”
- Marlous de Wit-Williamson, marketing communication at Bobike: “there are very strict guidelines for bicycle child seats. They are extensively tested, but not with respect to vibrational comfort.”

Moreover, according to the Fietsersbond, even VeiligheidNL did not think of this matter before. Kees Bakker, Consumer information officer at the Fietsersbond, attached a transducer on multiple bicycle child seat and measured the vibrational values (Fietsersbond, 2012). Product ergonomist Brecht Daams, Riender Happee, expert in biomechanics and Arend Schwab, expert in cycling dynamics at TU Delft, were worried about the outcomes. Unfortunately, the exact data has not yet been released due to publication potential.

Dutch online blogs and forums

Online research showed concerns regarding the vibrational comfort of infants when transported on a cargo bike.

From Viva forum, topic: Baby in bakfiets (English: infant in cargo bike):

- “You do not cycle with an infant, unless they can sit upright independtly. The same applies to cargo bikes. A Maxi-Cosi is used in car, because cars have proper shock absorbers. A cargo bike does not have those. An infant who cannot sit independely is vulnerable for shocking movements (shaken baby syndrome). No matter how well he is fastened in a Maxi-Cosi, the head moves into all directions.”

From Viva forum, topic: Baby in de bakfiets, vanaf hoe oud deden jullie dit? (English: infant in the cargo bike, from which age did you do that?):

- “I think that you have to assess how convenient and comfortable it is, and how safe it is. I found it in terms of shocks not very pleasant.”
- “From my point of view I think that the opinion are rather divergent. On the one hand, it is said: yes it is possible, because your child is just sitting in the Maxi-Cosi. And that Maxi-Cosi is also allowed to be attached to the back of the bicycle (there are special carriers for this). But on the other hand, it is also claimed that the shocks during cycling are too intense for such a small child. Personally, to play it safe, I would go for a walk.”

Moreover, an online questionnaire (next 6 pages) was sent to parents in the bakfietservaringen (English: cargo bike experiences) Facebook page. Parents who owned an infant carrier (e.g. Steco Baby Mee) were asked about their experiences with their current solution. The purpose of this online questionnaire was to map the usage of infant carriers on cargo bikes. When asked how to make it safer:

- “I have no idea how to make it safer, but I found it fairly bouncing, what in my opinion is not always safe for the little one.”
- “Making it slightly more sensitive to shocks. Although it has springs, when cycling over bumps, it still bounces quite a lot.”

Gebruik van babydrager op de (bak)fiets

Pagina 1

Beste ouder(s),

Wat leuk dat je even de tijd wil nemen om mijn vragen de beantwoorden. De vragen hebben allemaal betrekking op het gebruik van jouw 'babydrager' op de (bak)fiets. Met 'babydrager' wordt het product bedoelt dat wordt gemonteerd op de (bak)fiets en waarop vervolgens de baby autostoel (b.v. Maxi-Cosi Cabriofix, Joolz iZi Go, etc.) kan worden bevestigd.

Het zal slechts 5 minuutjes duren.

Dank je wel!

Pagina 2

Welk type/merk babydrager gebruik je op de (bak)fiets?

Indien de 'babydrager' een ander soort constructie betreft (b.v. een eigen oplossing), kan dat ook hier genoemd worden.

Vanaf welke leeftijd heb je je baby meegenomen in de babydrager?

Na __________ maanden

Tot welke leeftijd heb je je baby meegenomen in de babydrager?

Tot __________ maanden

Onder welke weersomstandigheden neem/nam je jouw baby mee in de babydrager?

Meerdere antwoorden mogelijk

- ☐ Bij warme weersomstandigheden (zon, 25+ graden)
- ☐ Bij normale weeromstandigheden (licht bewolkt, 12-25 graden)
- ☐ Bij koude weeromstandigheden (12 graden of kouder)
- ☐ Met regen (met regenhuif)
- ☐ Anders, namelijk: ______

Krijg/kreeg je veel reacties van anderen? Zo ja, welke reacties en van wie (fietsers, wandelaars, etc.)?

______

Hoe vaak nam/neem je jouw baby mee in de babydrager op de bakfiets per week?

Let op: heen én terug fietsen (b.v. naar en van het kinderdagverblijf) telt als 2 keer.

- ○ 1 Keer
- ○ 2-4 Keer
- ○ 5-8 Keer
- ○ Meer dan 8 keer

Hoe lang duurt/duurde een gemiddeld ritje als je jouw baby mee neemt/nam in de babydrager op de (bak)fiets?

- ○ 0 - 5 minuten
- ○ 6 - 10 minuten
- ○ 11 - 15 minuten
- ○ Langer dan 15 minuten

Hoe veilig zou je het meenemen van je baby in de babydrager op de (bak)fiets omschrijven?

- ◯ Zeer onveilig
- ◯ Onveilig
- ◯ Niet veilig, noch onveilig
- ◯ Veilig
- ◯ Zeer veilig

Hoe veilig vind je de bevestigingsmethode van de baby autostoel op de babydrager?

- ◯ Zeer onveilig
- ◯ Onveilig
- ◯ Niet veilig, noch onveilig
- ◯ Veilig
- ◯ Zeer veilig

Welk kenmerk omschrijft het gedrag van jouw baby het beste wanneer hij of zij 'meereist' in de (bak)fiets?

- ◯ Net als anders, geen verschil
- ◯ Lacht meer
- ◯ Huilt meer
- ◯ Valt in slaap
- ◯ Kijkt om zich heen
- ◯ Anders, namelijk: ____________

Hoe zou de babydrager veiliger gemaakt kunnen worden volgens jou?

Wat doe je met de babydrager als je jouw baby niet mee neemt op de bakfiets?

Meerdere antwoorden mogelijk

- [ ] De babydrager zit vast (er gebeurd vervolgens niks mee)
- [ ] De babydrager zit vast (af en toe leg ik er andere spullen op, zoals boodschappen)
- [ ] De babydrager zit vast (andere kinderen stoten er soms tegen met hun voetjes)
- [ ] Ik haal de babydrager los
- [ ] Anders, namelijk:

Raad je de babydrager aan aan andere ouders? En waarom?

Heb je de babydrager zelf gemonteerd of laten monteren? Waarom heb je het zelf gemonteerd of laten monteren?

Wat is het grootste nadeel aan jouw babydrager? Wat kan er verbetert worden?

Vind je dat de babydrager te veel ruimte in beslag neemt?

- ◯ ja
- ◯ nee

Er bestaat tot nu toe nog geen babydrager met een officiëel goedkeuringslabel, ben je hier van op de hoogte? Wat vind je hier van?

Een goedkeuringslabel geeft aan dat een product is goedgekeurd volgens bepaalde officiële (Europese) reglementen en testmethodes

Heb je je laten adviseren over het mee vervoeren van een baby op een bakfiets? Zo ja, wie gaf dit advies en waar moest je van hem of haar op letten?

Overige opmerkingen:

Pagina 3

Hartelijk dank voor het invullen van de vragenlijst.

» Redirection to final page of Enquêtes Maken

Appendix 15 Weight-for-age

World Health Organization

Weight-for-age BOYS

Birth to 5 years (z-scores)

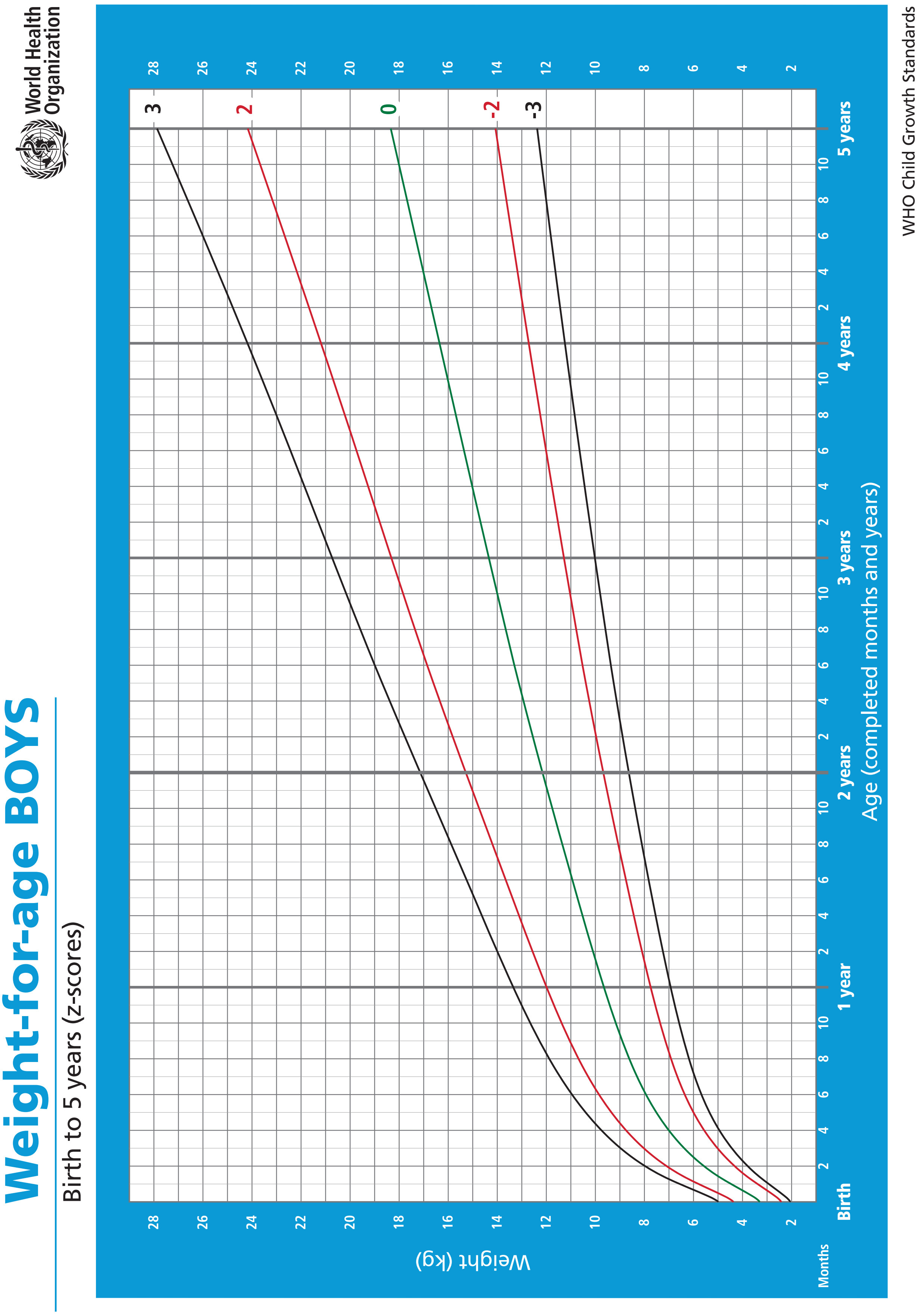
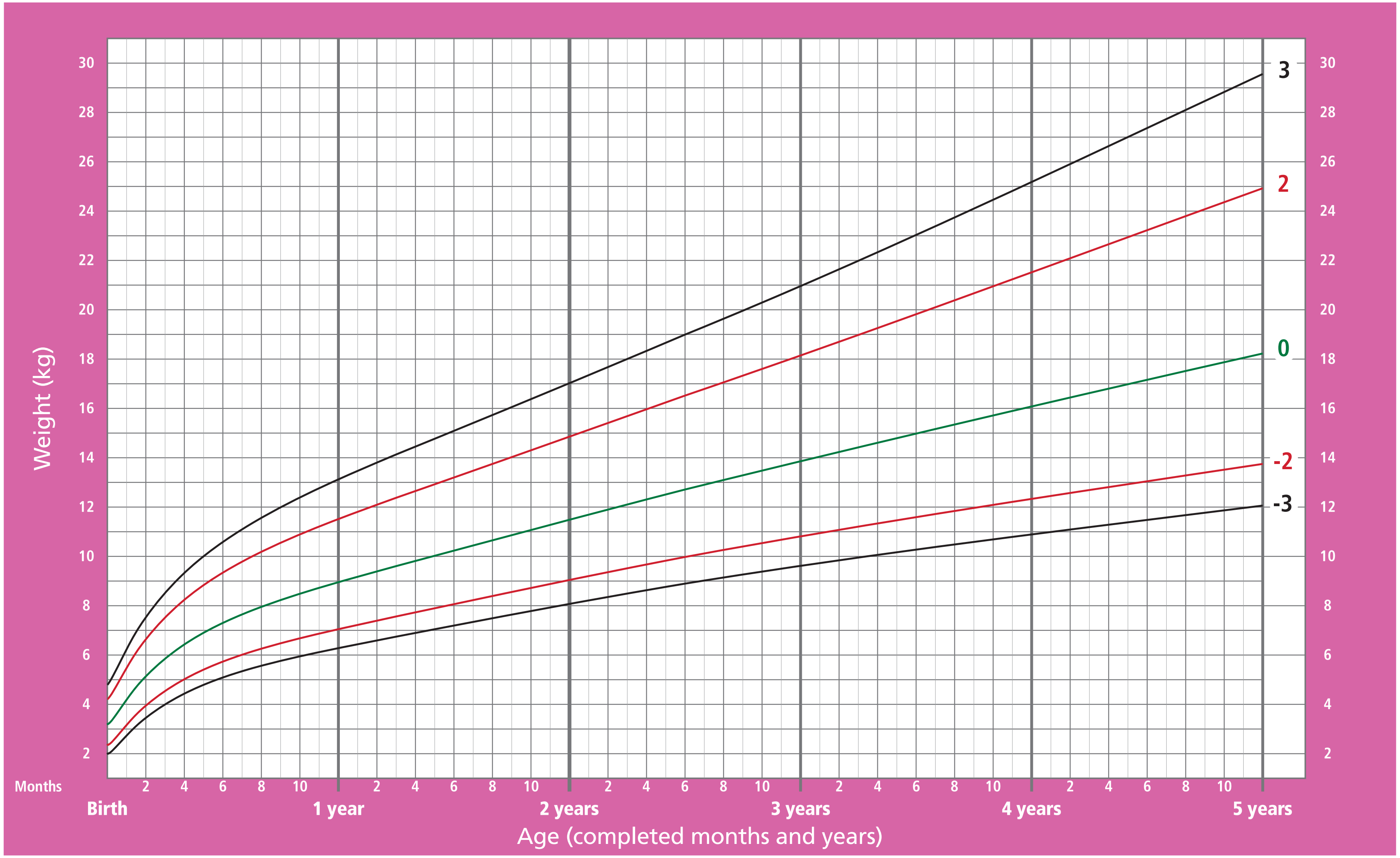


Chart 1: Weight-for-age BOYS. Birth to 5 years (z-scores). Originated from the World Health Organization

Weight-for-age GIRLS

Birth to 5 years (z-scores)

World Health Organization

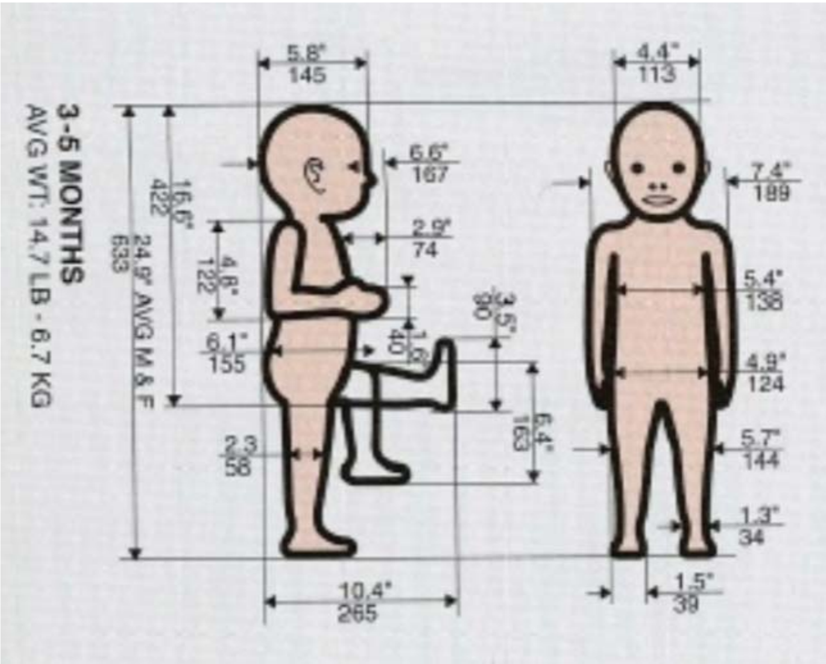


WHO Child Growth Standards

Chart 2: Weight-for-age GIRLS. Birth to 5 years (z-scores). Originated from the World Health Organization

Appendix 16

anthropometric measurements for humans



Tilley (2001) provided average anthropometric measurements for humans starting from age 2 months. The anthropometric data of an infant (m+f, P50, 3-5 months) and of an infant (m+f, P50, 11 months) can be found here.

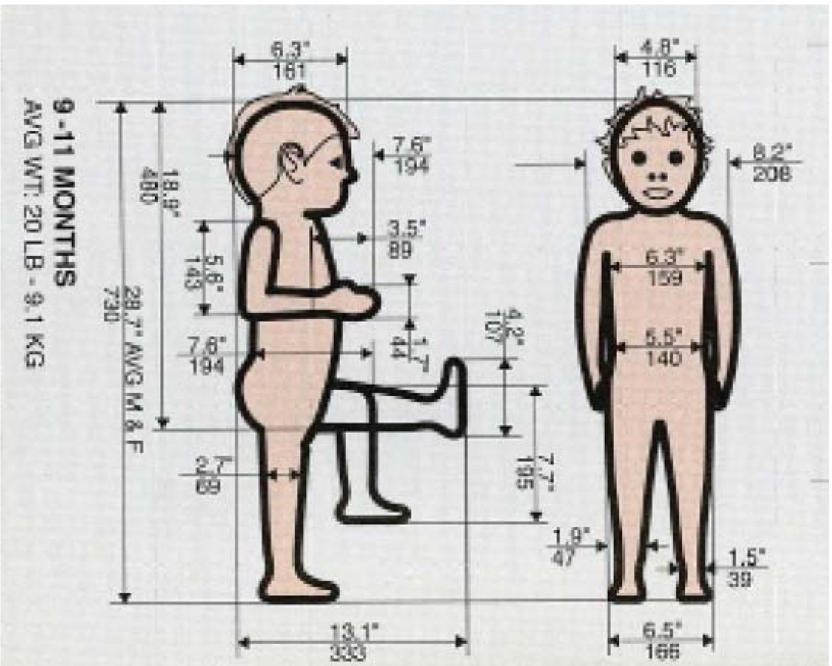


Figure 19: (top) The anthropometric data of an infant (m+f, P50, 3-5 months)

Figure 20: (bottom) The anthropometric data of an infant (m+f, P50, 11 months).

Appendix 17
Meeting **Consumentenbond**

A meeting with Ronald Vroman, expert in the field of crash testing and infant safety seats at the Dutch Consumers Association (de Consumentenbond), was arranged to change opinions and to share the initial digital sketch that can be found here.

Conclusions of the meeting

Misuse

Correct use of car seats for small children is essential to prevent serious injuries and death from automotive accidents. Failure to use a car seat properly can contribute to serious injury or death of a child. The same applies to the design proposal. Therefore:

It is desirable that an (visual) indication (e.g. a red and green sign) is present that signifies the person who mounts the seat system prior to usage when the seat system is not properly or fully positioned in place.

If any confusion about positioning a part in the correct position might occur (e.g. left and right part), the matching parts should have an indication that guides the user.

Figure 21: Initial digital sketch shared with the Consumentenbond. The sketch shows a seating system consisting of:

A) A compact and lightweight removable infant carrier
B) A robust base seat. The removable infant carrier can be attached to the base seat.
C) Mechnical interface between the base seat and the bench of the cargo bike.

The advantage of such a solution is that the heavy and robust base seat can be attached permanently, while a lightweight carrier can be carried without effort.

Appendix 18

Vibration management

List of definitions

A list of definitions that are necessary to understand vibration management in more detail and to make appropriate calculations.

Vibration: A magnitude (force, displacement, or acceleration) which oscillates about some specified reference where the magnitude of the force, displacement, or acceleration is alternately smaller and greater than the reference.

Frequency: Frequency may be defined as the number of complete cycles of oscillations which occur per unit of time.

$$Frequency = f = \frac{cycles}{second}\ (cps) = Hertz\ (Hz)$$

Period: The time required to complete one cycle of vibration.

$$Period = \lambda = \frac{1}{f}$$

Forcing/disturbing Frequency: Defined as the number of oscillations per unit time of an external force or displacement applied to a system.

$$Forcing\ frequency = fd$$

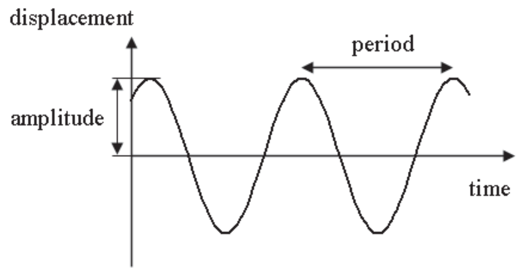
Natural Frequency: Natural frequency may be defined as the number of oscillations that a system will carry out in unit time if displaced from it equilibrium position and allowed to vibrate freely. (See Figure 3)

$$Fn = \frac{1}{2\pi}\sqrt{\frac{K}{M}}\ [Hz]$$

Amplitude: The amplitude of a harmonic vibration such as displacement, velocity, or acceleration is the zero to peak value corresponding to the maximum magnitude of a harmonic vibration time-history. (See Figure 3.)

Displacement: Displacement is a vector quantity that specifies the change of the position of a body or particle and is usually measured from the mean position or

$$Displacement = x\ [m]$$



equilibrium position. In general it can be represented by a translation or rotation vector or both. (See Figure 3)

Velocity: Velocity is a vector that specifies the time rate change of displacement with respect to a frame of reference.

$$Velocity = v = \dot{x}\ \left[\frac{m}{s}\right]$$

Acceleration: Acceleration is a vector that specifies the time rate of change of velocity with respect to a frame of reference. The acceleration produced by the force of gravity, which varies with the latitude and elevation of the point of observation, is given by g = 9.81 m/s2, which has been chosen as a standard acceleration due to gravity.

$$acceleration = g = \ddot{x}\ \left[\frac{m}{s^2}\right]$$

Deflection: Deflection is defined as the distance a body or spring will move when subjected to a static or dynamic force, F.

$$deflection = \Delta\ [m, mm, etc]$$

Spring Stiffness: Described as a constant which is the ratio of a force increment to a corresponding deflection increment of the spring.

$$Spring\ stiffness = k = \frac{F}{\Delta x}\ \left[\frac{N}{mm}\right]$$

Damping Coefficient: Damping for a material is expressed by its damping coefficient.

$$Damping\ coefficient = c\ \left[\frac{N}{mm}\cdot s\right]$$

Critical Damping: A system is said to be critically damped when it is displaced from its static position and most quickly returns to this initial static position without any over-oscillation. The damping coefficient required for critical damping can be calculated using

$$Critical\ damping = Cc = 2 \cdot \sqrt{\frac{K}{M}}$$

Damping Factor: The non-dimensionless ratio which defines the amount of damping in a system

$$Damping\ factor = \frac{c}{Cc} = \zeta$$

Resonance: When the forcing frequency coincides with the natural frequency of a suspension system, this condition is known as resonance.

Transmissibility: Defined as the ratio of the dynamic output to the dynamic input.

$$Transmissibility = T = \sqrt{\frac{\left(1 + \left(2\frac{fd}{fn} \cdot \frac{c}{Cc}\right)^2\right)}{\left(1 - \frac{fd^2}{fn^2}\right)^2 + \left(2\frac{fd}{fn} \cdot \frac{c}{Cc}\right)^2}}$$

Appendix 19
different types of **passive damping**

19.1 Coulomb (dry or friction) damping
Arises chiefly from the electrostatic forces of attraction between the sliding surfaces and converts mechanical energy of motion, or kinetic energy, into heat. If the damping force in a vibratory system is constant and independent of the position or velocity of the system, the system is said to have coulomb or dry friction damping.

19.2 Hysteresis (structural) Damping
Damping which results from the molecular structure of a material when that material is subjected to motion is referred to as hysteresis damping. Elastomers are good examples of materials which possess this type of damping. In hysteresis damping, some of the energy involved in the repetitive internal deformation and restoration to original shape is dissipated in the form of random vibrations of the crystal lattice in solids and random kinetic energy of the molecules in a fluid.

19.3 Viscous Damping
Caused by such energy losses as occur in liquid lubrication between moving parts or in a fluid forced through a small opening by a piston. If any particle in a vibrating body encounters a force which has a magnitude proportional to the magnitude of the velocity of the particle in a direction opposite to the direction of the velocity of the particle, the particle is said to be viscously damped. This is the easiest type of damping to model mathematically.

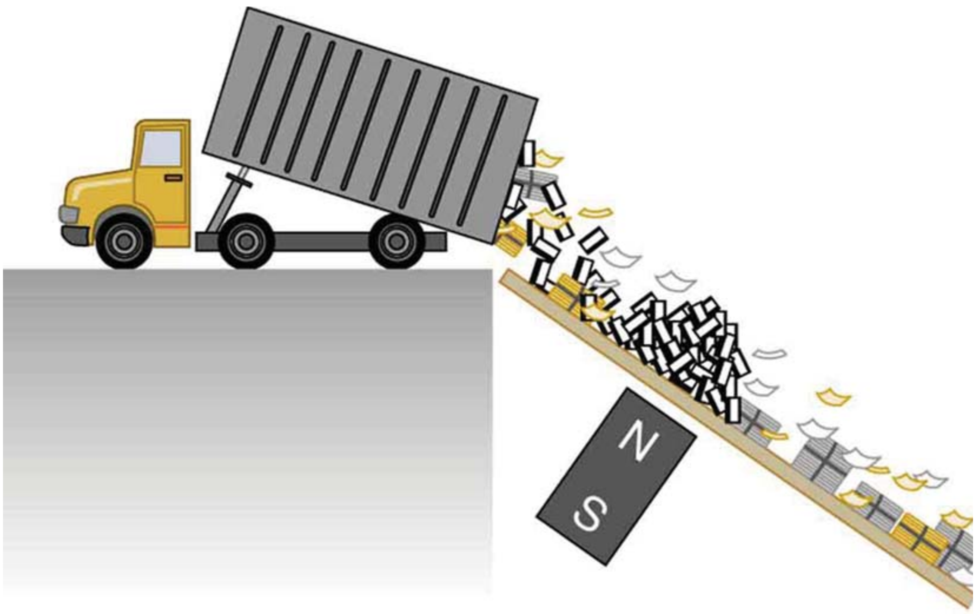
19.4 Magnetic damping
In magnetic damping, energy of motion is converted to heat by way of electric eddy currents induced in either a coil or an aluminum plate (attached to the oscillating object) that passes between the poles of a magnet.

Figure 22: (top) Almost all washing machines make use friction dampers. Friction dampers essentially consist of a housing, a tappet, and a friction element that acts like a connecting member. The damping or friction force is generated by the friction element due to the relative movement between the housing and tappet. This type of damping is independent of velocity.

Figure 23: (bottom) Bicycle seats are a nice example of hysteresis damping. The rubber used in these parts damp vibrations that are transmitted to the cyclist, making cycling as comfortable as possible.

Figure 24: (top) Probably, the most known example of viscous damping is the (coil-over) shock absorber of a car. Resistance (damping) is produced as the oil flows through the piston (orifices).

Figure 25: (bottom) Since magnetic damping occur only in conductors, recycling centers can use magnets to separate metals from other materials. Trash is dumped in batches down a ramp, beneath which lies a powerful magnet. Conductors in the trash are slowed by magnetic damping while nonmetals in the trash move on, separating from the metals.



Appendix 20

Vibrational research

20.1 Background information

20.1.1 Infant's anatomy

Children, in general are more exposed, to increased risks of fatalities and serious health losses in the traffic system owing to several factors, one is their anatomy (Evans, 1991). The infant and child differ structurally from the adult in a number of ways which are critical to the design for protection against impact forces and for adequate occupant restraint systems (Huelke, 1998).

20.1.1.1 Proportional body changes

At birth the head is one-fourth the total body length, whereas in the adult it is one-seventh (Fig. 2, Huelke, 1998). Changes in body height and body proportions also have specific age trends (Fig. 1). Based on Huelke's findings in figure 1 and 2, it can be stated that the infant's leg length represents about 30% of the total height at birth, compared to about 50% for adults.

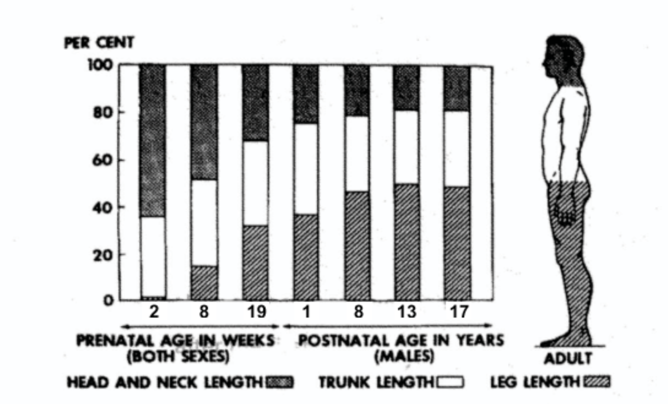


Figure 27: Percentage distribution of body segments as related to pre- and postnatal development (modified from Salzmann, "Principles of Orthodontics") (Huelke, 1998).

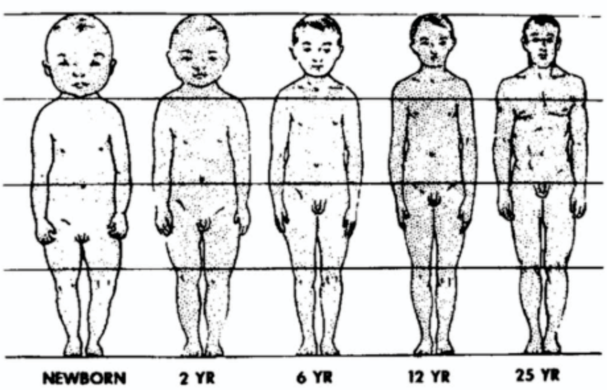


Figure 26: The proportional changes in body segments with age (Huelke, 1998).

20.1.1.2 Head

Infant head shape differs significantly from that of the adult (figure 3). At birth, the infant's cranium is huge relative to its face (Marieb, 2004). In the infant the cranium is much more elongate and bulbous, with large frontal and parietal (side) prominences (Huelke, 1998). The infant head has approximately 25% the volume of the adult head, (Prange et. al., 2004) and the infant head mass is ~1 kg, whereas the 50th percentile adult male head is ~4.5 kg (Prange et. al., 2004).

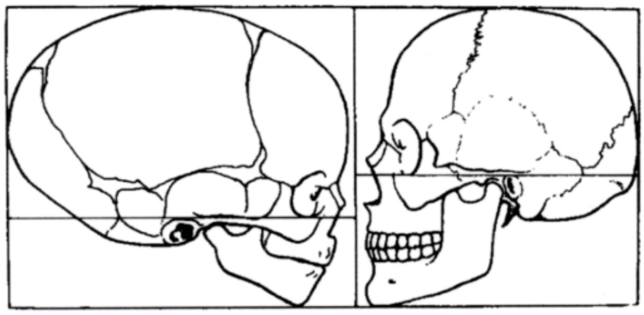


Figure 28: A comparison of face-braincase proportions in the child and adult. The horizontal line passes through the same anatomical landmarks on both skulls.

20.1.1.3 Neck (cervical spine)

Young children have weaker neck muscles, and the head is relatively heavy (Araki et. al., 2017). Because a child's head is proportionately larger than an adult's, it exerts greater stress on the neck structures during a deceleration injury (Pollak, 2005). Furthermore, ligamentous laxity, unossified vertebrae (Myers & Winkelstein, 1995) and the poor ability to cushion against external forces of the infant's skin (Araki, Yokota, & Morita, 2017) can subject the infant to uncontrolled and passive cervical spine movements.

In addition, head injuries are far more common among

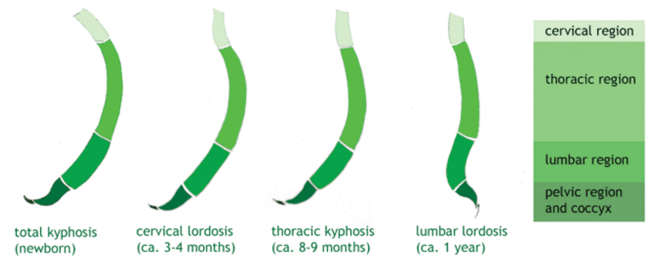


Figure 29: Development of the infant's spine (modified from 'Carried with Love Babywearing Consultant' in "Basics of Baby's Anatomy: Development of the Spine").

children than spine injuries, and spine injuries are more frequent among adults than children (Hall & Boydston, 1984). However, when children experience spinal injuries, they tend to be located in the cervical spine; up to 75% of spinal column injuries between infancy and age 8 years occur in the cervical spine (Hall & Boydston, 1984). The Boston Children's Hospital (2016) reported similar findings: 60 to 75% of all Spinal Cord Injury (SCI) for children occurred in the neck area.

20.1.1.4 Vertebral column

When a baby is born the spine is in total kyphosis (figure 4), which means it's rounded in the shape of a C (Brockmann, 2009). It is the natural position of the spine when an infant curls into the fetal position (Sinicropi, 2016). Around 1 year of age, when the child's muscles are strong enough to hold up the whole back, the spine curvature has the similar S-shape as seen in adults' spines.

20.1.2 Whole-body vibration

Whole-body vibration is transmitted to the body as a whole, generally through the supporting surface (e.g. feet, buttocks, back). The vibrations transmitted from the bicycle or cargo bike to a child fastened in a child safety seat are considered to be whole-body vibrations. Exposure to whole-body vibration can cause permanent physical damage, or disturb the nervous system (Brüel & Kjær, 1989). Daily exposure to whole-body vibration over a number of years can result in serious physical damage (Abercromby et al., 2007; El Sayed, Habashy, & El Adawy, 2012).

The magnitude of the vibration can be quantified by its displacement, its velocity or its acceleration (Griffon, 1990) and are related mathematically by a function of frequency and time. The form and period of the vibration remain the same whether it is the displacement, velocity or acceleration that is being considered. The main difference is that there is a phase difference between the amplitude-time curves of the three parameters as shown in figure 6 (Brüel & Kjær, 1982). ISO Standard 2631 for human vibration measurement requires that acceleration is the parameter used to measure vibration levels.

20.1.2.1 Risk of health impairment

Biodynamic research as well as epidemiological studies have given evidence for an elevated risk of health impairment due to long-term exposure with high-intensity whole-body vibration (Nederlands Normalisatie instituut, 1997). Spinal column disease and complaints are perhaps the most common diseases associated with the long-term exposure to whole-body vibration (Archer, 2011). It generally takes several years for health changes caused by whole-body vibration to occur. It is therefore important that exposure measurements are representative of the whole exposure period.

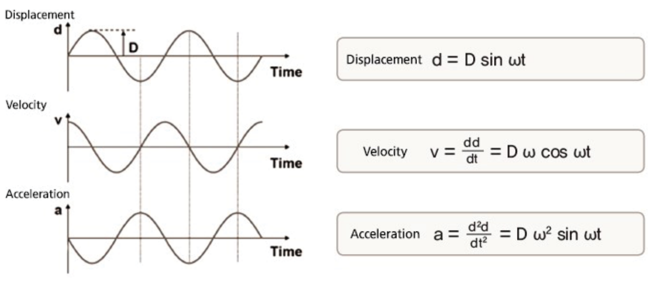


Figure 30: Phase difference and mathematical relation between the amplitude-time curves of displacement, velocity and acceleration.

On average, the health risk increases with higher intensity or duration of exposure (Bovenzi, 2006; Seidel & Heide, 1986), while the pattern of exposure (continuous, intermittent, rest periods) seems to play an important role to reduce the risk (Bovenzi, 2006; Herren, Rogan, Hilfiker & Radlinger, 2009; Haas, 2008).

20.1.2.2 Vibrational comfort

A particular vibration condition may be considered to cause discomfort in one situation but may be classified as pleasant or exhilarating in another. Many factors combine to determine the degree to which discomfort may be noted or tolerated. Comfort expectations and annoyance tolerance are quite different in transportation vehicles compared to commercial or residential buildings. Discomfort can be significantly influenced by peak values and underestimated methods involving r.m.s. averaging. Acceptable values of vibration magnitude for comfort depend on many factors which vary with each application. The following values give approximate indications of likely reactions to vibration of various magnitudes (Nederlands Normalisatie instituut, 1997):

Less than 0,315 m/s^2	not uncomfortable
0,315 m/s^2 to 0,63 m/s^2:	a little uncomfortable
0,5 m/s^2 to 1 m/s^2:	fairly uncomfortable
0,8 m/s^2 to 1,6 m/s^2:	uncomfortable
1,25 m/s^2 to 2,5 m/s^2:	very uncomfortable
Greater than 2 m/s^2:	extremely uncomfortable

20.1.2.3 Frequency sensitivity

The manner in which vibration affects health, comfort, perception and motion sickness is dependent on the vibration frequency content (Nederlands Normalisatie instituut, 1997), see Chart 3 and Chart 4.

People are most sensitive to whole-body vibration within the frequency range of 1 to 20 Hz (Mansfield, 2005), although many measurements include slightly smaller frequency ranges: according to an article by Griffin (1978) the maximum sensitivity to vertical vibration acceleration was indicated to be in the 4 to 16 Hz range; Wieckowski (2013) mentioned that vibrations are most easily absorbed by the child's body in the 3-16 Hz range; Groenendijk (2012) stated that vertical vibration of the supporting surface for adults is most easily perceived at about 4-8 Hz. The values of frequency weighting Wk (of ISO 2631) for the vertical recumbent direction largely conforms the frequency range mentioned by Groenendijk (Chart 3).

The head, however, indicates to have a different frequency sensitivity range. According to the values of

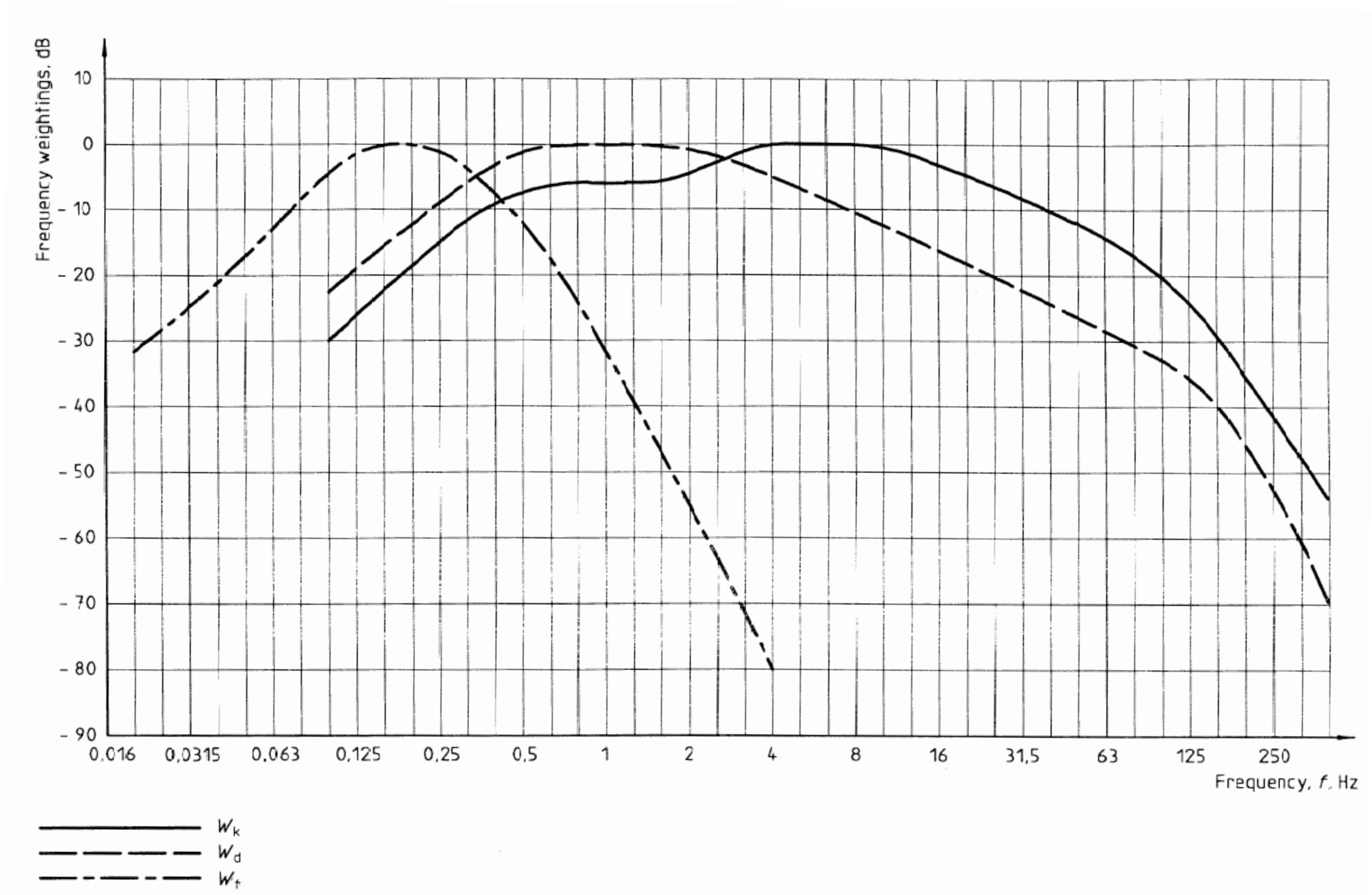


Chart 3: Frequency weighting curves for principal weightings

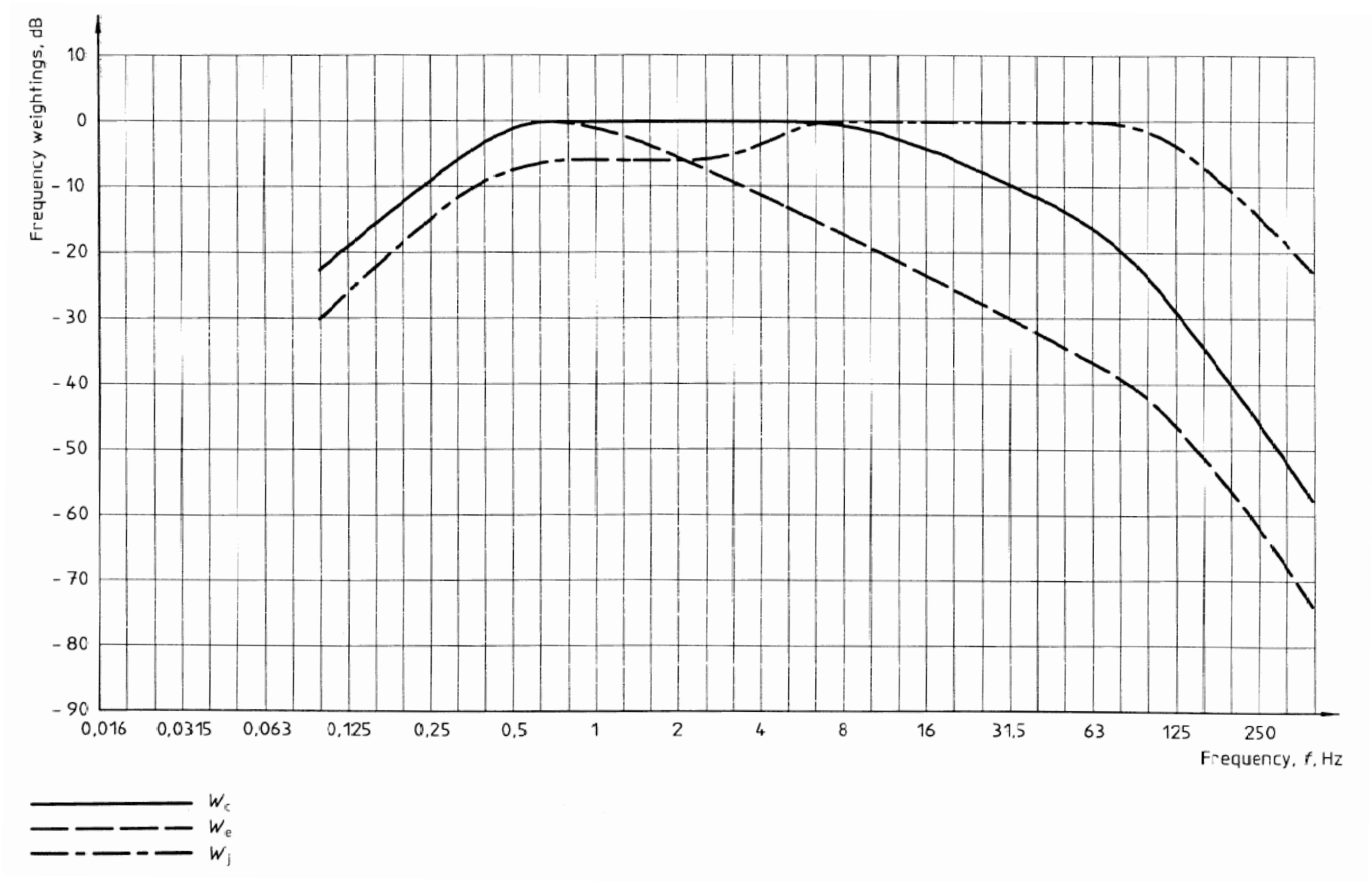


Chart 4: Frequency weighting curves for additional weightings

frequency weighting Wj (of ISO 2631) vibrations under the head of a recumbent person are more sensitive to frequencies in the 8 – 60 Hz range (Nederlands Normalisatie instituut, 1997).

20.1.3 Shaken Baby Syndrome

In few cases, the Shaken Baby Syndrome (SBS) is linked to travelling with infants on a bicycle or cargo bike (Mobiel21, 2010). Shaken baby syndrome — also known as abusive head trauma, shaken impact syndrome, inflicted head injury or whiplash shake syndrome — is a serious brain injury resulting from forcefully shaking an infant or toddler (Mayo Clinic, 2017).

There is a wide spectrum of clinical signs. The mildest are non-specific so that injury may never be detected; the most severe being the shocked, unconscious, convulsing child. The non-specific signs that may persist for days or weeks are poor feeding, vomiting, lethargy, and irritability (Blumenthal, 2009). The most severe clinical signs could show some form of neurological or cognitive dysfunction, which may not be fully apparent before 6 years of age (Gilles & Nelson, 1998; Jayawant et al., 1998; Prasad, Ewing-Cobbs, Swank, & Kramer, 2002).

When an infant is severely shaken, the head and neck make a kind of whiplash movement (figure 7). Due to the space in between the brain and the skull of an infant's head – the brain needs room to grow – the brain moves about inside the skull as well. This phenomenon might cause one of the aforementioned clinical signs (Mobiel21, 2010).

Under the age of 3 months, babies are still very vulnerable and their head and brain can easily be damaged. After 3 months, babies' neck muscles are stronger and they are better protected against the risks of violent shaking. After this age, the effect of front-to-back vibrations decreases. Once children are 1 year or older, it is very unlikely they will get SBS (Mobiel21, 2010).

Figure 31: Head movement due to severely shaking an infant. Graphic originated from: Shaken baby syndrome – review (Blumenthal, 2009).

20.1.4 Vibration nuisance

The research report 'Verhardingskeuze voor fietsverbindingen: asfalt, beton of tegels?' (KOAC WMD, 2002), provided data concerning the measurement results of the longitudinal flatness, the visual assessment of fraying, transverse flatness, cracking and edge damage of different road surfaces. In this report, the vibration accelerations were also listed (table 2). Measurements were collected with the FietsComfortMeter (FCM, figure 10). The FCM registered acceleration of two loaded bicycle wheels that ware attached behind a minivan. Consequently, the acceleration on saddle height was calculated based on software.

When comparing the accelerations with graph 1 in appendix 1 'health guidance caution zones', the Fietsersbond (2009) made the following observations:

- Only tarmac (perfect and average) falls within the zone 'minimal risk to health';
- Bad concrete tiles and road bricks fall within the caution zone.
- Peak values on bad concrete tiles and road bricks road surfaces exceed the minimum value where health risks are likely.

Road surface	Condition	Average periodic vibration [m/s2]	Peak vibration [m/s2]
Tarmac	Perfect	0,4	0,7
	Average	0,6	1,2
	Bad	1	2,4
Concrete tiles	Perfect	0,8	1,8
	Average	1,3	3
	Bad	2	4,6
Road bricks	Perfect	0,9	2,2
	Average	1,5	3,8
	Bad	2,2	5,8

Table 1: vibration nuisance for different road surfaces. Measurements were collected with the FietsComfortMeter (FCM, appendix 20). The FCM registered acceleration of two loaded bicycle wheels that ware attached behind a minivan. Consequently, the acceleration on saddle height was calculated based on software.

Figure 32: The FietsComfortMeter (FCM)

20.1.5 Measured r.m.s. accelerations

20.1.5.1 In cars

Studies done by Giacomin & Gallo (2003) and Nilsson (2005) presented r.m.s. acceleration levels recorded in a driving car. For both studies the levels measured at the child seat were always higher than those at the driver's seat, and, more importantly, the reduction in vibration from floor to human occupant was lower for the child than for the driver in all systems tested (Giacomin & Gallo, 2003).

The ratio of the acceleration arriving at the human occupant divided by the acceleration present at the guide of the vehicle seat (transmissibility vibration) was 64% in the case of the driver and 80% in the case of the child for the 20 km/h tests (Giacomin & Gallo, 2003). The same ratio was 59% for the driver and 74% for the child at 40 km/h. The results suggest that the system composed of vehicle seat, child seat and child is less effective at attenuating vibrations than the vehicle primary seating system (Giacomin & Gallo, 2003).

Giacomin & Gallo's study showed r.m.s. acceleration values of between 1 to 1,5 m/s2 and between 1,5 to 2 m/s2, for respectively the test performed at 20 km/h (pave road) and the test performed at 40 km/h (pave road), both measured at the child seat. Nilsson's tests performed at 30 km/h (country road) showed r.m.s. acceleration values of between 0,4 to 0,5 m/s2 measured at the child seat, which are remarkably lower than Giacomin & Gallo's findings. Nilsson's tests performed at 50 km/h (graveled road) showed r.m.s. acceleration values of between 1,3 to 1,8 m/s2. Nevertheless, it is difficult to compare the findings of both studies with one another, because many parameters influence the r.m.s. acceleration values. The type of road surface, the travelled speed, the car, the vibration transmissibility, the vibration resonance and the type of child seats could all have influence on the measured r.m.s. acceleration values. Further, there could have been inevitable minor differences due to the body sizes and shapes of the test subjects involved, and due to their exact postural positions during the test (Giacomin, J.A., personal communication, Mai 31, 2018). Appendix 2 summarizes the mean levels measured for both studies in graph and table form.

20.1.5.2 On bicycles

The master graduation study done by Speelberg (2012) is one of the few studies that measured acceleration values on bicycles. For his tests, Speelberg mounted a Steco Baby Mee on the luggage carrier of a bicycle. Subsequently, an infant safety seat was fastened to the Steco Baby Mee, by means of its elastic bands, and loaded with 8 kg's of weight. Speelberg's study showed acceleration values of around 0,75 to 1,5 m/s2 and around 1 to 2,2m/s2, for respectively an asphalt road and brick road. It is, however, strongly debatable whether these values are scientifically usable, since the research method and conditions were barely documented and the signal processing was missing. Furthermore, it was not clear which type of vibration evaluation method from international standard ISO 2631 Speelberg used for his measured accelerations.

20.1.6 Tire pressure

Abdelghaffar et. al. (2014) found that vibrational transmissibility in cars decreases as pressure is reduced, but reducing it after a certain threshold will reduce the driver's car control and pose a danger to him and his surroundings (Abdelghaffar et al., 2014). The same relation

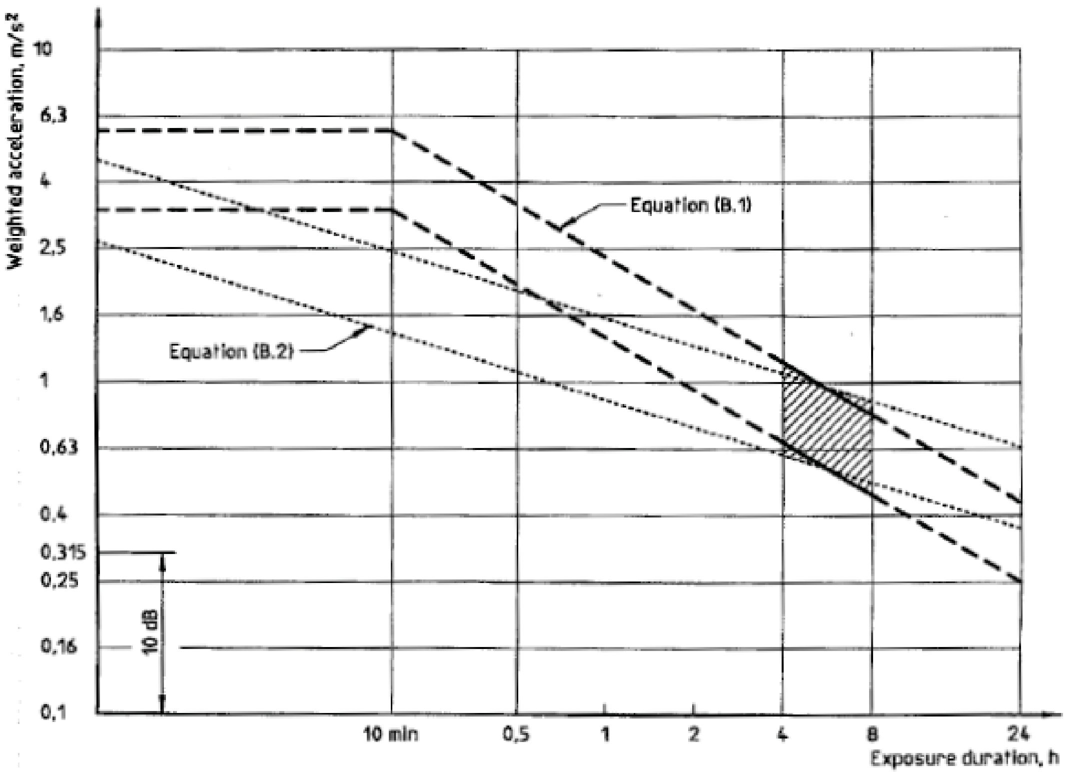


Table 2: Health guidance caution zones. The r.m.s. value of the frequency-weighted acceleration can be compared with the zone shown here at the duration of the expected daily exposure.

between tire pressure and vibrational transmissibility applies to bicycles.

The difference in vibrational transmissibility is caused by the amount of energy absorption of the inflated tire, as it can considered to be a simple spring-mass system. An over-inflated tire does not properly deflect after road imperfections: it does not absorb a lot of energy, therefore, resulting in a higher vibrational transmissibility. Lowering air pressure of the tires, contrariwise, increases the flex of the tire and leaves room for the air to move through the tire: it absorbs more energy, therefore, decreasing the vibrational transmissibility.

The exact relation, however, between tire pressure and vibrational transmissibility on bicycles remains difficult to predict.

20.2 Method

Due to lack of scientific studies that include tests to determine the influence of vibrations on the infant's body and to find out more about the vibrational environment in infant safety seats – mounted on a luggage carrier or cargo bike –, field acceleration measurements were made. The vibration experiment consisted of measurements in infant safety seats during runs over different road surfaces.

20.2.1 ISO 2631-1

The method for measuring vibrational comfort in infant seats was drafted based on ISO 2631-1 – Mechanical vibration and shock – evaluation of human exposure to whole-body vibration. The primary quantity of vibration magnitude was acceleration and measured according to coordinate systems originating at the points from which vibration was considered to enter the human body.

20.2.2 Child safety seats

A Maxi-Cosi Cabriofix was used in this study (Figure 36). The seat was fastened to a Steco Baby Mee with two integrated springs. The Steco Baby Mee was fastened to a special carrier that was anchored to the floor of the cargo bike (Figure 35).

20.2.3 Measurement equipment

All transducers used were manufactured by Xsens. The specific model was the MTw Awinda (MTW-38A70G20) wireless motion tracker (first generation, see Figure 33). The acceleration time histories were sampled at a rate of 1000 Hz.

The speed on the mother bicycle was measured by using a standard speedometer. The speed on the cargo bike was measured with the smartphone application Bike Computer.

20.2.4 Resilient materials

Vibration which was transmitted to the body from a non-rigid or resilient material (e.g. the seat cushion) was measured with the transducer interposed between the 'infant' and the principal contact areas of the surface.

Figure 33: Xsens Mtw Awinda (first generation) transducer

This was achieved by securing the transducers within a suitable formed mount. The mount did not greatly alter the pressure distribution on the surface of the resilient material.

20.2.5 Bicycles

Tests were performed on a cargo bike 'Cangoo Groovy 270E', Figure 34. All tires were inflated until the recommended tire pressure: 3,5 bar.

20.2.6 Speed

According to the Fietsersbond (2017), most cyclists should be able to easily cycle at an average speed of 18 km/h (cycling with 100 Watt) under favorable conditions – 20 degrees Celsius and no wind. For adults, this speed can be considered as a moderate intensive effort. 100 Watt – power – is an intensity that every healthy adult and teenager can cycle effortless for one hour. Furthermore, due to electrical assistance of e-bicycles and e-cargo bikes, the assumption was made that this speed would represent current cycling behavior. Therefore, the cyclist cycled with an average speed of 18 km/h (+- 1 km/h).

Weight of the cyclist

The cyclist's weight was 71 kg, excluding equipment. Equipment was weighted to be 3 kg.

Root-mean-square acceleration

The vibration evaluation included measurements of the weighted root-mean-square (r.m.s.) acceleration. The weighted r.m.s. acceleration was determined for each axis (x, y and z) of translational vibration on the surface which supports the infant. The assessment of the effect of a vibration on health and comfort was made independently along each axis.

Spectral analysis

To gain a deeper understanding of the vibration profiles, the vibration evaluation included Discrete Fourier Transforms (DFT). The DFT's present the original vibrational signal deconstructed into its individual sine wave components. Spectral analysis can be used to identify the dominant disturbing/resonance frequency.

Figure 34: (Right) Tests were performed on a cargo bike 'Cangoo Groovy 270E

Figure 35: (Left) The Steco Baby Mee was installed on a special carrier that was anchored to the floor of the cargo bike.

Figure 36: Test scenario. Here, a 5-kg test dummy is placed in the infant safety seat (Maxi-Cosi Cabriofix).


Cangoo
Cango

Appendix 21

Sales potential

Today Germany is Europe's largest market for cargo bikes in terms of volume – with industry data showing sales for electrically assisted cargo bikes alone surged to 21,000 in 2017 (Febvre, 2018). According to the biennial survey of German cycling monitor 2017, on behalf of the Federal Ministry of Transport and Digital Infrastructure, cargo bikes are used by 1 percent of the German population (Bundesministerium fur Verkehr und digitale Infrastruktur, 2017).

In 2017, Germany counted more than 11.500.000 households with one or more children (Statista, 2017). Assuming 0.7 percent actually owns a cargo bike (e.g. some people make use of cargo bike sharing platforms or use them for professional childcare), this means that around 80.500 households own a cargo bike in Germany.

Using the same number, 0.7 percent, for Belgium and The Netherlands, adds up the total to around 115.000 cargo bike owners. Assuming 5% of the cargo bike owners in Germany, The Netherlands and Belgium wants to cycle with an infant if a safe and comfortable solution is available, the total sales reaches around 6.000 potential users.

Today Germany is Europe’s largest market for cargo bikes in terms of volume – with industry data showing sales for electrically assisted cargo bikes alone surged to 21,000 in 2017, 42 percent over the previous year.

(Febvre, 2018)

Appendix 22
List of requirements

1. Mounting method
Requirements for child proof retention for the mounting method of the seat system and the mounting method of the infant safety seat.

1.1
To avoid inadvertent release of the seat system from the cargo bike the locking or attachment mechanism shall require:

a) the use of a tool (e.g. spanner or screwdriver) for at least one of the locking or attachment mechanism; or
b) two independent locking mechanisms that are operated simultaneously; or
c) two or more automatically engaging locking mechanisms that cannot be simultaneously released by one unintentional action; or
d) two consecutive actions, the first of which must be maintained while the second is carried out; or
e) A force of at least 40 N to open the enclosure, with a maximum of 60 N.

2. Edges, corners and projections
2.1
Edges, corners and projections shall conform to either the minimum radii given in Figure 2 a), 2 b) or 2 c) or, if arising from a wall thickness smaller than 4 mm, to at least one of the following requirements:

- They shall be rounded; or
- They shall be folded, rolled or spiralled as given in Figure 2 d), 2 e) or 2 f); or
- They shall be protected with a plastic coating or other adequate means as given in Figure 2 g).
- These requirements do not apply to small components such as hinges, brackets and catches.

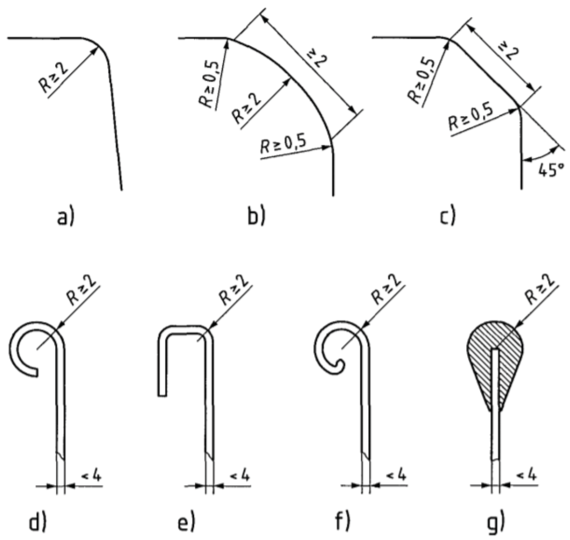


Figure 38: Examples for minimum radii of edges and corners

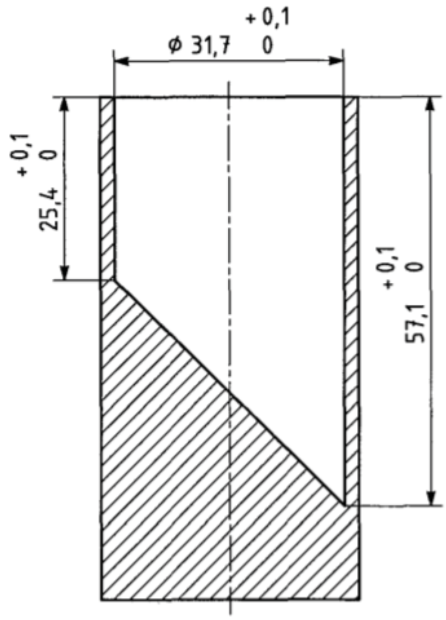


Figure 37: Test equipment - small parts cylinder

3. Entrapment
3.1
There shall be no gaps in the accessibility zone of the assembled seat between 5 mm and 12 mm. The accessibility zone includes any part that is visible when looking at the product from the outside. Padding, restraint systems and buckles are excluded.

4. Small parts
Requirements for detachable and non-detachable components.

4.1
In order to avoid ingestion or inhalation of small parts, components shall conform to the following requirements:

a) detachable components shall not, whatever orientation and without compressing, fit entirely within the cylinder according to Figure 3;
b) non-detachable components, i.e. those parts which are not intended to be removed, shall conform to one of the following requirements:

1) the components shall be so embedded that the child cannot grip them with its teeth or fingers; or

2) the components shall be so fixed to the product that they cannot become detached when a tensile test is carried out in accordance with EN 71-1:1998 - Safety of toys; or
3) any components that become detached when the tensile test is carried out shall comply with the requirement for detachable components.

5. Strength and durability

5.1
All structural components shall be assembled in accordance with the manufacturer's instructions.

5.2
After testing the seat system in accordance with NEN-EN 14344 - Child use and care articles - Child seats for cycles - Safety requirements and test methods:

- 5.2.1 high temperature test
- 5.2.2 low temperature test and low temperature drop test, and;
- 5.2.3 fatigue tests

And, after testing the seat system in accordance with:

- 5.2.4 the stepping impact strength test, and;
- 5.2.5 test method for kicking impact strength test;

The tested parts or attachment points shall:
a) Not be broken, nor present visible cracks or splits;
b) Still perform its function;
c) Not be moved in any direction more than 3 mm compared with the test fixture.

The seat system, tested parts or attachment points shall be checked after each test.

5.2.1 High temperature test
Store the seat system for (4 ± 1) h in a chamber at a temperature of (65 ± 5) °C. Remove the seat from the chamber.

5.2.2 Low temperature test and low temperature drop test
Store the seat for (4 ± 1) h in a chamber at a temperature of (– 20 ± 1) °C. Remove the seat from the chamber and within 15 s drop the seat system from a height of 1 m onto a smooth, level, concrete floor. Drop the seat in such a way that the side hits the floor.

5.2.3 Fatigue tests
5.2.3.1 Vertical dynamic test
Vibrate the seat with a sinusoidal motion in a vertical direction at 7 Hz with an amplitude of 5 mm (total stroke of 10 mm) for 50 000 cycles.

5.2.3.2 Lateral dynamic test
Vibrate the seat system from side to side with a sinusoidal motion about a horizontal axis representing the line of contact between the cargo bike tires and the road positioned at a distance 2a or 2b below the seat (see Table 3 and Figure 6).

Set the arc of travel at 10° and continue the test for 50 000 cycles at a frequency of 1 Hz.

5.2.4 test method for stepping impact strength test
Apply a force equal to the maximum weight of a toddler (P50, 6 years old, mixed) vertically downwards onto the center of each separate part that is permanently locked or attached to the bottom of the box of the cargo bike for 1 minute.

5.2.5 Test method for kicking impact strength test
Apply a force equal to the maximum kicking force of a toddler in sitting posture (P50, 6 years old, mixed), horizontally onto the front of the seat system for 100 cycles.

5.3
Any attachment point shall withstand a tensile force of twice the maximum allowable weight of the infant plus the weight of the seat system.

6.Material

6.1
The seat system must be designed to operate within the temperature range -25° C to +40° C

6.2
Chemical hazards
The seat shall comply with the requirements of EN 71-3. Nickel shall not be used in parts of the seat which may come into direct contact with the skin, if the rate of nickel release from these parts is greater than 0,5 mg/cm2/ week when tested in accordance with EN 1811.

6.3
Corrosion
6.3.1 Requirements for protection against corrosion
All metal parts shall be protected against corrosion.

After testing in accordance with 11.2.2, no part of the product proposal shall exhibit corrosion greater than that indicated in ISO 4628-3 by Ri2 in the case of ferrous metal parts (either painted or plated) or Ri3 in the case of nonferrous or Zn plated parts (those tending to produce "white" corrosion).

6.5

Any non-removable padding should be either of closed cell material or wholly encased in a waterproof covering material.

6.4

Decay and insect attack

Wood, wood based materials and materials of vegetable origin shall be free from decay and insect attack.

6.5

UV resistance

The UV resistance of the material should at least be rated as fair

7. Human health and comfort

7.1.

Road conditions

The product must be tested in compliance to all of the following test roads:

a) A properly maintained concrete tiles cycle path or road with a minimum length of 200 meters, cycling at a constant speed of 18 km/h, and;

b) A properly maintained road bricks cycle path or road with a minimum length of 200 meters, cycling at a constant speed of 18 km/h, and;

c) A properly maintained tarmac cycle path or road with a minimum length of 200 meters, cycling at a constant speed of 18 km/h, and;

d) A speedbump, cycling at a constant speed of 12 km/h.

The test roads a), b) and c) may not contain any road cracks (e.g. due to growing tree roots) or potholes that may cause significant peak values and, therefore, alter the weighted r.m.s. acceleration.

7.1.1 Weighted r.m.s. accelerations measured on the surface supporting the head

After testing the product according to the requirements of section 7.1 - road conditions, the weighted r.m.s. acceleration shall not exceed:

- 1,45 m/s2 in the x, y and z-axis.

7.1.1.1

It is desirable that the weighted r.m.s. acceleration does not exceed 1.2 m/s2 for the x, y and z-axis

7.1.2 Weighted r.m.s. accelerations measured under the pelvis

After testing the product according to the requirements of section 7.1 - road conditions, the weighted r.m.s. acceleration shall not exceed:

- 1,45 m/s2 in the x, y and z-axis

7.1.2.1

It is desirable that the weighted r.m.s. acceleration does not exceed 1.2 m/s2 for the x, y and z-axis

7.1.3 First resonance frequency amplitude

The amplitude area of the first resonance frequency measured under the head (+- 0.5 Hz) must be lowered by 50%.

7.2

The seat system should reduce the occurrence of bottoming and topping of the infant safety seat, reducing the risk of injury to the infant while travelling on a cargo bike.

7.3

Assuming a floor excitation r.m.s. value of 3.5 m/s2, the vibrational transmissibility between the floor of the cargo bike and the surface supporting the head should be at least 41%.

7.3.1

Assuming a floor excitation r.m.s. value of 3.5 m/s2, it is desirable that the vibrational transmissibility between the floor of the cargo bike and the surface supporting the head is 34%.

8. Weight

8.1

The maximum allowable weight of the infant is 10.8 kg (P85, 12 months old, male).

9. Construction

9.1

Persons must be adequately protected against the risk of injury or other damage which may be caused by direct contact with the mechanism;

9.1.1 The seat system shall incorporate (a) protective skirt(s) to prevent a child or adult accidentally being injured in the mechanism.

9.2

The total suspension travel should be at least 40 mm (20 mm up and 20 mm down from the centerline) for any infant's weight until the maximum allowable weight of the infant.

9.3

It is desirable that an indication (e.g. a red and green sign) is present that signifies the person who mounts the seat system prior to usage when the seat system is not properly or fully positioned in place.

9.4

Due to outdoor usage, water accumulation (the process of water collecting) may not occur in any part.

9.4.1 Parts that have a closed bottom need to be provided with drainage holes.

9.5

The center of gravity should be positioned as low as possible.

9.6
It is desirable that a (non-detachable) lock or part geometry (e.g. an opening where a padlock can be passed through) prevent theft, vandalism or harm.

10. Manufacturing

10.1
The seat system should be manufactured out of a limited quantity of parts
10.2
Scrap material should be kept to an absolute minimum.

10.3
Any metal or plastic scrap should be collected and processed as a recycled raw material.

10.4
It is desirable that manufacturing takes place in South-East Asia (e.g. China).

10.5
The total manufacturing cost may not exceed 80 euro.

11. Aesthetics

11.1
The seat system should have the aesthetic appeal as visualized in section XXXX.

12. Usage

12.1
Interaction with the product should not create dangers or harm to the user

12.2
If detachable parts are used, positioning and fastening these parts should be simple and intuitive.

12.3
The full seat system should be installed within 2 minutes.

12.4
Mounting the seat system to the cargo bike should be easy understandable

12.5
It should be immediately clear in which position (the parts of) the seat system should be placed

12.5.1 If any confusion about positioning a part in the correct position might occur (e.g. left and right part), the matching parts should have an indication that guides the user.

12.6
The probability and the degree of possible injury or damage to the health of a person during installation must be limited

13. Assembly

13.1
The required time for assembly should be less than five minutes.

13.2
The construction as well as the constituent parts thereof must be constructed in such a way that they can be safely and properly assembled and connected.

13.2.1 Parts may not contain sharp edges that might harm manufacturing workers

14. Transport

14.1
The packaging should be made out of a shape that is stackable.

14.2
The packaging should protect the seat system and should be able to withstand transport by boat or plane.

14.3
The packaging should protect the seat system from a drop test of 1.5 meter high. After the drop test, the seat system shall:
- Not be broken, nor present visible cracks or splits;
- Still perform its function;
- Not be moved in any direction more than 3 mm compared with the standard geometry.

14.4
The weight and surface area of the packaging should be kept to an absolute minimum.

14.5
The packaging should include a user manual

15. Durability

15.1
The seat system should be operable for at least five years, with a operating time of 1 hour per day.

16. Color

16.1
Visible parts must have a high sunlight fade resistance:
- Color loss; maximum colorfast pigment combined with optimum UV stable resin(s) or polymers is the objective;
- Chalking; minimum degree of chalking is the objective, and;
- Gloss retention; a high-performance coating that has a very long gloss retention and that lasts for at least 5 years is the objective.
-

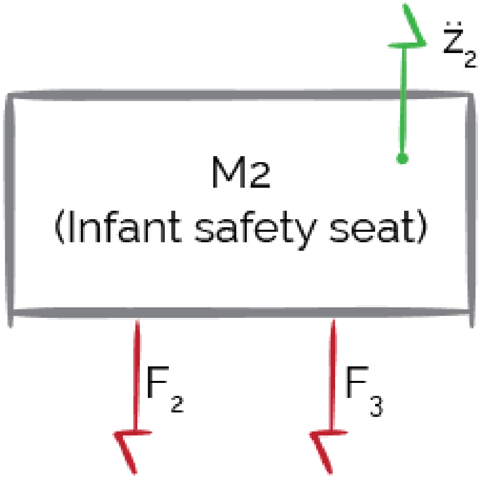
16. Size

16.1
- The seat system must fit in the box of a three-wheeled cargo bike.

16.2
- It is desirable that the seat system fits in a two-wheeled cargo bike.

Appendix 23

Maple file



$$F_2=-k_2*(z_2 - z_1)$$

$$F_3=-c_1*(\dot{z}_2 - \dot{z}_1)$$

$$\Sigma F_{M2}=m_2*\ddot{z}_2$$

$$-F_2-F_3=m_2*\ddot{z}_2$$

$$-(-k_2*(z_2 - z_1))-(-c_1*(\dot{z}_2 - \dot{z}_1))=m_2*\ddot{z}_2$$

Fd = disturbing frequency
Fn = isolator natural frequency
g = gravity
m = mass
k = spring constant
c = dampingcoefficient
R = damping Factor / Frequency ratio
ζ = damping ratio / fraction of critical damping
Cc = critical damping

T = Transmissibility
Tb = Transmissibility in dB
ACF = Angle Correction Factor

```
> mbracket := 0.742 :          # Weight of the upper bracket
  mdiagonal := 0.446 :         # Weight of the diagonal
  madapter := 0.270 :          # Weight of the upper Maxi-Cosi adapter
  maxis := 0.052 :             # Weight of the upper axis that is welded to the diagonal
  mmc := 3.5 :                 # Weight of the Maxi-Cosi
  mchild := 8 :                # Weight of the child
  k := 2670 :
  g := 9.81 :
  Fd := 8.1 :
  α := 30 :                    # shock absorber angle
```

$> ACF := evalf\left(\cos\left(\alpha\cdot\frac{\pi}{180}\right)\right)$ # Angle Correction Factor

$$ACF := 0.8660254040 \quad (1)$$

$> mconstruction := (2\cdot mbracket) + (4\cdot 0.5\cdot mdiagonal) + (2\cdot madapter) + (4\cdot maxis)$

$$mconstruction := 3.1240 \quad (2)$$

$> mtotal := mchild + mconstruction + mmc$

$$mtotal := 14.6240 \quad (3)$$

$> kangle := k\cdot ACF$

$$kangle := 2312.287829 \quad (4)$$

$> FG := mtotal\cdot g$

$$FG := 143.461440 \quad (5)$$

$> Fn := \frac{1}{2\cdot \mathrm{Pi}}\sqrt{\frac{kangle}{mtotal}}$

$$Fn := 2.001280615 \quad (6)$$

$> R := \frac{Fd}{Fn}$

$$R := 4.047408414 \quad (7)$$

$> Cc := 2\sqrt{kangle\cdot mtotal}$

$$Cc := 367.7765474 \quad (8)$$

$> c := 100 :$

$> \zeta 1 := \frac{c}{Cc}$

$$\zeta 1 := 0.2719042329 \quad (9)$$

$> T := \sqrt{\frac{\left(1+2\cdot\zeta 1\cdot\left(\frac{Fd}{Fn}\right)\right)}{\left(1-\left(\frac{Fd}{Fn}\right)^2\right)^2+\left(2\cdot\zeta 1\cdot\left(\frac{Fd}{Fn}\right)\right)^2}}$

$$T := 0.1151445317 \quad (10)$$

$> Tb := 10\log(T)$

$$Tb := -21.61567142 \quad (11)$$

> $FS1 := (-k \cdot y1(t)) \cdot ACF$

$$FS1 := -2312.287829\, y1(t) \tag{12}$$

> $FD1 := (-c \cdot diff(y1(t), t)) \cdot ACF:$

> $\Sigma Fy1 := -FG + FS1 + FD1 = mtotal \cdot diff(y1(t), t\$2);$

$$\Sigma Fy1 := -143.461440 - 2312.287829\, y1(t) - 86.60254040 \frac{d}{dt} y1(t) = 14.6240 \frac{d^2}{dt^2} y1(t) \tag{13}$$

> $ics := y1(0) = 0, D(y1)(0) = 0:$

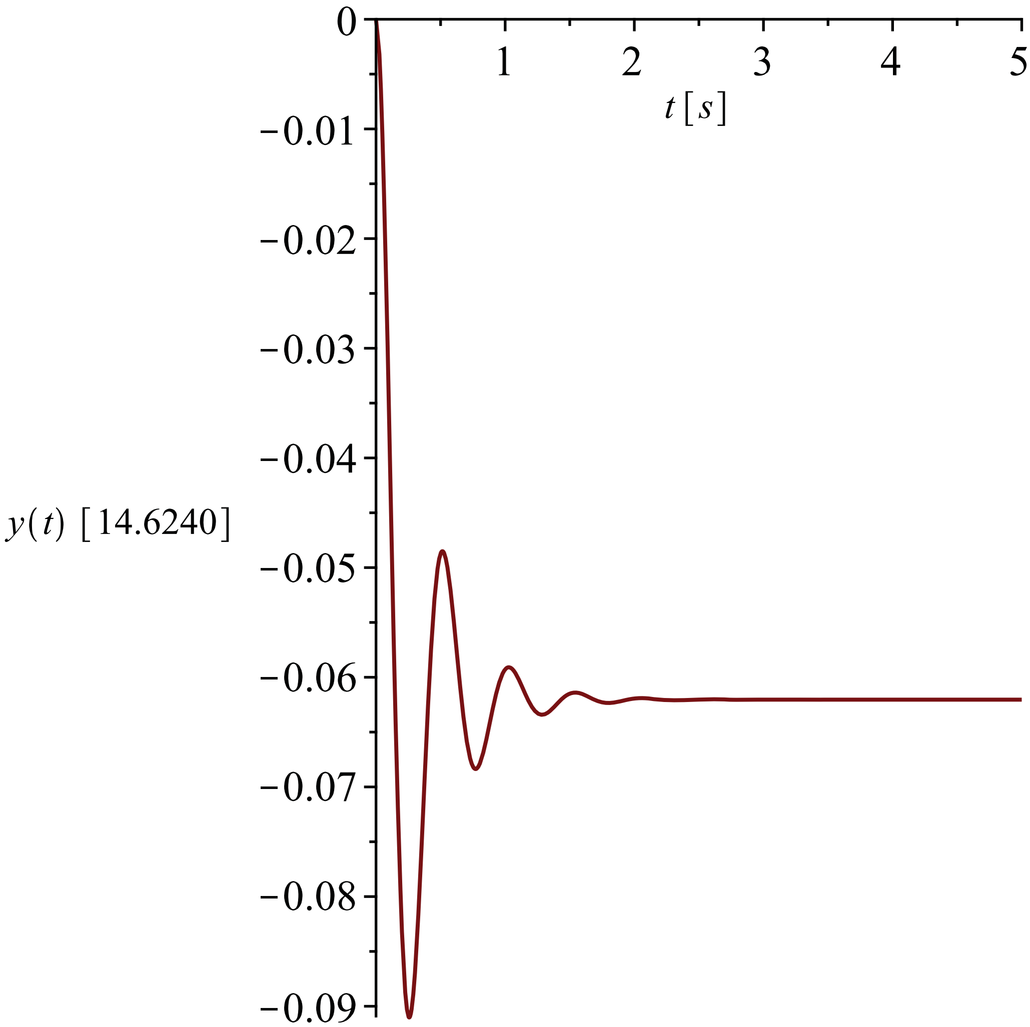
> $sol := dsolve(\{\Sigma Fy1, ics\})$

$$sol := y1(t) = \frac{1}{6154519631586039505500010457} \left(10353437627868480\, e^{-\frac{216506351\, t}{73120000}} \sin\left(1/33415840000 \left(\sqrt{1667653898121754242063 51}\, t\right)\right) \sqrt{798497430259064799}\right) + \frac{143461440\, e^{-\frac{216506351\, t}{73120000}} \cos\left(\frac{\sqrt{166765389812175424206351}\, t}{33415840000}\right)}{2312287829} - \frac{143461440}{2312287829} \tag{14}$$

> $y1 := rhs(sol)$

$$y1 := \frac{1}{6154519631586039505500010457} \left(10353437627868480\, e^{-\frac{216506351\, t}{73120000}} \sin\left(1/33415840000 \left(\sqrt{166765389812175424206351}\, t\right)\right) \sqrt{798497430259064799}\right) + \frac{143461440\, e^{-\frac{216506351\, t}{73120000}} \cos\left(\frac{\sqrt{166765389812175424206351}\, t}{33415840000}\right)}{2312287829} - \frac{143461440}{2312287829} \tag{15}$$

> $plot(y1(t), t = 0..5, labels = ['t'\,[s], 'y(t)'\,[mtotal]])$



> $t := 2$

$$t := 2 \quad \mathbf{(16)}$$

> $\Delta l := evalf(y1)$

$$\Delta l := -0.06194062646 \quad \mathbf{(17)}$$

> $t :=\text{'}t\text{'}$

$$t := t \quad \mathbf{(18)}$$

> $FG := mtotal \cdot g :$

> $FS2 := -k \cdot (y2(t) + \Delta l) :$

> $FD2 := -c \cdot diff(y2(t), t) :$

> $\Sigma Fy2 := -FG + FS2 + FD2 = mtotal \cdot diff(y2(t), t\$2) :$

> $ics := y2(0) = 0, \mathrm{D}(y2)(0) = 0 :$

> $sol := dsolve(\{\Sigma Fy2, ics\})$

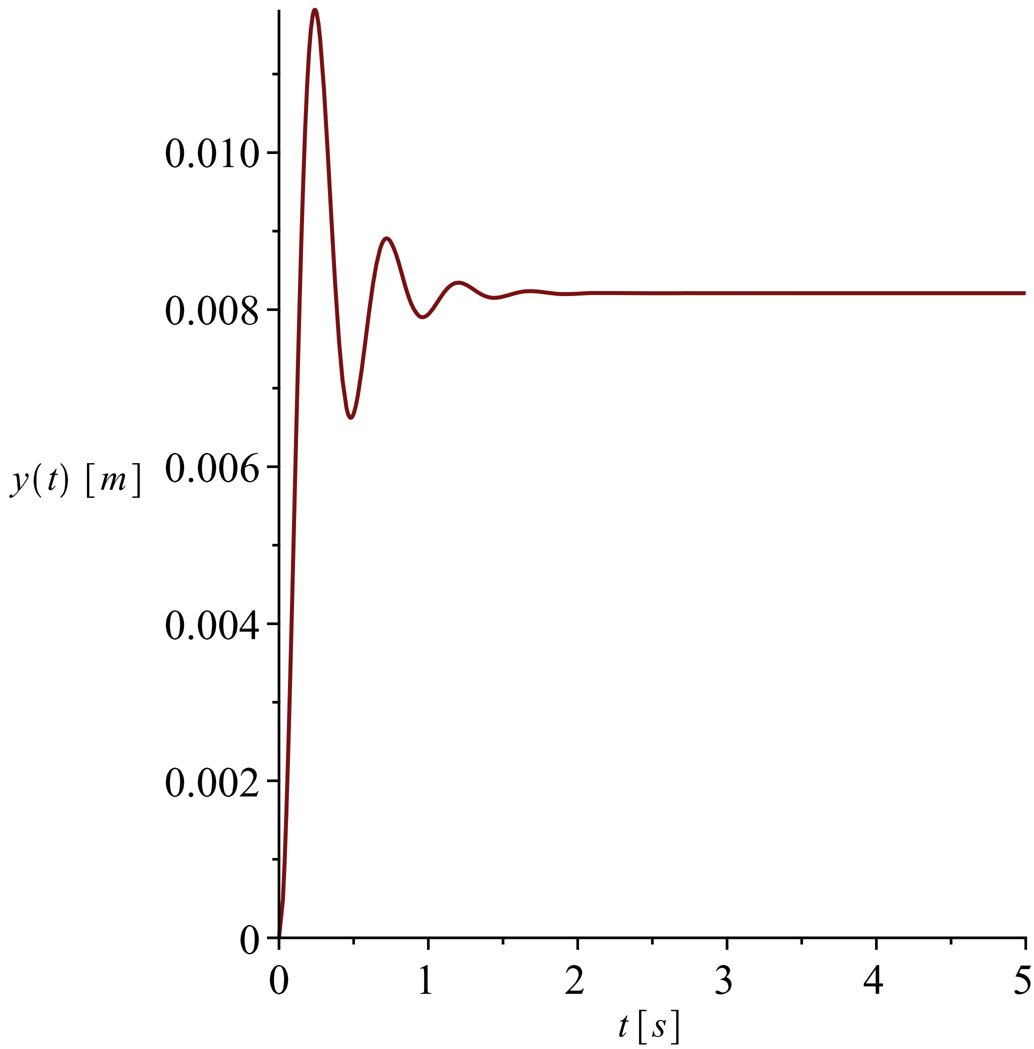
$$sol := y2(t) = -\frac{109600163\, \mathrm{e}^{-\frac{3125\, t}{914}} \sin\left(\frac{25\sqrt{47703826637}\; t}{417698}\right)\sqrt{228413}}{24394508400000} \quad \mathbf{(19)}$$

$$-\frac{109600163\, e^{-\frac{3125\,t}{914}} \cos\left(\frac{25\sqrt{47703826637}\; t}{417698}\right)}{13350000000} + \frac{109600163}{13350000000}$$

> $y2 := rhs(sol)$

$$y2 := -\frac{109600163\, e^{-\frac{3125\,t}{914}} \sin\left(\frac{25\sqrt{47703826637}\; t}{417698}\right)\sqrt{228413}}{24394508400000} - \frac{109600163\, e^{-\frac{3125\,t}{914}} \cos\left(\frac{25\sqrt{47703826637}\; t}{417698}\right)}{13350000000} + \frac{109600163}{13350000000} \quad \textbf{(20)}$$

> $plot(y2(t), t = 0\,..5, labels = [\text{'t' } [s], \text{'}y(t)\text{' } [m]])$



Appendix 24
Shock absorber

The functionality of a shock absorbers is determined by a spring which determine posture and cushioning buffer action and a damper which suppresses vibration (Showa Corporation, n.d.). One of the simplest shock absorber is an oil-filled coil-over shock absorber (Figure 39). These products work by converting kinetic energy to thermal energy. Motion applied to the piston of a hydraulic shock absorber pressurizes the fluid and forces it to flow through restricting orifices (Figure 40), causing the fluid to heat rapidly. The thermal energy is then transferred to the cylinder body and harmlessly dissipated to the atmosphere (Enidine, n.d.).

23.1 Flow rate

The volumetric flow rate (the volume of fluid that passes through a valve or orifice per unit time, Figure 40) greatly affects the characteristics of the shock absorber. The flow resistance of a tube is defined from the relationship: Subsequently, the resistance can be calculated from:

$$F := \frac{\Delta P}{R}$$

Where:

$$R := \frac{8 \cdot \eta \cdot L}{\pi \cdot r^4}$$

r = radius of the orifice
η =viscosity of the fluid
L = length of the orifice

In other words, the flow rate can be changed by changing the radii of the orifices, the viscosity or the length of the orifice. The greater the flow rate, the softer the shock absorber (low resistance to flow); the lower the flow rate, the stiffer the shock absorber (high resistance to flow). The radii of the orifices have the largest effect on the flow rate, due to its value to the fourth power.

23.2 Shock absorber characteristics

A Miniature 1:8 oil-filled coil-over shock absorber for scale cars was used in the test set-up. This shock absorber had a stroke of 80mm and a spring with an unloaded length (L0) of 100mm.

23.3 Spring rate

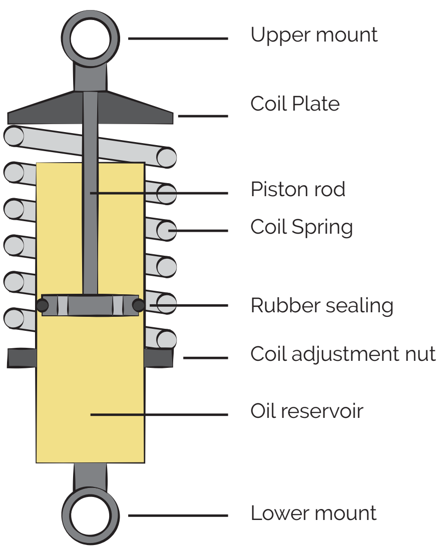
The spring rate was empirically validated. A set-up was built consisting of an incised aluminium tube and a bent nail that moved in the incision (Figure 41). By applying a certain weight to the nail the compression of the spring was determined. Thereafter, the spring rate could be calculated with the equation:
In which k is the spring rate in N/mm, F the force in

$$Spring\ stiffness = k = \frac{F}{\Delta x} \left[\frac{N}{mm}\right]$$

Newton and x the compression of the spring in mm. The spring rate of the supplied spring was 2.67 N/mm, which is a relatively soft spring. Applying a weight of 8 kg (representing the infant) would compress the spring around 20 mm.

23.4 Orifices hole diameter

By optimizing the radii of the orifices holes, the shock absorber can react precisely to bumps in the road. Small orifice radii creates more damping (high resistance to move the piston to the oil). Yet, this might be overdamped: the approach to static equilibrium is slow. If the damping is too high, it is possible that the shock absorber can no longer follow the movement of the road (Martijn



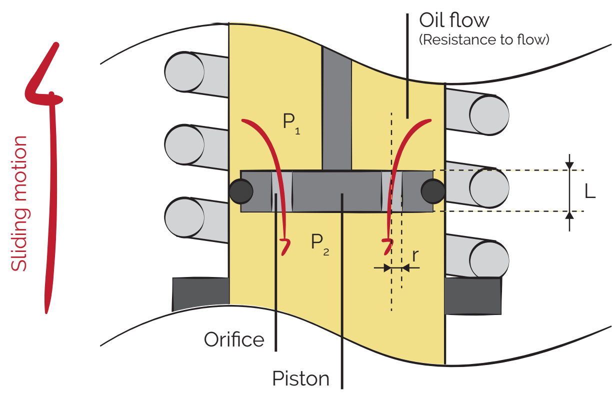


Figure 39: (left) Oil-filled coil-over shock absorber consisting out of a spring, an oil-filled cylinder, a piston, a piston rod, an upper mount and a lower mount.

Figure 40: (right) Flow Resistance for a shock absorber

Stolk, November 26, 2018, personal communication). In this case, the rebound movement might be too slow for short road imperfections. Large radii creates less damping (low resistance to move the piston to the oil). Yet, this might be underdamped: the approach to static equilibrium is more quickly, but oscillates around it.

The supplied piston had a diameter of 18.9 mm and two orifices holes with a radius of 1 mm. After each test, both holes were drilled larger in steps of 0.25 mm. Table X provides an overview of the acceleration values and their corresponding orifice hole diameters. Until radii 1.5 mm, the vibrational transmissibility improved significantly. The difference in vibrational transmissibility between orifice radii 1.5 mm and 1.75 mm barely differs: radii 1.5 mm works slightly better. It was assumed that increasing the radii even more, would result in a too high flow rate: the damping would become too low and, thus, the vibrational transmissibility would worsen. In other words, the shock absorber with orifice radii 1.5 mm showed the lowest vibrational transmissibility.

Orifice, r	Sensor	avr. rmsz	Vib. Trans.
1 mm	Floor	1.745	
	Interface	0.996	
	Head	1.362	78.02%
1.25 mm	Floor	1.744	
	Interface	0.915	
	Head	1.279	73.34%
1.5 mm	Floor	1.843	
	Interface	0.873	
	Head	1.242	67.42%
1.75 mm	Floor	1.820	
	Interface	0.906	
	Head	1.236	67.89%

Table 3: Overview of the acceleration values and their corresponding orifice hole diameters

Figure 41: Test set-up to validate the spring rate, consisting of an incised aluminium tube and a bent nail that moved in the incision.

Appendix 25

Vibrational research

insights

24.1 Platform

24.1.1 Hysteresis

Sylomer® foam

In collaboration with AMC Mecanocaucho, an international company that designs and produces anti-vibration mounts as well as noise insulation, a construction was proposed based on Sylomer® damping foam (Figure 42). Foams can have damping ratios as high as 20% (Rogers Corporation, 2012).

Main findings:

- After static loading, the Sylomer® foam was already compressed in such a way that only small deflections were possible.
- The construction was rather complex
- The first iteration of the construction made use of a 1.5mm steel 'ground plate', which had a relatively high natural frequency (in comparison with e.g. wood).
- The canned aluminum parts at the corners might not have been stiff enough, therefore resulting in a certain degree of resonance.

Regufoam®

As a cheaper alternative for Sylomer® foam, Regufoam can be used for damping.

Main findings:

- Commonly foam materials (e.g. Regufoam, urethane and silicone) are designed to absorb high impact energy by controlling the rapid deceleration. However, these materials are less suitable for vibration control.

Purchase rubber isolators

Rubber is often used as vibration isolator. Several purchase rubber damping elements were used, such as dome mounts and ring mounts. The natural frequency of many rubber isolators start at around 6 Hz (see table X). However, many rubber isolators have a higher natural frequency starting around 9 Hz.

Main findings:

- A system will not benefit from using a rubber isolator whose natural frequency is higher than the disturbing frequency. Due to the disturbing frequency of 8.5 Hz, the construction might have been started to resonate.
- Both the dome mounts as well as the ring mount were too stiff, leaving little deflection allowance.
- Rubber is a non-linear material. This makes predicting

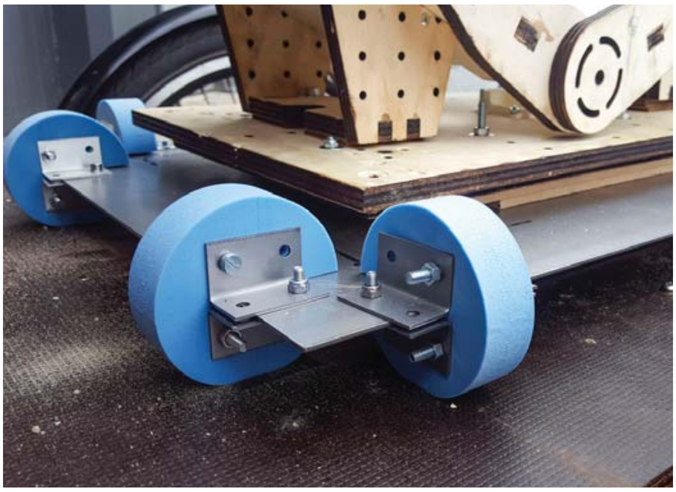


Figure 42: Sylomer® foam cylinders attached to a metal platform. After static loading, the Sylomer® foam was already compressed in such a way that only small deflections were possible.

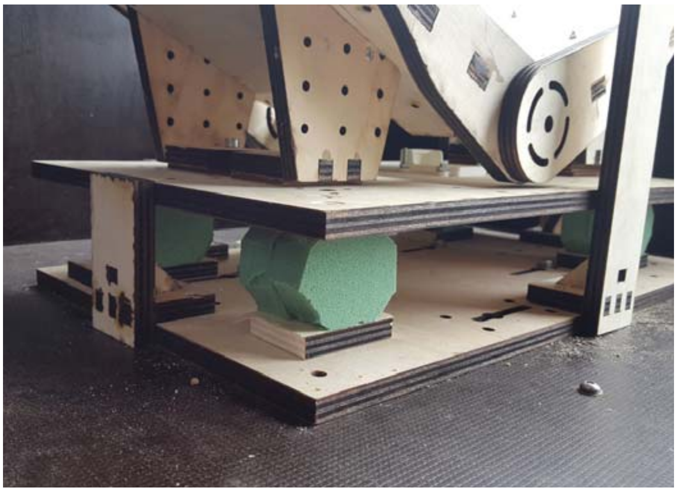


Figure 43: Out of a Regufoam ® foam plate, multiple hexagons were cut that served as damping material. The vertical wood construction on the sides served as guidance.

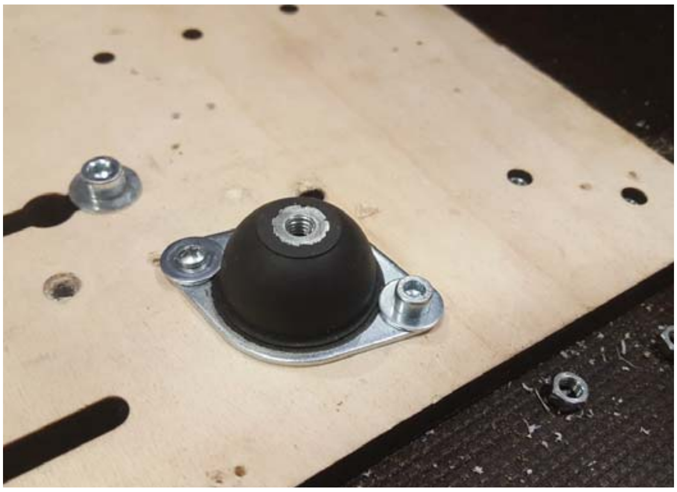


Figure 44: Several purchase rubber damping elements were used, such as dome mounts and ring mounts.

the dynamic behavior of a rubber isolator rather complicated.

- In some cases, the natural frequency as calculated based on static load vs. deflection data can give inaccurately lower natural frequencies than will be realistically experienced during dynamic vibration. Any isolator with a calculated natural frequency based on static deflections may not behave in the predicted way because the dynamic spring rate differs from the static spring rate. This might have been one of the issues in the tests with the purchase rubber isolators.

Casted rubber isolators (damping balls)

Rubber damping balls are often attached between a camera and drone to stabilize camera images. After having seen the effects of these rubber damping balls, small, medium and large rubber damping balls were poured with self-made molds. A silicone rubber shore 40 was used. In order to have a hollow part PVA cores where used. After the silicone rubber had been cured the parts we placed into a water basin, dissolving the PVA material and resulting in a neat hollow uniform damping ball. For maximum elastically supported stability, rubber isolators should be positioned at an angle to the vertical loads, resulting in a combination of shear and compression. Ideally the shear and compression deflection should be almost the same. To achieve this the angle should be 30 (Farrat, 2015). Stainless steel brackets were lasercutted and bent at an angle of 45˚ degrees to create more stability.

Main findings:

- Rubber damping balls are not stable in the radial direction and, therefore, need some sort of guidance (Figure 46). The lack of guidance might have had detrimental effect on the r.m.s. values
- Although the rubber damping balls were positioned at an angle of 45 degree, the vertical load was distributed over the curve of the rubber damping balls (Figure 47). As a result, this positioning had barely any effect on the stability of the system.
- Although the system will continue to oscillate after

Figure 45: small, medium and large rubber damping balls were poured with self-made molds.

Figure 46: Four rubber damping balls were placed at the corners of the platform construction. Inspiration was found from drones that use rubber damping balls to stabilize camera images

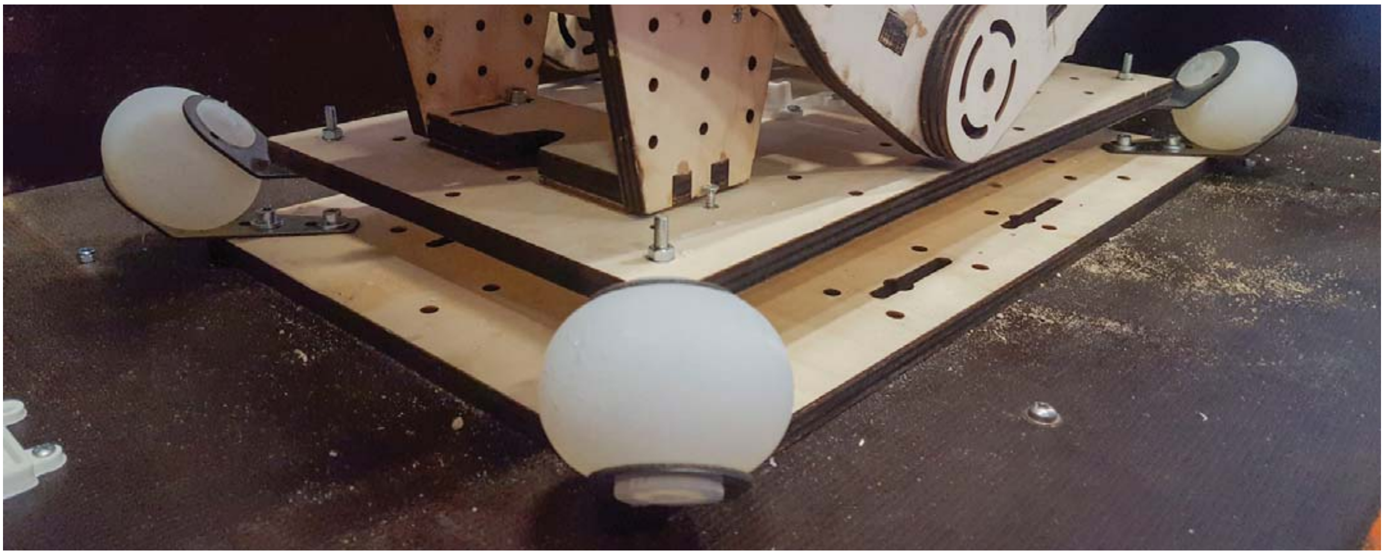


Figure 47: For maximum elastically supported stability, rubber isolators should be positioned at an angle to the vertical loads, resulting in a combination of shear and compression.

Figure 48: Possibilities were being evaluated to make rubber damping balls airtight. This would create some sort of air suspension.

a shock event due to low damping, rubber damping balls could be used to reduce the shock acceleration.

- The natural frequency of a system can be lowered by increasing the load. However, by overloading the system the rubber damping balls may simply crush.
- Usually very low frequency isolators are only used for steady state vibration problems like mounting large factory equipment with very high static loads and no shock loading (Greene Rubber, personal communication, April 30, 2018). The light static load and shock environment make designing a mount for such an application very difficult or even unfeasible.

*The information concerning the positioning angle of rubber isolators and its effect on stability was found online after already having bent the

Figure 49: This type of isolator used a coil spring together with a solidified silicone gel for damping.

stainless steel brackets.

EKI Foam rubber

Main findings:

- The foam was too stiff. Compression was barely possible

Gel Mount

This type of isolator uses a coil spring together with a solidified silicone gel for damping.

Main findings:

- Due to the high natural frequency, the average r.m.s. were too high.

Coil springs in combination with foam

Main findings:

- The four aluminum rods were not perfectly aligned, creating undesired tilting of the platform and friction between the rods and the 'bearings'.

24.1.1.2 Viscous

Rubber damping ball

Possibilities were being evaluated to make the rubber damping balls – that were used in previous tests solely due to their elastic characteristics - airtight and, therefore, adding a viscous behavior (Figure 48). This would create some sort of air suspension. Despite the efforts to make the rubber damping balls airtight, it did not succeed. Together with Iginio Voorhorst, CEO at VB-Airsuspension in Varsseveld (the Netherlands), and Pieter Schalk Els, professor at the Department of Mechanical & Aeronautical Engineering at the University of Pretoria (South-Africa), this test element and air suspension in general was discussed. They provided the following and valuable feedback (Iginio Voorhorst, April 05, 2018, personal communication and Pieter Schalk Els, Mai 15, 2018, personal communication):

- Air suspension only works if air is being compressed (increase in pressure). Or in other words, when the volume decreases. The test element, if properly airtight, would result in hardly to none volume change and, therefore, no stiffness.
- Making a system airtight is always the biggest problem and requires very specific glue or vulcanizing components.
- Air spring characteristics are highly non-linear. Complex calculations are needed to predict these characteristics.
- Air behaves as a spring and has hardly to none damping characteristics. To make an air damper, different chambers are needed in which the air can flow from and to.
- Polyurethane or Silicone could work for a prototype, but may have limited life due to lack of reinforcement.
- In air suspension, the stiffness contribution of the rubber is very small but the change in effective area and volume is the dominating factor. In the test element, however, the Polyurethane or Silicone may already be strong enough on its own. The stiffness contribution of the rubber is, therefore, much larger.
- The challenge with casting is to get all the air bubbles out. Even small bubbles will weaken it a lot and create stress concentrations. Vacuum and/or a vibrating platform are needed to get all the air bubbles out of the element.

Wheelbarrow inner tube

A different type of air suspension was being tested based on the feedback provided (Figure 51). Within this construction, the platform was mounted on top of an inflated wheelbarrow inner tube.

Main findings:

- The available vertical travel depends on the load that is placed on the platform and its initial pressure and volume. If the inner tube is under-inflated (low pressure, low stiffness), it will be largely compressed when loaded, resulting to a point in which no vertical travel is possible anymore. If the inner tube is over-inflated (high pressure, high stiffness), the inner tube will not be compressed a lot when loaded. Thus, although a large vertical travel remains, little to none vertical travel is actually possible. It was very difficult to find the optimum pressure.
- Normally, an inner tube is enclosed by a stronger and rigid tire that limits the volume change and elongation of the inner tube. In this case, the inner tube could elongate freely: inflating the inner tube to 1 bar resulted in a diameter of barely 4 cm, while inflating the inner tube to 3 bar resulted in a diameter of 8.5 cm.
- The stiffness contribution of the inner tube when under-inflated is very low, making the whole construction wobbly and unstable.
- Due to the closed air system of the inner tube, the system does not have any damping characteristics.

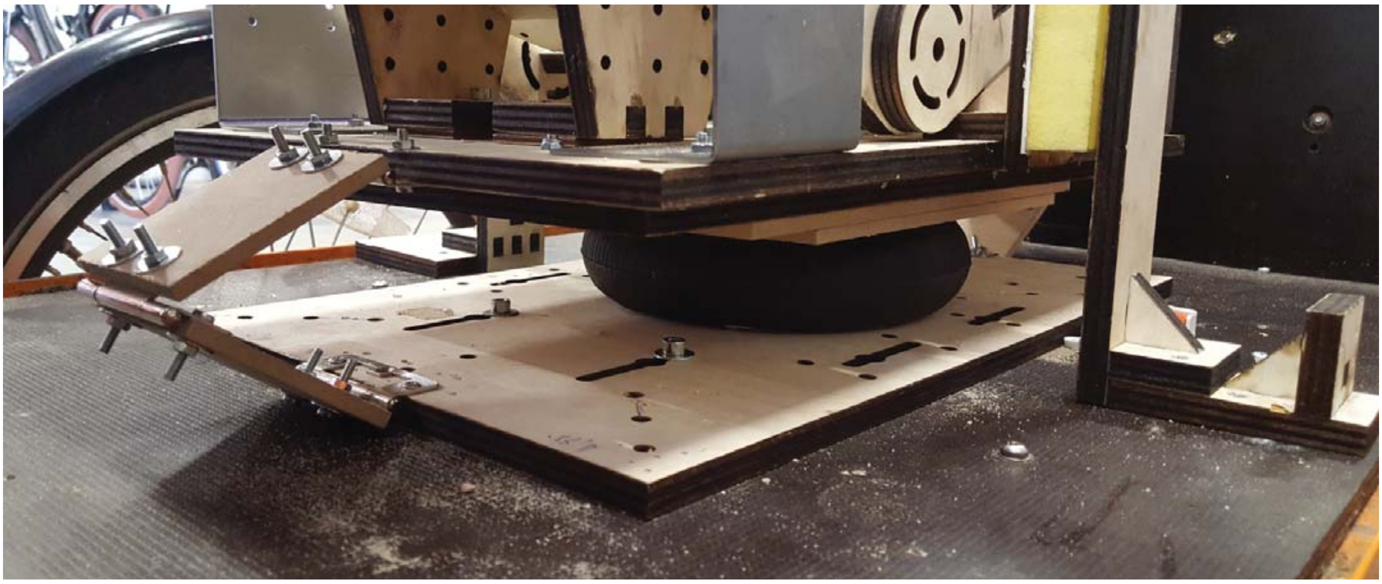
Figure 50: An inflatable mat was cut and glued together to fit in the cargo bike. The inflatable mat was too unstable and wobbly.

Inflatable mat

Main findings:

- Too unstable and wobbly

Figure 51: Within this construction, the platform was mounted on top of an inflated wheelbarrow inner tube.



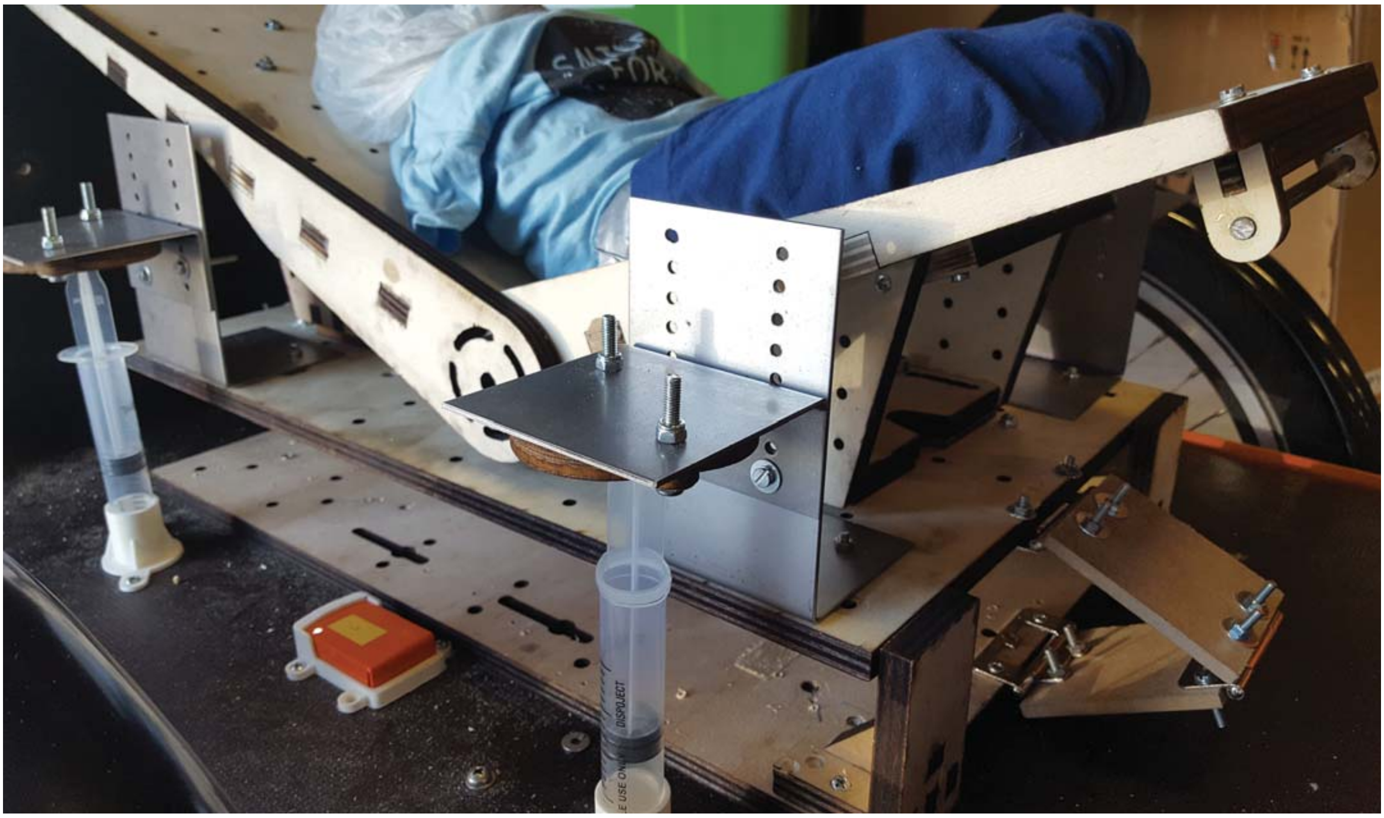


Figure 52: Placing the syringes next to the platform resulted in a lower center of gravity, thus creating more stability.

Syringe

Main findings:

- Placing the syringes next to the platform resulting in a lower center of gravity, therefore creating more stability.
- Since the syringes are rigid elements, this damping principle makes use of air pressure change and no volume change.
- The circumference of the piston of the syringe might have influence on the acceleration values. The movement of the piston can be considered to be friction damping.

24.2 Parallelogram

This construction made clever use of inertia due to the accelerations and de-accelerations during cycling.
Ik heb het parallellogram opnieuw gemaakt: nieuwe pianoscharnieren gebruikt, de vier losse delen 'perfect' uitgelijnd zodat er zo min mogelijk frictie ontstaat, nieuwe scharnieren gemaakt/geboord.

24.2.1 Hysteresis

Sylomer® foam

The cylindrical parts that were provided by AMC were also tested in this construction. The different densities, as well as the quantity of the foam cylinders, were tested.

Main findings:

- Placing one blue Sylomer® foam part, which had the lowest density, was insufficient to withstand the weight that was placed on the parallelogram: the cylinder collapsed.
- The Sylomer foam worked significantly better in this construction

Casted rubber isolators (damping balls)

The casted rubber damping balls were also tested in this construction. The different sizes, as well as the quanties, were tested.
Main findings:

- Placing one small rubber damping ball was insufficient to withstand the weight that was placed on the parallelogram: the rubber damping ball collapsed.
- The rubber damping balls worked significantly better in this construction

24.2.2 Viscous

(Push) gas spring in combination with tension spring
A gas spring is a hydro-pneumatic adjustment element, filled with nitrogen that is compressed into a cylinder with a preset force. Together with a tension spring the system could be considered to be a spring-damper system. The pushing force of the gas spring delays the speed at which the tension spring pulls back the system and can be considered to be a damping element. The tension spring was attached to two turnbuckles that made it possible to adjust the pre-tension of the tension spring.

Main findings:

- A gas spring pushes (or pulls) with a constant

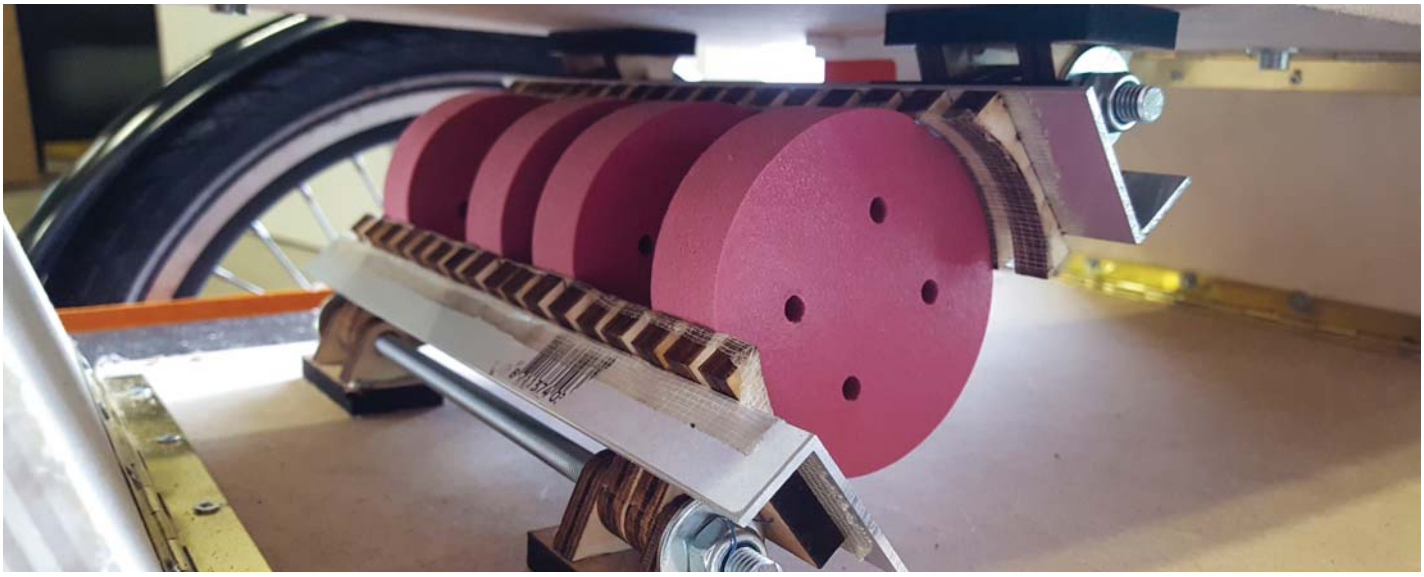


Figure 53: The cylindrical foam parts that were provided by AMC were also tested in the parallelogram construction. The different densities, as well as the quantity of the cylindrical foam parts, were tested.

Figure 54: Placing one rubber damping ball was insufficient to withstand the weight that was placed on the parallelogram: the rubber damping ball collapsed. Placing two rubber damping balls worked better.

Figure 55: A gas spring pushes with a constant and preset force. Whether the system worked, depended on the resulting force between the gas spring, the tension spring and the weight that was laid on the parallelogram.

and preset force. A damper does not have this characteristic, since it solely slows down the movement (due to energy absorption). Consequently, whether the system will work depends on the resulting force between the gas spring, the tension spring and the weight that is placed on the parallelogram. If the resulting force is negative, the tension spring is unable to pull back the system into its neutral position: the system will remain in its lowest position. If the resulting force is positive, the tension spring will be able to pull back the system: the system will oscillate around its neutral position. If, however, the resulting force is very positive (e.g. a low weight or high pre-tension of the tension spring), the vertical travel of the system will be limited, since the resulting force tries to keep the system in its neutral position.
In short, it is almost impossible to adjust the system for various weights.

- The results showed relatively higher horizontal acceleration values (x-direction), which means the system moves back and forward too much.

Radio Controllable (RC) shock absorber

RC competition cars make use of small shock absorber that are highly suitable for this configuration due to their size. Therefore, a 1:8 shock absorber was placed in the system.

Main findings:

- The results showed a very low acceleration value.

24.2.3 Double diagonal

This construction was based on seat pedestals that are commonly used in speedboats. Just like the parallelogram, the double diagonal makes use of inertia

Figure 56: (Left) Parallelogram construction. Here, mounted with a shock absorber. The side panels of the cargo bike were removed to enable efficient and fast adjustment and removal of the shock absorber.

Figure 57: (Right) Double diagonal construction. Here, mounted with a shock absorber.

(back and forward movement due to acceleration and de-acceleration).

Main findings:

- The results showed a very low acceleration value.
- Different holes were drilled into the piston. The bigger the holes in the piston, the easier oil would flow from one side of the piston to the other side. The hole sizes have influences on the damping characteristics of the shock absorber.
- The double diagonal showed little to none increased acceleration value in the horizontal direction (x-direction).

Figure 58: In order to let the shock absorber react precisely to bumps in the road, both holes of the piston were drilled larger in steps of 0.5 mm after each test.


ELCON MODELS
18330 - Silicon Oil

Appendix 26

Vibrational research

Results - Platform construction

Company Merford
Type of vibrati Anti-vibration pad

Brand type Regufoam type 150 - green

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.737	0.560	1.599	0.499	0.715	1.584	0.618	0.638	1.592
292	1.258	0.787	2.544	0.656	0.851	2.470	0.957	0.819	2.507
293	1.854	1.782	3.615	1.481	1.305	3.464	1.668	1.544	3.539

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.658	0.518	1.802	0.481	0.806	1.856	0.570	0.662	1.829
292	0.770	0.598	2.102	0.616	0.725	2.126	0.693	0.661	2.114
293	0.789	0.845	2.909	0.892	0.930	2.885	0.841	0.887	2.897

Company Atis International
Type of vibrati Anti-vibration pad

Brand type Solymer SR11- yellow

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.616	0.660	1.847	0.521	0.647	1.960	0.569	0.653	1.903
292	0.783	1.336	2.651	0.786	1.034	2.828	0.784	1.185	2.739
293	1.862	1.636	4.167	1.778	1.269	4.253	1.820	1.452	4.210

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.765	0.910	1.628	0.557	0.600	1.443	0.661	0.755	1.535
292	0.716	0.945	2.435	1.069	1.650	2.065	0.893	1.298	2.250
293	1.121	1.810	3.736	2.983	2.317	3.440	2.052	2.064	3.588

Company AMC Mecanocaucho
Type of vibrati Anti-vibration pad

Brand type Solymer SR28 - blue

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.719	0.705	1.883	0.543	0.678	2.000	0.631	0.692	1.942
292	1.311	0.858	2.480	0.709	0.965	2.691	1.010	0.912	2.585
293	2.299	1.114	3.137	1.226	1.291	3.476	1.762	1.203	3.306

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.404	0.535	1.929	0.460	0.545	1.896	0.432	0.540	1.913
292	0.567	0.714	2.723	0.668	0.809	2.735	0.617	0.762	2.729
293	0.914	0.867	3.443	1.507	1.060	3.428	1.210	0.963	3.436

Brand type Solymer SR55 - green (8)

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	1.277	0.525	2.447	0.583	0.692	2.456	0.930	0.608	2.452
292	0.716	1.178	3.034	0.731	0.709	3.001	0.723	0.943	3.018
293	2.544	1.212	3.747	1.254	1.297	3.724	1.899	1.255	3.736

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.460	0.545	1.896	0.854	0.656	1.753	0.657	0.601	1.824
292	0.668	0.809	2.735	0.575	0.807	2.441	0.621	0.808	2.588
293	1.507	1.060	3.428	1.296	0.987	3.098	1.401	1.023	3.263

Brand type Solymer SR55 - green (4)

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	1.177	0.649	2.116	0.476	0.635	2.096	0.827	0.642	2.106
292	0.763	1.226	2.801	0.616	0.687	2.783	0.689	0.957	2.792
293	2.758	1.053	3.144	0.917	0.946	3.053	1.838	0.999	3.098

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.576	0.631	1.768	0.490	0.552	1.901	0.533	0.592	1.835
292	0.812	0.701	2.398	0.609	0.688	2.590	0.710	0.695	2.494
293	1.656	0.853	2.584	0.890	1.029	2.805	1.273	0.941	2.694

Brand type Solymer SR220 - red (8)

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.570	0.628	2.228	0.546	0.664	1.971	0.558	0.646	2.100
292	0.705	0.821	2.835	1.020	0.781	2.590	0.862	0.801	2.712
293	1.247	1.083	3.539	1.190	1.122	3.300	1.218	1.102	3.420

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.600	0.540	1.923	0.469	0.660	2.038	0.535	0.600	1.980
292	0.734	0.868	2.617	0.646	0.738	2.798	0.690	0.803	2.707
293	0.979	0.907	3.362	1.102	1.082	3.597	1.041	0.994	3.480

Brand type Solymer SR220 - red (4)

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.534	1.162	1.955	0.503	0.626	2.172	0.518	0.894	2.063
292	0.797	1.105	3.036	0.861	0.962	3.501	0.829	1.034	3.268
293	1.066	1.468	3.583	1.370	0.869	4.214	1.218	1.169	3.899

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.488	0.771	1.488	0.658	0.500	2.171	0.573	0.635	1.829
292	0.653	1.161	2.177	0.703	0.872	3.424	0.678	1.016	2.800
293	0.640	1.062	2.607	1.121	0.857	4.125	0.881	0.960	3.366

Company EKI B.V.
Type of vibrati Anti-vibration pad

Brand type EKI 493

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.826	1.192	1.883	0.607	1.108	2.049	0.716	1.150	1.966
292	1.464	0.882	3.523	1.258	0.838	3.582	1.361	0.860	3.552
293	1.303	1.996	4.861	1.452	2.138	4.853	1.377	2.067	4.857

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.824	0.965	1.828	0.634	0.977	1.783	0.729	0.971	1.806
292	0.980	1.113	2.890	1.002	0.954	2.990	0.991	1.034	2.940
293	1.700	1.738	4.219	1.026	1.774	4.379	1.363	1.756	4.299

Company Dierenwinkel
Type of vibrati Air damping

Brand type Syringe - 20ml ** ** placed under seat

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.589	0.655	2.393	0.532	0.799	2.144	0.561	0.727	2.268
292	1.713	1.798	2.322	1.314	1.441	2.280	1.513	1.619	2.301
293	2.979	1.755	2.787	2.207	1.404	2.708	2.593	1.580	2.748

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.960	0.783	1.808	0.616	0.841	1.512	0.788	0.812	1.660
292	0.881	0.896	1.716	0.856	1.033	1.612	0.869	0.964	1.664
293	1.626	0.960	1.987	0.855	0.995	1.894	1.241	0.978	1.941

Brand type Syringe - 10ml

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.683	0.834	2.182	0.481	0.828	1.716	0.582	0.831	1.949
292	1.159	0.933	2.129	1.067	1.135	1.960	1.113	1.034	2.045
293	1.301	0.987	2.734	1.321	1.204	2.505	1.311	1.096	2.620

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.601	0.559	1.877	2.558	2.394	1.635	1.579	1.476	1.756
292	1.067	1.446	1.732	1.237	0.911	1.670	1.152	1.178	1.701
293	1.429	1.401	2.174	1.405	1.449	2.151	1.417	1.425	2.162

Brand type Syringe - 20ml*

* placed next to seat (lower center of gravity)

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.825	0.841	1.843	0.652	0.612	1.747	0.739	0.726	1.795
292	1.805	1.999	1.941	1.051	1.088	1.942	1.428	1.543	1.941
293	3.617	2.088	2.819	1.308	1.382	2.621	2.463	1.735	2.720

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.795	0.608	1.861	0.771	0.602	1.606	0.783	0.605	1.734
292	1.154	0.931	1.763	1.030	0.882	1.656	1.092	0.906	1.710
293	1.360	1.080	2.378	1.199	1.322	2.305	1.280	1.201	2.341

Brand type Syringe - 50ml

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.676	1.007	1.932	0.530	0.764	2.103	0.603	0.886	2.017
292	1.321	1.582	2.633	1.403	1.198	3.034	1.362	1.390	2.833
293	7.307	2.423	6.384	1.873	1.300	4.072	4.590	1.861	5.228

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.834	0.674	1.744	0.728	0.685	1.976	0.781	0.679	1.860
292	1.149	1.497	2.439	0.976	1.242	2.665	1.063	1.369	2.552
293	2.579	1.199	3.201	1.797	1.658	3.410	2.188	1.429	3.306

Company None
Type of vibrati Hysteresis

Brand type Rubber damping ball - small

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.705	0.574	2.325	0.794	0.580	2.176	0.749	0.577	2.250
292	1.045	0.914	3.728	0.964	0.707	2.924	1.004	0.810	3.326
293	2.307	3.420	4.519	1.447	1.606	3.447	1.877	2.513	3.983

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.963	0.799	2.020	0.613	0.549	1.800	0.788	0.674	1.910
292	0.894	0.834	2.788	0.944	0.683	2.432	0.919	0.758	2.610
293	1.261	2.074	3.297	1.298	1.159	3.355	1.279	1.617	3.326

Brand type Rubber damping ball - large

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.733	0.648	1.596	0.735	0.764	2.182	0.734	0.706	1.889
292	0.933	0.741	2.584	1.090	1.054	3.304	1.011	0.898	2.944
293	1.538	1.329	3.278	1.656	2.112	3.970	1.597	1.721	3.624

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.588	0.524	1.845	0.741	0.702	1.701	0.665	0.613	1.773
292	0.750	0.719	2.481	0.909	0.773	2.170	0.829	0.746	2.325
293	1.017	1.282	2.737	1.380	1.161	2.672	1.198	1.222	2.705

Company Berkel Industrial
Type of vibrati Hysteresis

Brand type SH40 - dome mount

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	1.196	0.764	2.571	0.741	0.670	2.260	0.968	0.717	2.415
292	1.599	1.657	4.067	1.718	1.291	3.656	1.658	1.474	3.862
293	3.275	2.186	6.347	3.112	1.855	5.749	3.194	2.020	6.048

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.685	0.619	1.889	0.584	0.775	1.742	0.635	0.697	1.815
292	1.340	1.595	3.146	1.457	0.961	3.021	1.398	1.278	3.083
293	2.014	2.473	4.690	2.239	2.083	4.705	2.127	2.278	4.698

Brand type SH60 - dome mount

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	1.553	0.770	3.075	0.579	0.786	2.390	1.066	0.778	2.732
292	1.718	1.276	3.750	0.842	0.775	2.967	1.280	1.026	3.359
293	1.892	2.351	5.666	1.627	1.203	4.200	1.760	1.777	4.933

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.456	0.498	1.285	0.543	0.588	2.381	0.499	0.543	1.833
292	1.064	0.846	2.499	0.780	0.809	2.992	0.922	0.827	2.745
293	1.322	1.573	3.678	1.621	1.289	4.420	1.472	1.431	4.049

Company GMT Benelux B.V.

Type of vibrati Hysteresis

Brand type Soft gel isolator BG7

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.581	0.704	2.372	0.611	0.631	2.159	0.596	0.667	2.265
292	0.942	1.312	3.909	1.051	1.167	3.771	0.997	1.239	3.840
293	1.814	2.539	4.768	2.170	1.896	4.607	1.992	2.217	4.687

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.493	0.824	2.264	0.587	0.662	2.186	0.540	0.743	2.225
292	1.044	1.894	3.439	1.278	1.142	3.812	1.161	1.518	3.625
293	3.133	2.287	4.181	2.187	1.767	4.804	2.660	2.027	4.493

Brand type Ring mount 551800360

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.458	0.855	2.722	0.538	0.634	3.092	0.498	0.744	2.907
292	1.023	1.315	2.943	1.118	1.056	3.350	1.071	1.186	3.147
293	2.777	2.107	4.153	2.234	1.748	4.993	2.506	1.928	4.573

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.477	0.522	2.580	0.728	0.472	3.041	0.602	0.497	2.810
292	0.780	1.251	2.901	1.213	1.012	3.402	0.997	1.132	3.151
293	1.810	2.018	4.214	2.203	1.269	4.920	2.006	1.643	4.567

Company None
Type of vibrati Air + foam

Brand type Sleeping mat

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.573	1.195	2.057	0.592	0.977	1.566	0.582	1.086	1.811
292	0.850	1.085	3.591	0.702	0.658	2.680	0.776	0.871	3.136
293	1.460	2.223	3.919	1.208	1.085	3.050	1.334	1.654	3.484

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.629	1.591	1.695	0.526	0.866	1.496	0.578	1.228	1.596
292	0.863	0.968	2.762	0.749	0.798	2.601	0.806	0.883	2.682
293	0.855	1.206	3.067	1.128	0.876	2.847	0.992	1.041	2.957

Company None
Type of vibrati Air

Brand type Binnenband Klein Haaks Ventiel 3.00-4 (260x85) Budget

Maxi-cosi loaded with 5 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287									
292									
293									

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.493	0.575	1.949	0.488	0.527	2.031	0.490	0.551	1.990
292	0.674	0.712	2.521	0.880	0.632	2.558	0.777	0.672	2.539
293	0.812	1.104	2.377	0.978	0.915	2.323	0.895	1.009	2.350

Appendix 27

Vibrational research

Results - Parallelogram construction

Company AMC Mecanocaucho
Type of vibrati Anti-vibration pad

Brand type Sylomer SR28 - blue (2)

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.697	0.551	2.206	0.734	0.493	1.723	0.716	0.522	1.964
292	0.484	1.652	2.499	0.594	1.266	2.038	0.539	1.459	2.268
293	1.607	1.284	2.441	1.309	1.371	1.993	1.458	1.328	2.217

Brand type Sylomer SR28 - blue (3)

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.989	0.488	2.117	0.874	0.657	1.991	0.931	0.573	2.054
292	0.575	1.842	2.558	0.885	1.522	2.416	0.730	1.682	2.487
293	2.298	1.150	2.444	1.728	1.401	2.252	2.013	1.275	2.348

Brand type Sylomer SR28 - blue (4)

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.721	1.064	1.913	0.664	1.023	1.911	0.693	1.043	1.912
292	0.651	1.926	2.313	0.861	1.797	2.535	0.756	1.861	2.424
293	2.300	1.931	2.339	1.851	1.525	2.431	2.075	1.728	2.385

Brand type Sylomer SR55 - green (1)

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.732	0.714	1.746	0.682	0.547	1.928	0.707	0.631	1.837
292	1.095	1.874	2.102	0.598	1.309	2.187	0.847	1.592	2.145
293	2.786	1.789	2.060	1.340	1.164	2.133	2.063	1.477	2.097

Brand type Sylomer SR55 - green (2)

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.684	0.871	2.071	0.815	0.465	1.877	0.750	0.668	1.974
292	0.941	2.137	2.647	0.477	2.195	2.330	0.709	2.166	2.489
293	2.446	1.328	2.593	2.580	1.391	2.217	2.513	1.360	2.405

Brand type Sylomer SR55 - green (3)

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287									
292									
293									

Brand type Sylomer SR55 - green (4)

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287									
292									
293									

Brand type Sylomer SR220 - red (1)

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.706	0.663	1.948	0.669	0.738	2.338	0.687	0.700	2.143
292	1.062	1.343	2.165	0.962	1.381	2.571	1.012	1.362	2.368
293	1.800	1.355	2.245	1.339	1.471	2.620	1.570	1.413	2.433

Brand type Sylomer SR220 - red (2)

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.689	0.705	2.009	1.158	0.777	1.950	0.923	0.741	1.980
292	0.868	1.357	2.521	0.553	2.216	2.369	0.710	1.787	2.445
293	1.576	1.125	2.348	1.447	2.032	2.283	1.512	1.578	2.316

Company none
Type of vibrati Rubber damping balls

Brand type n.a. - (2)

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.654	0.700	2.088	0.782	0.652	1.837	0.718	0.676	1.962
292	1.172	1.827	1.904	0.956	1.913	1.970	1.064	1.870	1.937
293	1.290	2.165	1.871	1.937	1.488	2.075	1.613	1.827	1.973

Brand type n.a. - (3)

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.707	0.615	2.098	0.668	0.718	2.064	0.687	0.667	2.081
292	0.656	1.951	1.886	1.169	1.525	1.824	0.913	1.738	1.855
293	1.711	1.384	1.932	1.196	1.886	1.918	1.454	1.635	1.925

Company T-technics + Alcomec
Type of vibrati Gas spring (damping) + tension spring (spring)

Brand type gas extension spring 563504 (100N)
Tension spring (T2030)

Maxi-cosi loaded with 8 kg infant

	Measurement 1			Measurement 2			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.654	0.700	2.088	0.782	0.652	1.837	0.718	0.676	1.962
292	1.172	1.827	1.904	0.956	1.913	1.970	1.064	1.870	1.937
293	1.290	2.165	1.871	1.937	1.488	2.075	1.613	1.827	1.973

Appendix 28

Vibrational research

Results - Revised parallelogram construction

Orifice hole quantity: 4
Orifice hole diameter: 3.5 mm (2x) + 1.5 mm (2)

Company	Elcron models
Type of vibratio	hydraulics
Brand type	Schokbrekers achterzijde

Maxi-cosi loaded with 8 kg infant

Distance 2 - Locknut height 47mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.642	0.481	1.707	0.635	0.797	2.045	0.641	0.632	1.836	0.640	0.637	1.863
292	0.695	0.965	1.002	1.526	0.789	1.156	0.679	1.601	1.020	0.967	1.118	1.059
293	0.974	0.834	1.255	1.264	0.979	1.444	1.737	1.011	1.311	1.325	0.941	1.337

Distance 2 - Locknut height 38.5mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.665	0.573	1.935	0.635	0.624	2.342	0.818	0.569	1.940	0.706	0.589	2.072
292	0.633	1.156	0.898	1.276	0.726	1.050	0.718	0.946	0.945	0.875	0.943	0.964
293	1.431	1.164	1.280	1.417	0.956	1.377	1.064	1.001	1.331	1.304	1.040	1.329

Orifice hole quantity: 2
Orifice hole diameter: 3.5 mm (2x)

Company Elcron models
Type of vibratio hydraulics

Brand type Schokbrekers achterzijde

Maxi-cosi loaded with 8 kg infant

Distance 2 - Locknut height 47mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.628	0.891	1.655	0.516	0.989	1.814		0.637	0.558	0.381	0.839	1.342
292	0.768	0.728	0.956	1.102	0.567	1.019		1.225	0.570	0.623	0.840	0.848
293	0.748	0.916	1.246	0.948	0.912	1.309		1.098	1.043	0.565	0.975	1.199

Distance 2 - Locknut height 38.5mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.842	1.220	2.311	0.668	0.493	2.123		0.542	1.026	0.503	0.752	1.820
292	1.316	0.810	1.023	0.990	0.841	0.963		1.105	0.732	0.769	0.918	0.906
293	1.195	0.919	1.409	0.898	1.071	1.402		1.026	0.895	0.698	1.005	1.236

Orifice hole quantity: 2
Orifice hole diameter: 3 mm (2x)

Company Elcron models
Type of vibratio hydraulics

Brand type Schokbrekers achterzijde

Maxi-cosi loaded with 8 kg infant

Distance 1 - Locknut height 47mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.538	0.482	1.534	0.976	0.597	1.849	0.601	0.523	1.813	0.705	0.534	1.732
292	0.626	1.117	1.200	0.950	0.725	1.407	0.595	0.932	1.410	0.724	0.925	1.339
293	1.072	0.856	1.398	0.873	0.990	1.645	1.050	0.846	1.679	0.998	0.897	1.574

Distance 1 - Locknut height 38.5mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.544	0.583	1.354	0.607	0.699	1.902	0.682	0.474	1.579	0.611	0.585	1.612
292	0.570	0.811	0.994	1.435	0.874	1.256	0.663	1.034	1.107	0.889	0.906	1.119
293	0.958	0.887	1.219	1.482	1.195	1.535	1.108	0.919	1.383	1.182	1.000	1.379

Distance 1 - Locknut height 30mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.833	0.525	1.495	0.814	0.591	1.878	0.884	0.602	1.693	0.844	0.573	1.689
292	0.666	1.077	0.938	1.182	0.585	1.106	0.770	1.086	1.056	0.872	0.916	1.033
293	1.062	1.042	1.154	1.006	1.519	1.403	0.892	1.073	1.366	0.987	1.211	1.308

Distance 2 - Locknut height 47mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.538	0.482	1.534	0.976	0.597	1.849	0.601	0.523	1.813	0.705	0.534	1.732
292	0.626	1.117	1.200	0.950	0.725	1.407	0.595	0.932	1.410	0.724	0.925	1.339
293	1.072	0.856	1.398	0.873	0.990	1.645	1.050	0.846	1.679	0.998	0.897	1.574

Distance 2 - Locknut height 38.5mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.808	0.620	2.043	0.667	0.615	1.956	0.574	0.635	1.529	0.683	0.624	1.843
292	0.597	1.037	0.961	0.999	0.604	0.870	0.706	0.998	0.788	0.767	0.880	0.873
293	1.028	0.986	1.367	0.948	0.895	1.232	1.043	0.848	1.128	1.006	0.910	1.242

Orifice hole quantity: 2
Orifice hole diameter: 2.5 mm (2x)

Company Elcron models
Type of vibratio hydraulics

Brand type Schokbrekers achterzijde

Maxi-cosi loaded with 8 kg infant

Distance 1 - Locknut height 47mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.720	0.508	1.667	0.937	0.892	2.080	0.970	0.576	1.619	0.876	0.659	1.789
292	0.689	0.847	1.315	1.477	1.022	1.634	0.666	1.284	1.247	0.944	1.051	1.399
293	0.864	0.831	1.581	1.250	1.704	1.985	0.968	0.924	1.530	1.027	1.153	1.699

Distance 1 - Locknut height 38.5mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.680	0.502	1.898	0.727	0.612	2.185	0.827	0.523	1.783	0.745	0.546	1.955
292	0.592	1.497	1.281	1.076	0.795	1.579	0.792	0.905	1.276	0.820	1.066	1.379
293	1.369	0.965	1.637	1.114	1.022	1.888	1.297	0.928	1.591	1.260	0.972	1.705

Distance 1 - Locknut height 30mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	1.257	0.611	1.570	0.766	0.639	1.848	0.662	0.517	1.756	0.895	0.589	1.724
292	0.840	0.847	1.060	0.973	0.719	1.153	1.047	1.002	1.180	0.953	0.856	1.131
293	1.003	0.881	1.282	0.994	1.093	1.496	1.525	1.009	1.458	1.174	0.994	1.412

Distance 2 - Locknut height 47mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.655	0.595	1.730	0.814	0.598	1.839	1.049	0.519	1.658	0.839	0.570	1.742
292	0.942	0.752	1.057	1.021	0.906	1.088	0.809	0.840	1.007	0.924	0.833	1.051
293	0.809	0.954	1.442	1.205	0.882	1.433	1.509	0.835	1.328	1.174	0.890	1.401

Distance 2 - Locknut height 38.5mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.711	0.647	1.841	0.555	0.747	1.673	1.464	0.654	1.718	0.910	0.683	1.744
292	0.766	0.836	0.948	0.877	0.873	0.896	1.399	0.905	0.899	1.014	0.871	0.915
293	0.988	0.959	1.274	0.915	0.892	1.255	0.863	0.954	1.309	0.922	0.935	1.279

Orifice hole quantity: 2
Orifice hole diameter: 2 mm (2x)

Company Elcron models
Type of vibratio hydraulics

Brand type Schokbrekers achterzijde

Maxi-cosi loaded with 8 kg infant

Distance 1 - Locknut height 47mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.665	0.519	1.914	0.659	0.574	1.906	0.635	0.562	1.793	0.653	0.551	1.871
292	0.961	0.856	1.513	1.023	0.634	1.547	0.757	0.883	1.490	0.913	0.791	1.517
293	1.603	0.988	1.824	1.149	1.017	1.883	0.969	0.852	1.794	1.241	0.953	1.834

Distance 1 - Locknut height 38.5mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.891	0.487	1.791	0.741	0.638	1.842	0.603	0.892	1.760	0.745	0.672	1.798
292	1.578	1.059	1.316	1.271	0.654	1.354	1.036	0.632	1.326	1.295	0.782	1.332
293	1.590	0.988	1.749	1.067	1.097	1.728	0.907	1.052	1.681	1.188	1.045	1.719

Distance 1 - Locknut height 30mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	1.409	0.746	1.626	0.615	0.742	1.710	0.992	0.744	1.742	1.005	0.744	1.693
292	1.179	1.107	1.074	0.921	0.621	1.183	1.629	1.176	1.128	1.243	0.968	1.128
293	2.129	0.934	1.488	0.915	1.025	1.564	1.691	1.011	1.482	1.578	0.990	1.511

Distance 2 - Locknut height 47mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.760	0.525	1.728	0.683	0.649	2.042	0.566	0.630	1.630	0.670	0.601	1.800
292	0.782	0.939	1.096	1.084	0.715	1.277	0.610	0.839	1.047	0.825	0.831	1.140
293	1.256	0.921	1.472	1.089	1.001	1.640	1.246	0.924	1.384	1.197	0.948	1.499

Distance 2 - Locknut height 38.5mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.773	0.605	1.676	0.696	0.935	1.747	0.697	0.549	1.812	0.722	0.696	1.745
292	0.692	0.834	0.977	0.974	0.729	1.005	0.881	1.121	1.005	0.849	0.895	0.996
293	0.932	0.875	1.281	1.003	0.886	1.393	1.213	1.179	1.411	1.049	0.980	1.362

Appendix 29

Vibrational research

Results - Double diagonal construction

Orifice hole quantity: 4
Orifice hole diameter: 3.5 mm (2x) + 1.5 mm (2)

Company	Elcron models
Type of vibratio	hydraulics
Brand type	Schokbrekers achterzijde

Maxi-cosi loaded with 8 kg infant

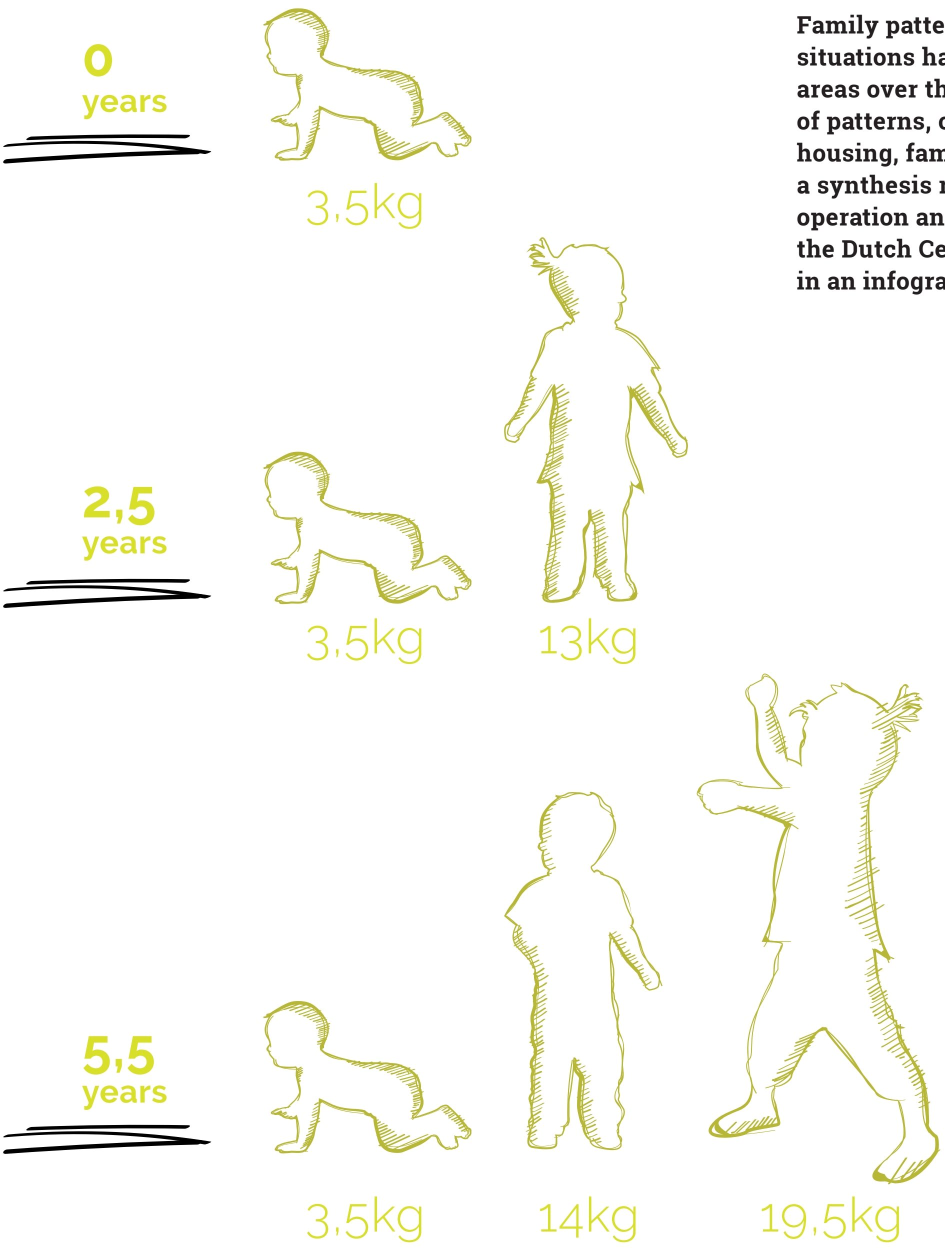
Distance 1 - Locknut height 44.5mm

	Measurement 1			Measurement 2			Measurement 3			Average values		
Sensor	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
287	0.750	0.391	2.120	0.630	0.586	2.503	0.511	0.571	1.718	0.630	0.516	2.114
292	0.540	0.437	0.665	0.488	0.606	0.724	0.416	0.746	0.635	0.481	0.596	0.675
293	0.840	0.467	0.982	0.659	0.882	1.158	0.698	0.598	0.955	0.732	0.649	1.031

Appendix 30

The modern **family**

Family patterns, household compositions and living situations have changed substantially in European urban areas over the past years. This section offers a representation of patterns, changes and trends, in relation to parenthood, housing, families and children, predominantly drafted by a synthesis report by the Organization for Economic Co-operation and Development (OECD) and statistic reports by the Dutch Central Agency for Statistics (CBS), and presented in an infographic.



29.1 Scenarios

According to the Dutch Central Agency for Statistics (CBS)

of the The majority of the total Dutch population lives in a household with children. In the case of a household with three children (15% of the Dutch households with children, CBS (2018)), three scenarios are possible:

1. Birth of first child
2. Birth of second child. The first child is now 2,5 years old
3. Birth of third child. The first child is now 5,5 years old, the second 3 years old (after one year the child is able to sit by him or herself).

29.2 Family composition

Since the share of families with more than three children is very small (5%, CBS 2016), the transportation solution will draw emphasis of a family consisting of up to three children.

the transportation solution needs to be suitable for a family consisting out of three children or less.

Figure 59: Infographic representating patterns, changes and trends, in relation to parenthood, housing, families and children

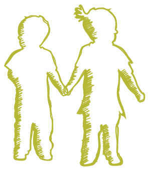
family composition

1,7 children

on average per household

43%

of Dutch families have at least one child



42% of Dutch families have at least two children

15% of Dutch families have at least three children

Child care

Availability of pre-school childcare has improved significantly

54%

of the total Dutch population lives in a household with children.

29,6

Age of entering first parenthood in the Netherlands

32,5

Age of entering first parenthood in the Netherlands

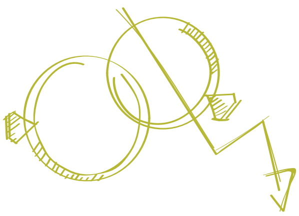
Housing

86%

Of all completed new-buildings in 2013 in Amsterdam, Rotterdam, the Hague and Utrecht were multi-family homes.

Martial status

Couple relationships have become less stable over time as consensual unions, which are more fragile than marriages have spread

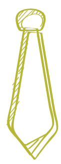


Decline in marriage

Work

Substantial increase of female labour force participation and female aspirations for education.

Family-friendly workplace: part-time work, flexible working hours, days off to care for sick children, employer-provided parental leave and/or childcare support



Appendix 31
Revised concept iteration

Several constructions were drafted that kept the infant safety seat as low as possible. Those constructions will be discussed here.

Pull-rod suspension system

(Push or) pull rod suspension systems (Figure 60) are clever systems used in racing cars. The advantages of such a system lies in the possibility to assemble most suspension parts lower to the ground (small installation space) and thus lowering the height of the center of gravity.

Racing cars (e.g. formula 1 cars) have a very small suspension travel and are firmly suspended. On a racing track there are little to none road imperfections and comfort is no requirement at all. Due to these smaller movements, the variables are easier to choose and the angular displacements are kept within a small range. By limiting the vertical travel, and thus limiting the angular displacement of the rocker arm, the spring force will remain constant: the influence of alpha will kept within a small range (Martijn Stolk, R&D Engineer Suspension Systems, personal communication, August 12, 2018). However, this behavior is not desirable in my application: heavy shocks needs to be prevented and the system needs to feel smooth.

Another additional benefit is that the rocker arm passes through the forces collinear with the shock absorber, thereby creating (close to) a 100% damper efficiency.

Several constructions were drafted (Figure 62) and the geometry was modelled in Solidworks (Figure 61).

Figure 60: Push rod suspension system of a Lamborgini Murcielago sports car

Modelling in Solidworks enabled me to play around with the dimensions and to see the effects of changing dimensions. However, there were too many unknown parameters that are all related to one another: changing one dimension influences the whole geometry.

In conclusion, these constructions and geometries were too complicated to use in this graduation project.

Revised parallelogram

A combination was made between the Steco Baby Mee and the parallelogram construction (Figure 64).

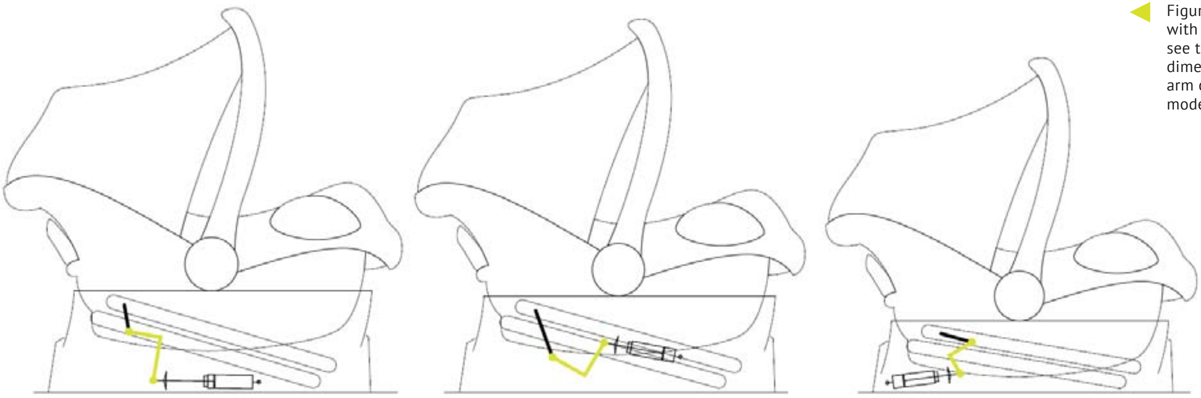
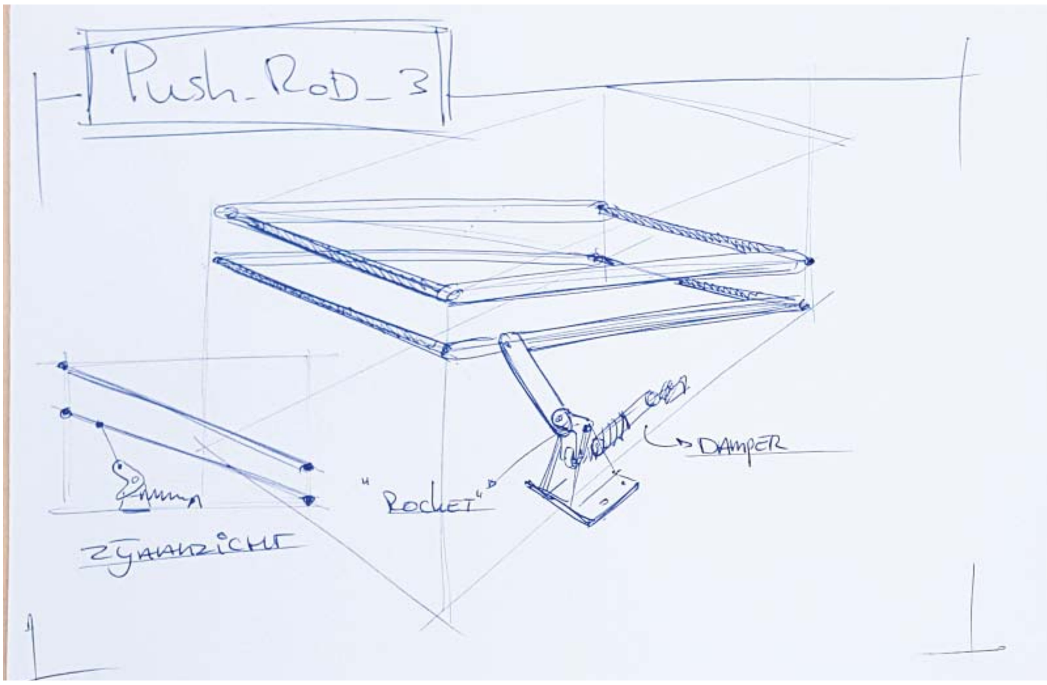
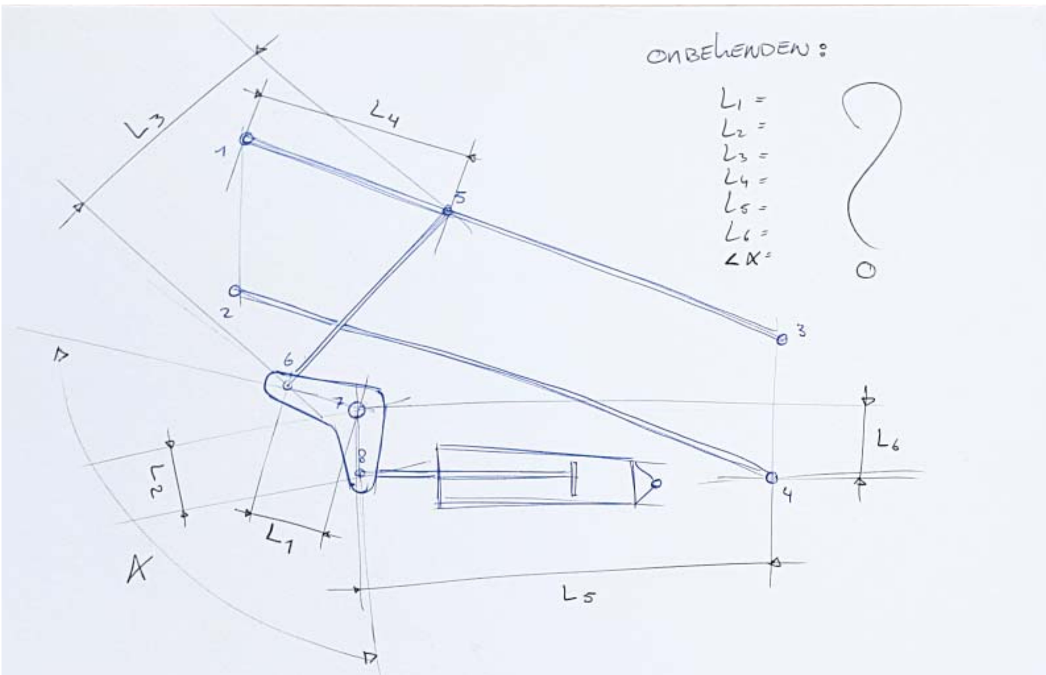


Figure 61: To play around with the dimensions and to see the effects of changing dimensions, different rocker arm constructions were modelled in Solidworks.





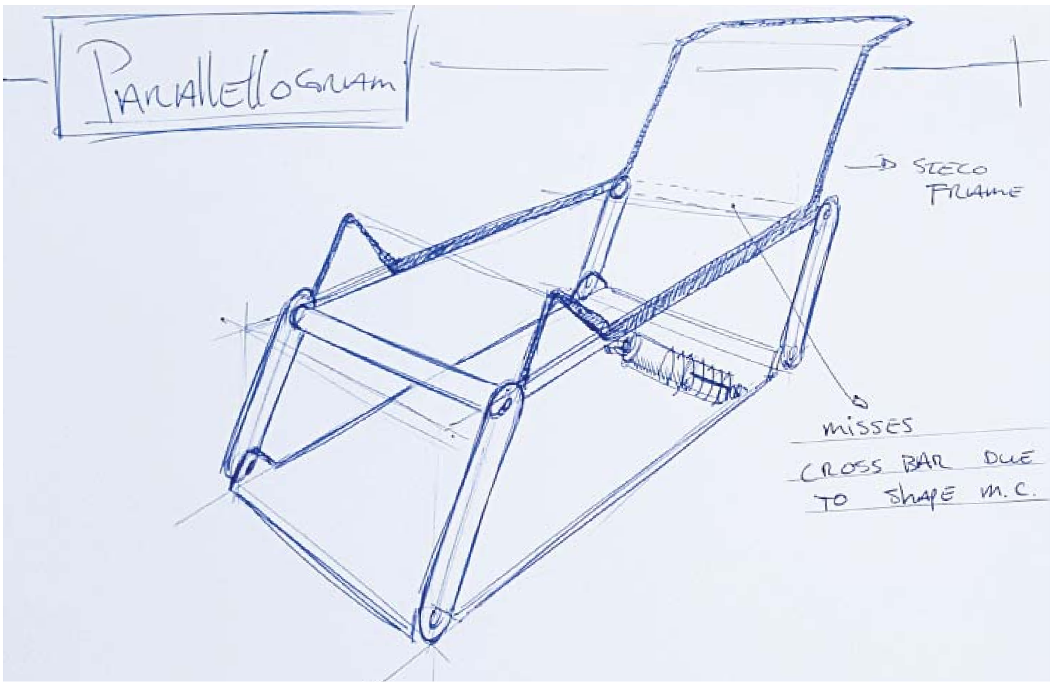
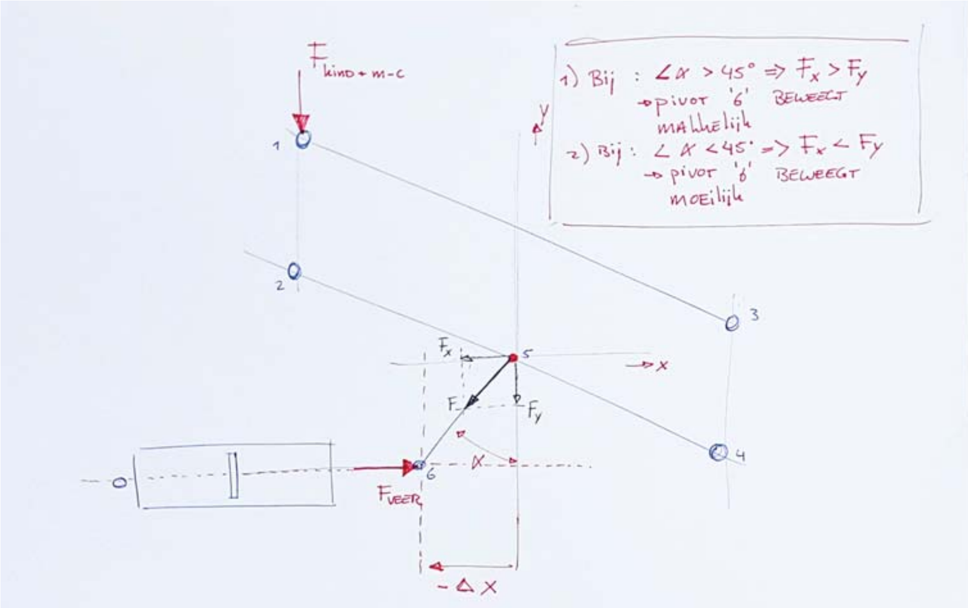


Figure 62: (upper) Double diagonal construction with the shock absorber placed next to the construction, rather than below the construction. This enabled the infant safety seat to be placed lower.

Figure 63: (middle) Illustration of the many unknown parameters of a push rod suspension system that were all related to one another: changing one dimension influences the whole geometry.

Figure 64: (lower) Combination between the Steco Baby Mee and the parallelogram construction with the shock absorber placed next to the construction, rather than below the construction. This enabled the infant safety seat to be placed lower.



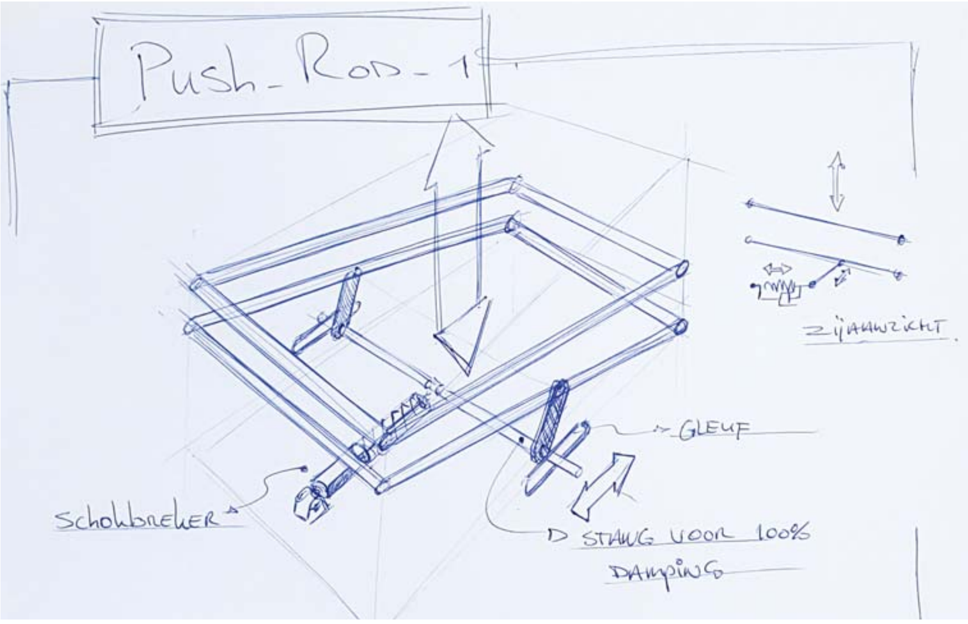


Figure 65: (upper) Free Body Diagram of a push rod system where the shock absorber is placed horizontally.

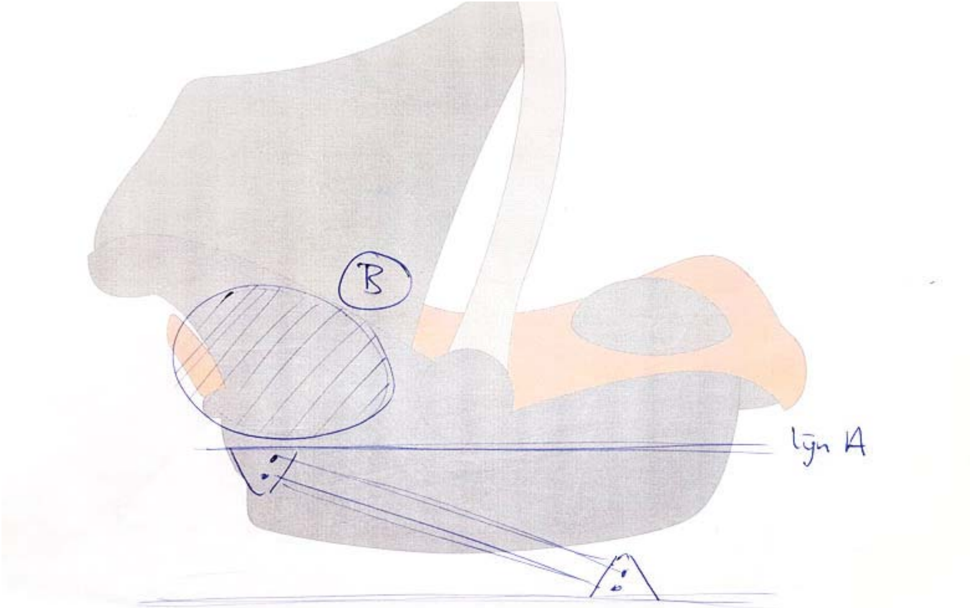
Figure 66: (lower) 3D visualization of the needed construction for a push rod system where the shock absorber is placed horizontally,

This construction was stripped down its bare essential. The result: a small metal construction with one (or two) shock absorbers placed next to the infant safety seat.

Horizontal pushrod suspension system

Derived from the pull-rod suspension system, a simpler system was composed (Figure 65-219). This system makes use of a slot that enables the damping efficiency is 100% at all times. However, several uncertainties still remained:

- The force ratio between pivot 5 and pivot 6 in Figure 65 is a matter of concern. Alpha is constantly changing, therefore, the needed spring force and spring rate is harder to determine.
- The linkage between pivot 5 and pivot 6 needs to lift up the whole construction. The point where pivot 5 will be attached on the linkage between pivot 2 and 4 has a large influence on the needed spring force, as it creates a larger moment.
- When placing several construction elements (e.g. shock absorber) horizontally below the infant safety seat, the whole construction needed to be lifted slightly higher (otherwise the infant safety seat might collapse with those elements). As a result, the center of gravity will be higher.



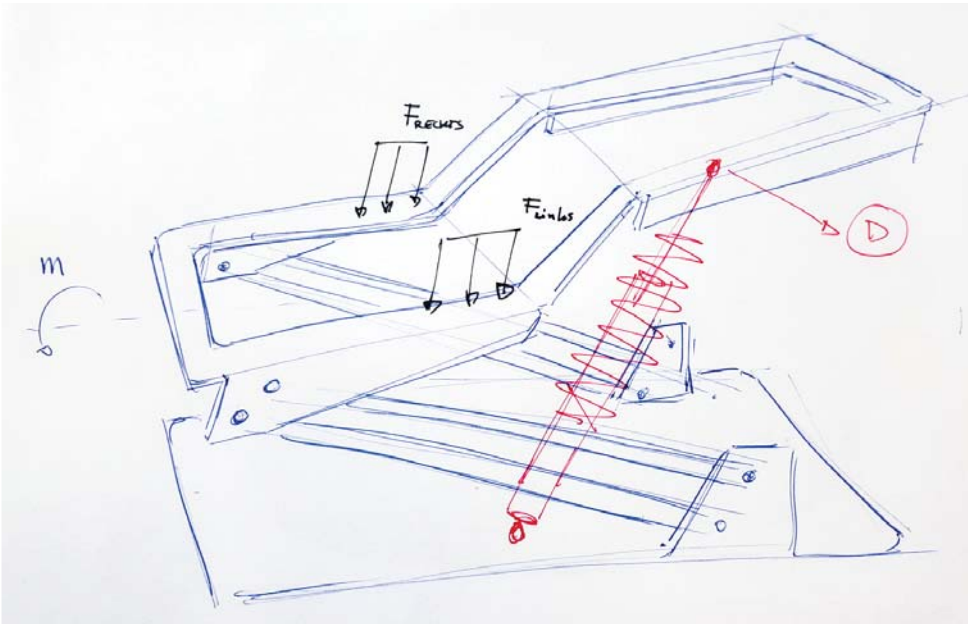


Figure 67: (upper) At first, the double diagonals were placed below line A. Yet, it was possible to make clever use of the empty area B.

Figure 68: 3D visualisation of the revised double diagonal. Here, the upper part was bent to make space for the shock absorber

Due to these uncertainties it was concluded that this construction might not work as intended and was, therefore, excluded for further elaboration.

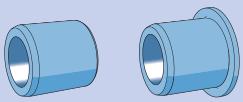
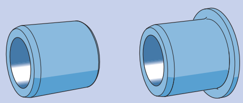
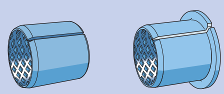
Revised double diagonal

In this construction the double diagonals are placed next to the infant safety seat rather than below. At first, the double diagonals were placed below the horizontal line in Figure 67. The horizontal line was positioned just below the pivot of the handle of the infant safety seat: the center of gravity. However, due to the geometry of the infant safety seat, a lot of space could be used at area B in Figure 67. As a result, in the second iteration, the upper part was bent. Also in this construction several uncertainties remained:

- When using one shock absorber, one side of the construction will remain unsupported, which creates a moment around the x-axis.
- It is desirable that the infant safety seat is placed as low as possible. This would mean the left and ride side should be separated and the linkage should be removed. The result removing the linkage.

Appendix 32 SKF Bushings

Product guide

	Solid Bronze The all-round runner	Sintered Bronze The fast runner	Wrapped Bronze The cross country runner
			
Self-lubricating performance	–	+	–
Maintenance-free operation	–	+	0
Dirty environment	+	0	++
Corrosion resistant	+	0	+
High temperature	+	–	+
High load	0	–	0
Shock loads/vibrations	+	0	+
High sliding velocity	–	++	0
Low friction	–	+	–
Poor shaft surface finish	+	–	0
Small operating clearance	–	0	0
Insensitive to misalignment	+	0	0
Low price level	0	+	+
Assortment			
Product series designation	PBM PBMF	PSM PSMF	PRM PRMF
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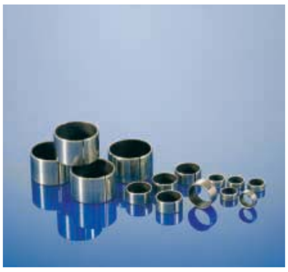
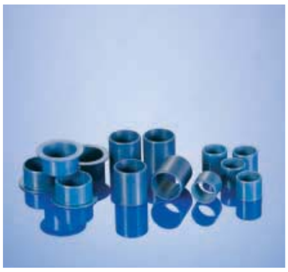
4 Excellent (++) Good (+)

				
PTFE Composite The long runner	**POM Composite** The up-hill runner	**Stainless Backed Composite** The smooth & shiny runner	**PTFE Polyamide** The jogging runner	**Filament Wound** The heavy duty runner
++	+	++	++	++
++	+	++	++	++
–	0	–	–	+
0	0	++	++	++
++	0	+	0	+
+	++	+	0	++
0	0	0	–	++
+	+	+	0	–
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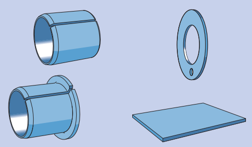
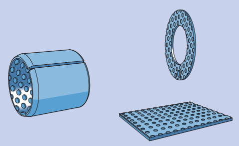
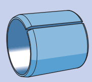
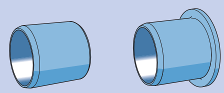
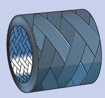
++	++	–	++	–
				
PCM .. E(B) PCMW .. B PCMF .. E(B) PCMS .. B	PCM .. M PCMW .. M PCMS .. M	PI	PPM PPMF	PWM
38	44	48	50	52

Suitable (0) Not suitable (–)

Appendix 33
Bushings Materials

Glass fiber (PTFE lubricated)

Glass giber is a very suitable material for this application. Glass fiber bushings have a particularly high Normal Working Pressure (around 200 MPa), in comparison to other bushing materials such as polyester or phenolic resin bonded composites (PTFE lubricated, both around 80 MPa). Another issue that composite bearings can address quite well is dimensional stability. If they are overloaded, they will not immediately collapse, but will deflect and return to their original form. This does not quickly create any play on the structure.

Glass fiber bearings can be manufactured with a flange. However, the head of these flanges does not have a sliding surface. With minimal axial load this is not problematic. However, an increase in axial load increases might cause wear at the steel parts (Marc Dalebout, July 25, 2018, personal communication).

Although assessed as most suitable in terms of shock loads/vibrations (based on the product guide in appendix X), glass fiber bushings were regarded not suitable, due to their very high production costs.

Polymer

Polymer materials (e.g. polyamide, POM) were regarded as not suitable. Polymer materials have a relatively low glass transition temperature of around 75˚ C, after which the aging process accelerates. Due to the high angular speeds at the pivot points, the temperature can be unexpectedly high, often causing the first problems in case of breakdown. Subsequently, play in the bearings and wear occur (Marc Dalebout, July 25, 2018, personal communication).

PTFE composite

These bushings combine a steel backing with a polymer lining such as PTFE. When a steel backing is combined with PTFE, the strength and stiffness properties are enhanced by the low friction of the polymer material (Bearing-news.com, n.d.). The use of a polymer layer such as PTFE also deals with issues such as corrosion and unwanted chemical interactions by providing protection the metallic layer(s).

Appendix 34

Sideways movement

email conversation

The issue:
unwanted sideways movement. Proposed solution: enlarging the flange of the bearing (enlarging the contact area) and, therefore, limiting the sideways movement. Additional disadvantage: more friction

Reply 1:
A large flange is no problem. Only when a very low coefficient of friction is necessary, it is advisable to keep the contact area as small as possible. In this application this is not necessary: the application is a spring-damper system, not a guidance system. The extra friction might decrease the load on the spring to a very little extent.

Pim van den Berg, August 23, 2018, personal communication

Reply 2:
The proposal is possible. However, most often composite bushings are wrapped, which give problems for large flanges. These problems arise because the load acts in the 'weak' direction of the composites. Composite bushing materials can absorb a lot of axial load, but only about 35% of the radial maximum load.

Alternatively, the flanges can be produced as separate disks (washers) and can simply be placed between the contacting surfaces.

The biggest advantages can be obtained from the optimum adjustment of the play in the construction (keeping the shafts of the construction on tension). When the clearances are correct, the construction can function without too many problems. An increase in clearances accelerates the wearing process extensively.

Marc Dalebout, August 21, 2018, personal communication

Appendix 35

Finite element analysis

A Finite Element Analysis was used to evaluate the side stability of the construction. For the FEA, a simplified construction was modelled. The diagonals were fixed at one end of the construction and loaded with 200N acting from the side, on the other end.

Iteration 1

The first iteration consisted out of two 4 mm diagonals.

The results showed a large displacement of 99.9 mm for aluminium and a displacement of 34.3 mm for steel (Figure 131).

Moreover, the stresses were too high and the diagonals deformed plastically.

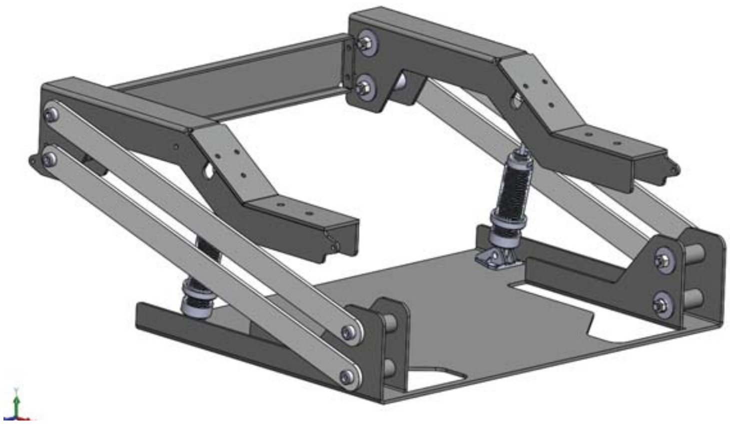


Figure 69: First iteration of the new double diagonal construction. Showing a 4 mm thick plate

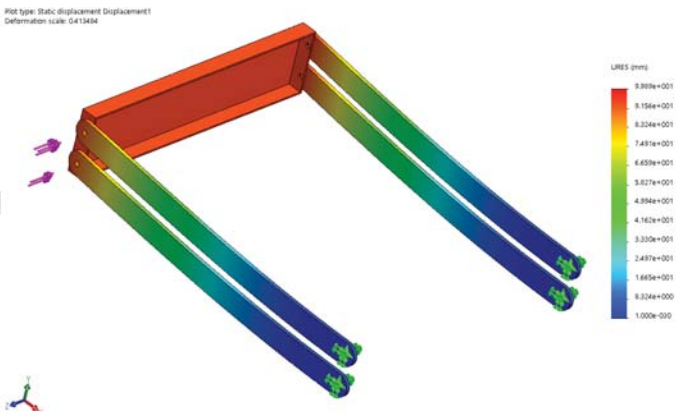


Figure 70: Displacement of the diagonals due to a side-to-side force of 200N. Diagonal material: Aluminium. Showing the first iteration.

Figure 71: Von Mises stress (N/m2) due to a side-to-side force of 200N. Showing a maximum stress of 1.033*10^9 (N/m2) for an aluminium construction. The maximum stress exceeds the yield strength of 2.76*10^7 (N/m2): the construction deforms plastically.

Figure 72: Displacement of the diagonals due to a side-to-side force of 200N. Diagonal material: Carbon steel. Showing the first iteration.

Figure 73: Von Mises stress (N/m2) due to a side-to-side force of 200N. Showing a maximum stress of 1.089*10^9 (N/m2) for a steel construction. The maximum stress exceeds the yield strength of 6.2*10^8 (N/m2): the construction deforms plastically.

Iteration 2

A plastic redesign (Figure 132) was proposed to reduce the weight of the diagonals and to create more stiffness. Although a smaller displacement, the results still showed a way too large displacement of 741 mm for ABS and a displacement of 26.2 mm for nylon 10% filled glassfiber.

Moreover, the stresses were too high and the diagonals deformed plastically.

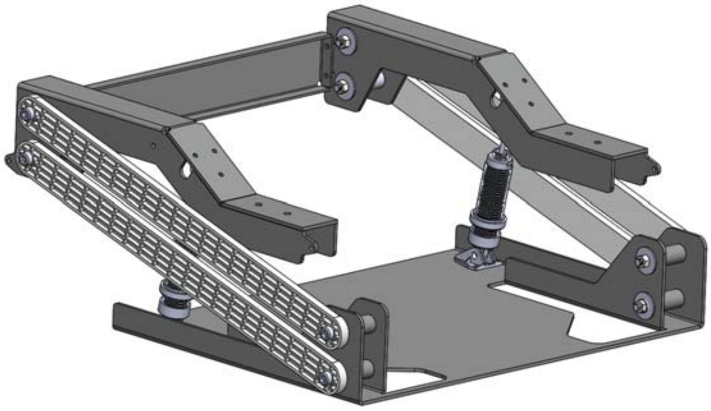


Figure 74: Second iteration of the double diagonal construction.

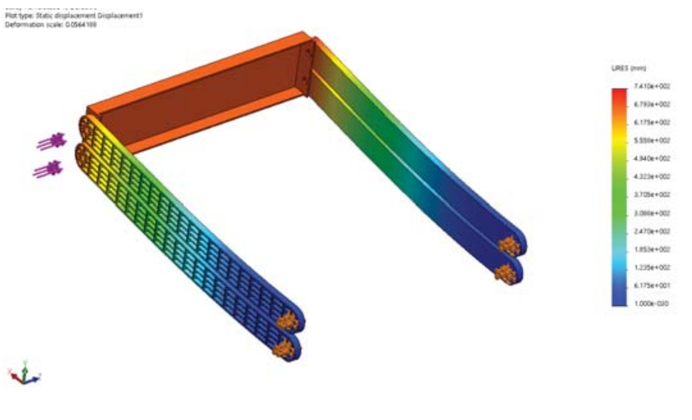


Figure 75: Displacement of the diagonals due to a side-to-side force of 200N. Diagonal material: ABS. Showing the second iteration.

Figure 76: Von Mises stress (N/m2) due to a side-to-side force of 200N. Showing a maximum stress of 2.9*10^8 (N/m2) for diagonals made out of ABS. The maximum stress exceeds the yield strength of around 3 to 6*10^7 (N/m2): the construction deforms plastically.

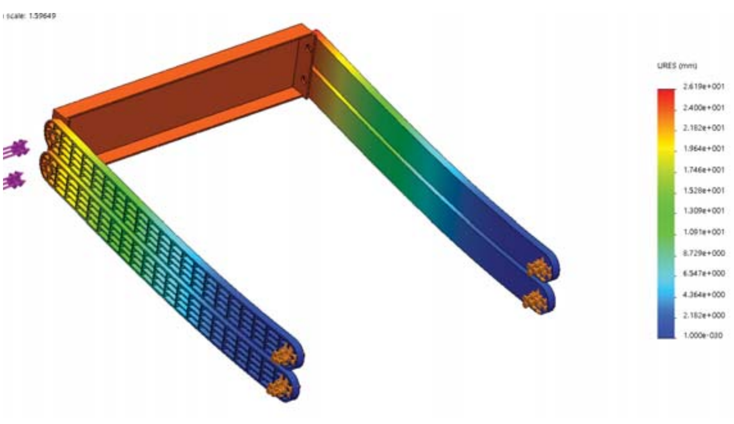


Figure 77: Displacement of the diagonals due to a side-to-side force of 200N. Diagonal material: nylon 10% filled glassfiber. Showing the second iteration.

Figure 78: Von Mises stress (N/m2) due to a side-to-side force of 200N. Showing a maximum stress of 2.85*10^8 (N/m2) for diagonals made out of nylon 10% filled glassfiber. The maximum stress exceeds the yield strength of around 9 to 11*10^7 (N/m2): the construction deforms plastically.

Iteration 3

The middle beam was considered to be a rather protruding and cumbersome piece of the construction. Furthermore, a cut-out in the (plastic) covers would be needed to enable the possibility to mount the middle beam to both upper brackets. In collaboration with the supervisors of the TU Delft, it was decided to find a solution that would make it possible to eliminate the middle beam.

A way to do this would be to mount a stiff U-profile in between the upper brackets, rather than next to it. Apart from creating more stiffness, this solution would also reduce the width of the suspension frame (Figure 131).

The results showed an acceptable displacement of 4.0 mm for aluminium, for a U-profile having the following dimensions: 32 x 50 x 32 x 2 mm. Yet, the stresses were still to high. When using steel, the stresses were acceptable and the diagonals did not deform plastically.

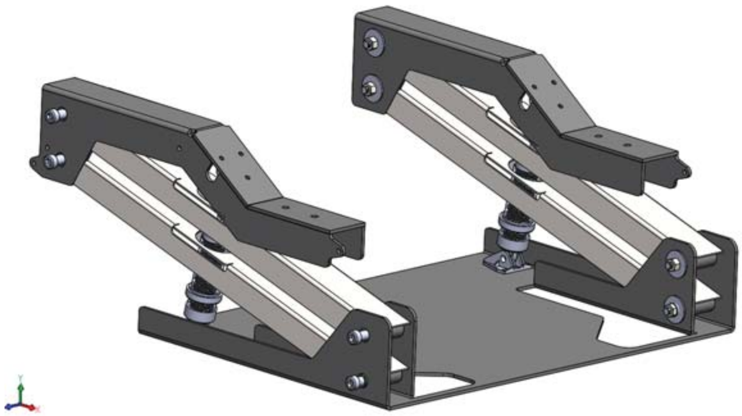


Figure 79: Third iteration of the diagonals. Showing a stiff U-profile placed in between the upper bracket.

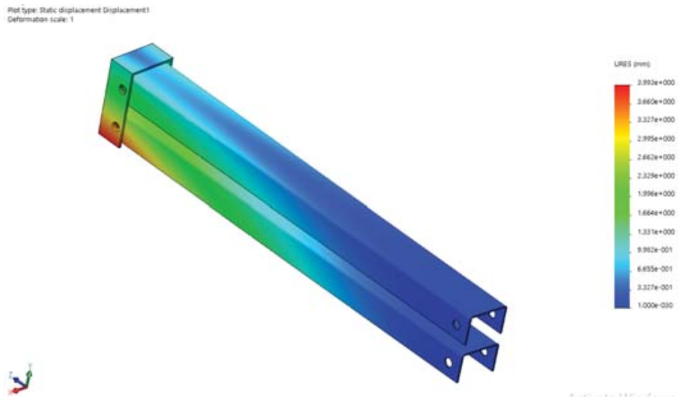


Figure 80: Displacement of the diagonals due to a side-to-side force of 200N. Diagonal material: aluminium. Showing the third iteration.

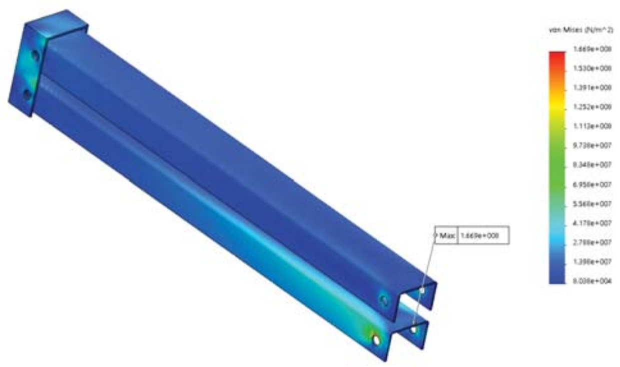


Figure 81: Von Mises stress (N/m2) due to a side-to-side force of 200N. Showing a maximum stress of 1.7*10^8 (N/m2) for diagonals made out of aluminium. The maximum stress exceeds the yield strength for aluminium of 2.76*10^7 (N/m2): the construction deforms plastically. Yet, when using steel with a yield strength of 6.2*10^8 (N/m2) the diagonals do not deform plastically.

Renewed mounting proposal

Appendix 36

To ensure maximum safety and rigidity a new mounting proposal was made (Figure 85). Inspiration was found in vehicle and aircraft floor tracking systems that add flexibility to a vehicle's or aircraft's seating configuration. One example of a floor tracking system is a standard duty L-track profile (Figure 83). These tracks can be used to add tie-down points for securing cargo or for locking seat legs.

35.1 Iteration 1

Unwin, a company specialized in delivering wheelchair safety solutions, developed an easy to operate seat fixture that locks the seat legs into a vehicle's floor tracking (the Unwin Seat Locker (USL), Figure 84). The USL has a pattern for gripping into the rails. To lock the seat, simply locate the USL into the tracking and press down the foot pedal.

The first major difference in comparison with the initial proposal was that the covered suspension frames were disconnected from the mounting plate and became two individual subparts.

35.1.1 Base frame

A base frame is anchored to the floor of the cargo bike by means of 6 bolts. The base frame consisted out of:

- Two extrusion profiles that have two lasercutted tracks;
- Two steel plates.
- Two bent profiles, having two lasercutted slots, that moves inside of the extrusion profiles.
- Two handles that are positioned at the end of the extrusion profiles.
- Two linkages that connect the handle with the bent profiles.

35.1.2 Covered suspension frames

Two small steel feet are welded at the bottom of the suspension frame. Simply locate these feet into the tracking and press down the handle. By rotating the handle downwards the linkage is moved backwards. The bent profile is moved backwards too. As a result, the two steel feet are clamped between the edges of the bent profile and the extrusion profile.

Advantages:

- In the case of a rapid brake (e.g. collision) the feet are pushed against the edge of the extrusion profile. Both parts are made from steel and can withstand much more forces.
- By making clever use of a toggle clamp principle (Figure 88) the handle can never be pushed back upwards without the handle being moved up by a human.

35.1.3 Toggle principle

Toggle action clamps operate through a linkage system of levers and pivots. The fixed length levers, connected by pivot pins supply the action and clamping force. Toggle action has an over-center lock point which is a fixed stop and linkage. Once in the over-center position, the clamp

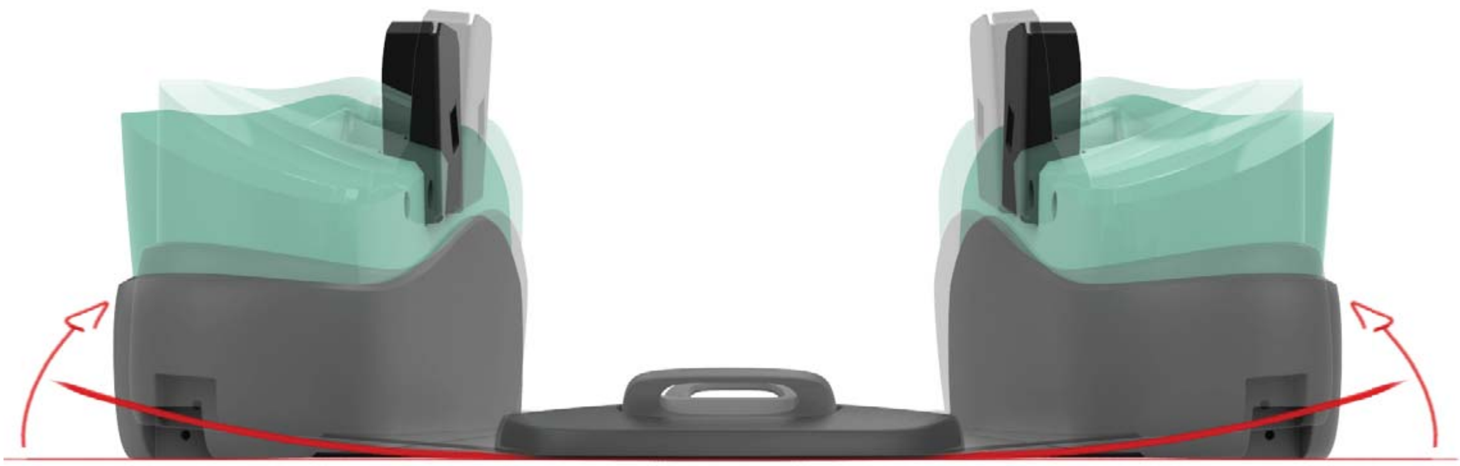
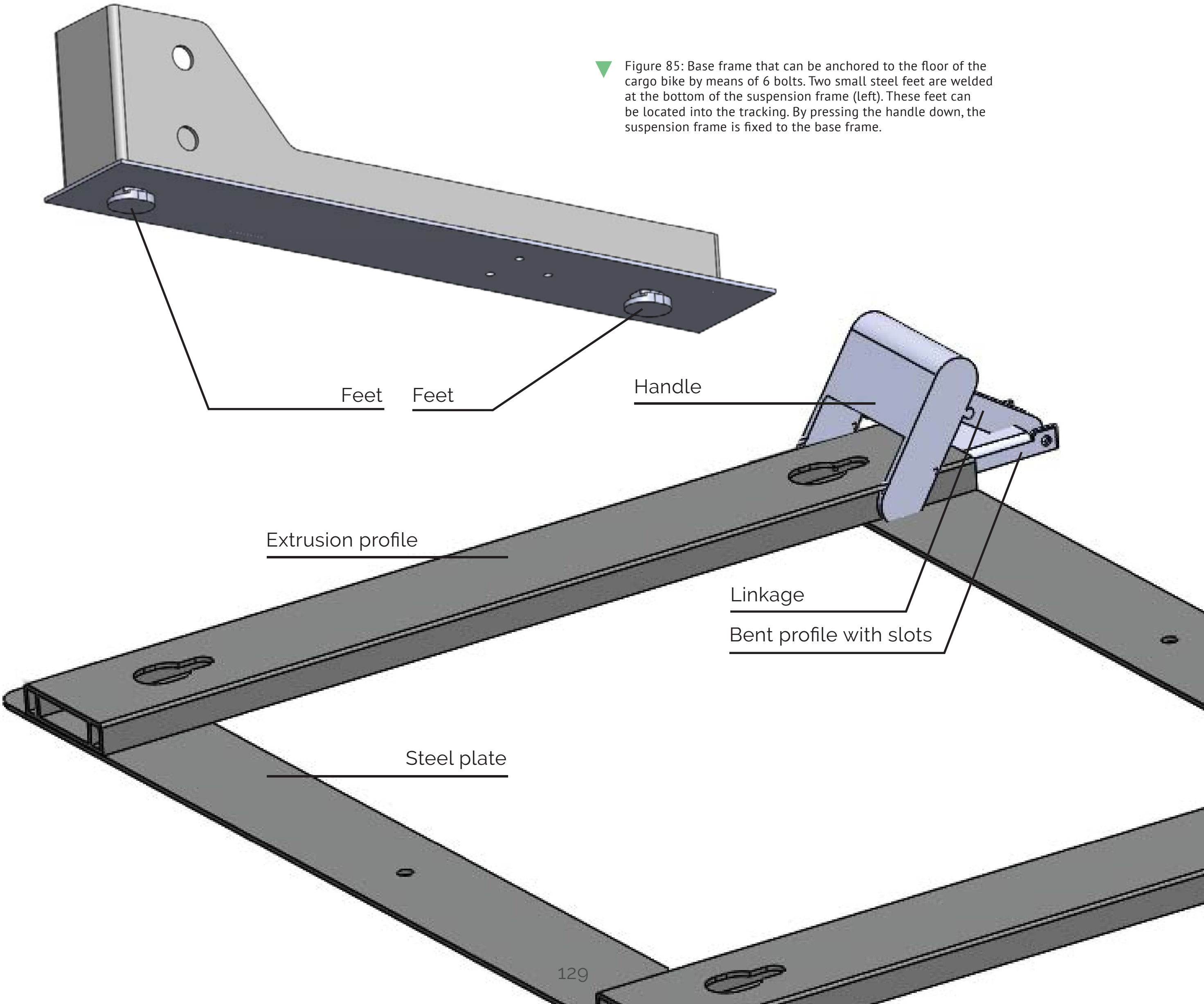


Figure 82: Due to the little support on the side of the construction - the closure between the pins and the ground tile act in the middle of the construction - , the construction could 'flap'.

Figure 83: floor tracking system, making use of a standard duty L-track profile.

Figure 84: Unwin Seat Locker, an easy to operate seat fixture that locks the seat legs into a vehicle's floor tracking.

Figure 85: Base frame that can be anchored to the floor of the cargo bike by means of 6 bolts. Two small steel feet are welded at the bottom of the suspension frame (left). These feet can be located into the tracking. By pressing the handle down, the suspension frame is fixed to the base frame.



cannot move or unlock unless the linkage is moved. All types of toggle clamps have same action, just oriented differently.

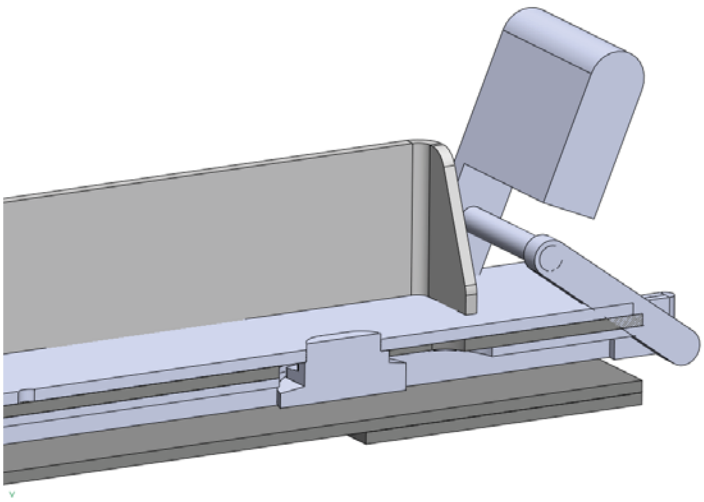
Unfortunately, I did not take into account the (plastic) covers. The position of the handle was not possible: the covers should be placed over it. Two solutions were possible:

- Positioning the handle at the end of the (plastic) cover. However, since it is desirable to place the whole product as far as possible against the front of the box of the cargo bike, there would be little to none clearance for a hand that needs to operate the handle.
- Positioning the handle at the middle. However, this construction was assessed as being too complicated: (1) the torsional stiffness might become an engineering issue and (2) an additional rod mechanism was needed to clamp the left and right side of the seat system simultaneously.

35.2 Iteration 2

In the new iteration, the handle toggle clamp, which was operated vertically (rotation in the y-axis), was replaced with a toggle clamp that was oriented horizontally (rotation in the y-axis).

The operation of both toggle clamps, in relation to ergonomics, was tested by means of two quick cardboard models. Two screws were used as pivot pins. I found that the vertical clamp was easier to operate, because the horizontal clamp was mounted close to the bottom of the box. As a result, the handle could not be grasped conveniently.



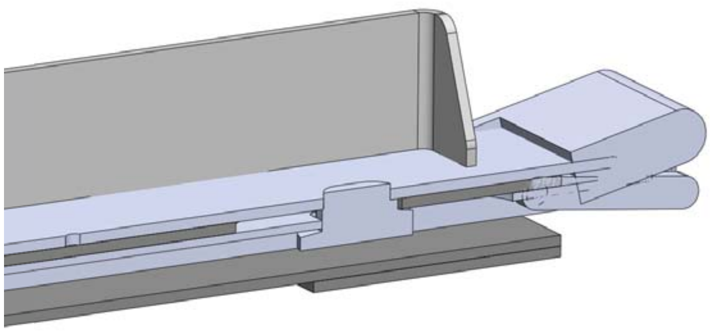
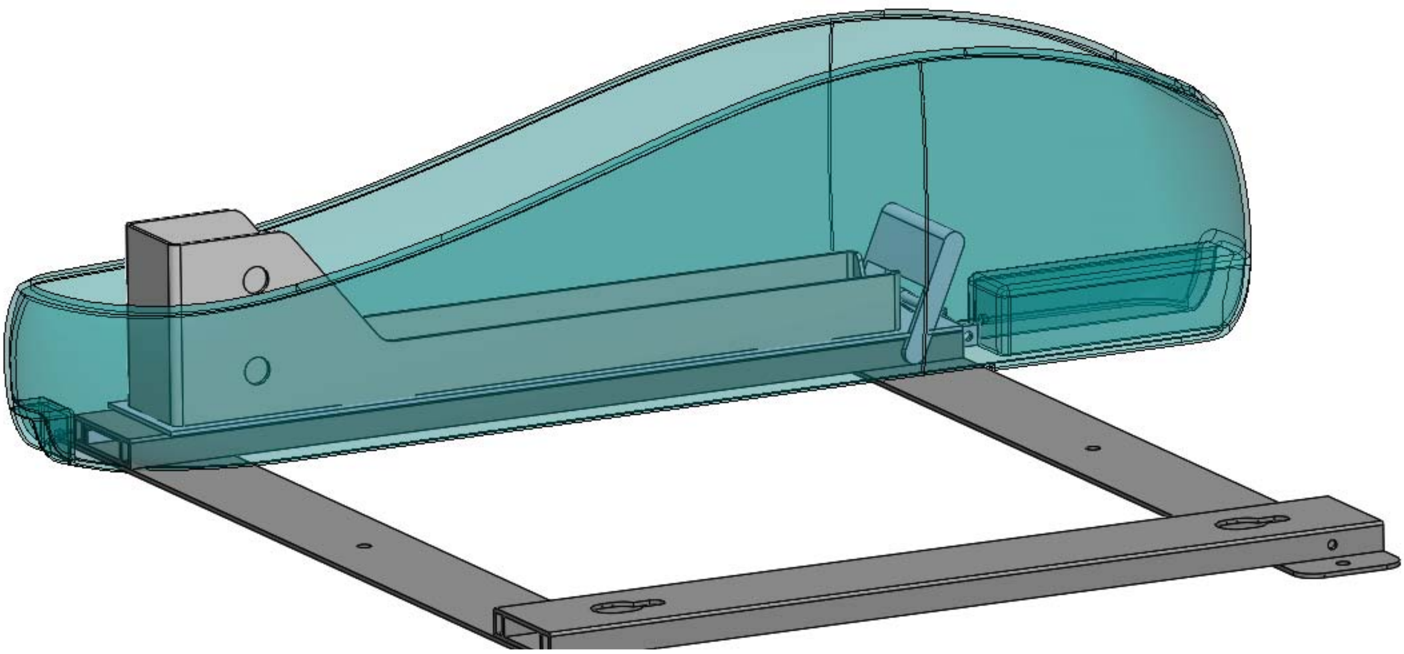


Figure 86: (upper) Open position (left) and closed position (right). The bent profile is moved backwards. As a result, the two steel feet are clamped between the edges of the bent profile and the extrusion profile

Figure 87: (lower) The covers make it impossible to operate the handles.



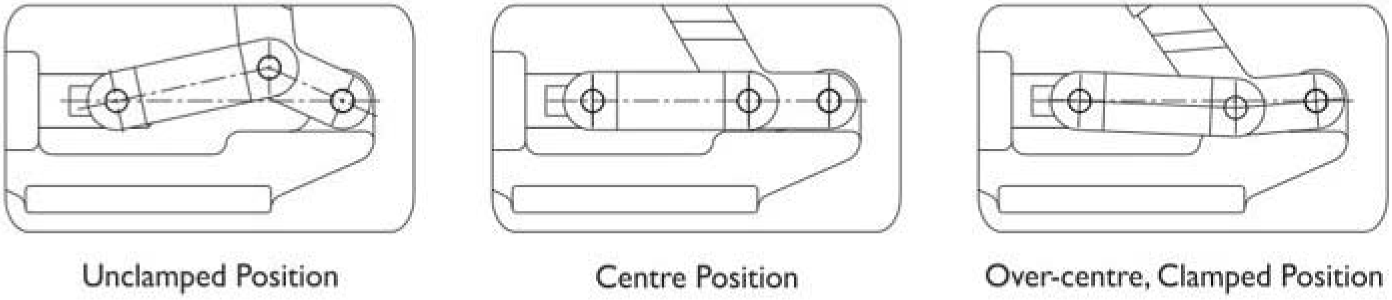
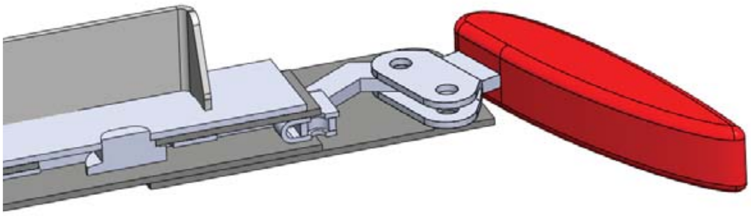
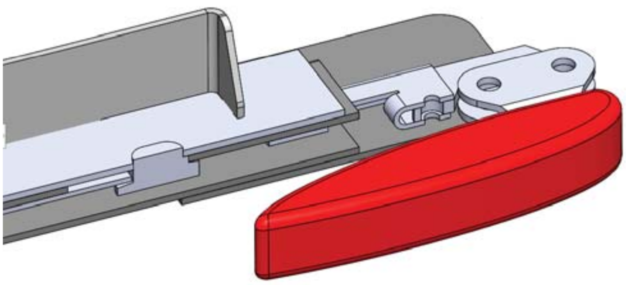


Figure 88: Toggle principle that prevents the handle to be pushed back upwards. The handle can only being moved up by a human action.

Conclusion

Nevertheless, the horizontal clamp can be nicely integrated into the covered suspension frames, creating a flush whole without protrusions. This is beneficial for the center of gravity, since possible protrusions that would be positioned below the infant safety seat might higher it. Furthermore, the horizontal clamp can be made more ergonomic by increasing the height of the handle. And lastly, the assumption was made that operating the handle was not a daily task. Ergonomics was not the highest priority: maintaining a low as possible infant seat was.





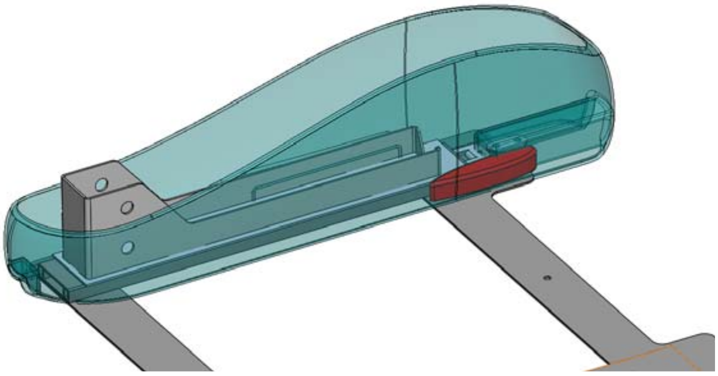


Figure 89: (upper) Horizontally oriented toggle clamp (rotation in the y-axis)

Figure 90: (middle) Open position (upper) and closed position (lower)

Figure 91: (lower) Visualisation of the second iteration that makes use of a toggle clamp that is oriented horizontally. The horizontal clamp can be nicely integrated into the covered suspension frames, creating a flush whole without protrusions.

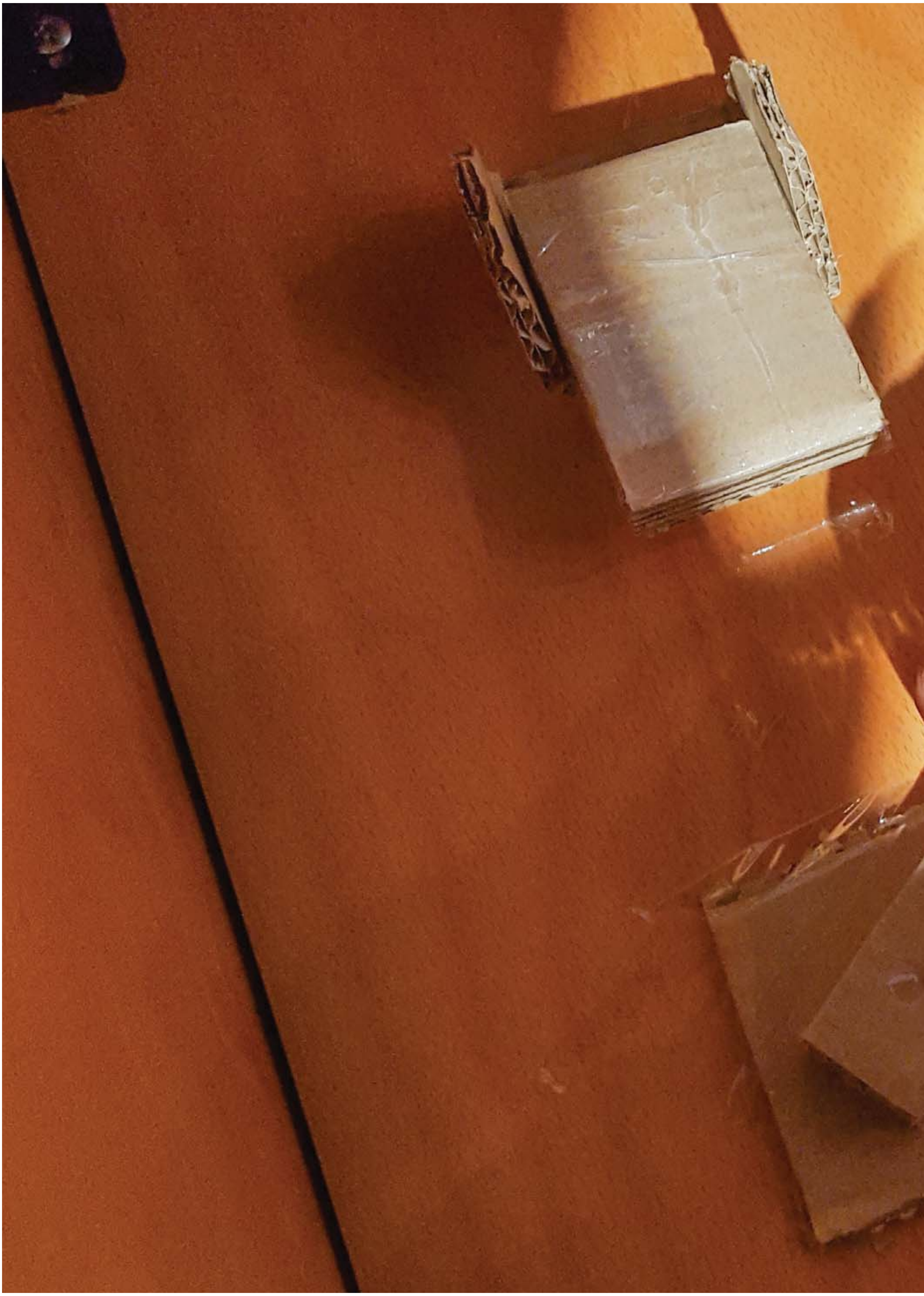


Figure 92: Testing the operation of both toggle clamps, in relation to ergonomics, by means of two quick cardboard models

Appendix 37

Quotation **rotational molding**

Bart van Driessche

From:	Info [Dragon Plastics] <info@dragonplastics.nl>
Sent:	donderdag 19 april 2018 16:57
To:	'Bart van Driessche'
Subject:	RE: mogelijkheden rotatiegieten

DRAGON PLASTICS ROTOMOULDING
PART OF YOUR SUCCESS!

Beste Bart,

n.a.v. ons gesprek van 27-3 geef ik U onderstaand de richtprijzen:

Matrijs alu productie gereed € 5.500,=
Product simpel afgewerkt geen inserts € 24,=

Als dit interessant genoeg is dan zullen wij een volledige, complete offerte maken.
Mocht je nog vragen hebben dan horen wij die graag!

Met vriendelijke groet,

Rick van Gils

DRAGON PLASTICS ROTOMOULDING

Verbindingsweg 1
4695 RV Sint Maartensdijk
The Netherlands
T. +31 (0)166 66 38 31
M. +31 (0) 648 17 91 02
rick@dragonplastics.nl
www.dragonplastics.nl
SPECIALISTS IN CUSTOM MADE ROTOMOULDING
PART OF YOUR SUCCESS!

Figure 93: Quotation for rotational molding.

Appendix 38
Aluminium mold

Aluminium mold
Due to the small production batch a hard steel alloy mold would significantly increase the initial investment. However, using aluminum for molds reduces costs and lead-times substantially. An aluminium injection mold tool can easily be used to generate 2000-5000 parts.

Moreover, aluminum tools are much better suited to adjustments after the fact if the injection molding process reveals required changes. Adjustments may need to be made because of a design oversight, because the tool itself produces an injection molding defect (such as uneven flow), or because product testing or consumer research reveals some type of shortcoming that needs to be fixed (Creative Mechanisms, n.d.).

Appendix 39
Trade-off between **Steel and Aluminium**

Costs
Steel is generally cheaper, $0,88/kg (Carbon Steel, A36 Plate, US, October 1, 2018) than aluminum $3,88/kg (Aluminium 3003-H14 sheet, US, October 1, 2018).

Strength
Steel strong and less likely to warp, deform or bend under weight, force or heat than aluminium.

Weight Differences
The density of steel varies based on the alloying constituents but usually is around 7850 kg/m3. Aluminium, however, is much lighter (up to three times lighter than steel): around 2720 kg/m3.

Corrosion Resistance
Aluminum's greatest attribute is that it is corrosion resistant without any further treatment after it is bent. Aluminum doesn't rust. With aluminum there is no paint or coating to wear or scratch off. Steel usually needs painted or treated after it has been laser cutted or bent, to protect it from rust and corrosion, especially if the steel part will be at work in a moist, damp or abrasive environment.

Welding
Steel is relatively easy to weld, while aluminum can be difficult.

Appendix 40
Cost price

Based on the data provided in appendix 21, the total sales was estimated to reach around 6.000 potential users. The first production batch shall most likely be small, ranging from 200 to 500 pieces the first year. It is estimated to produce 500 – 1000 pieces the second year. After the third year 3000 pieces should be sold.

Suspension frame

A quotation for the sheet metal parts was requested at an external company specialized in the manufacturing of sheet metal (Figure 95). This company provided a quotation for a single unit as well as up to a quanity of 500 pieces.

The price per 500 units was expected to be 167 euros. However, this price is based on a stainless steel material and Dutch manufacturing and labour costs. Internal communication with the director of Popal suggest that by optimizing the product and its material and labour costs, the costs for the sheet metal parts can be cut by more than 50% to below 80 euros (personal communication, Aryan Popal, January 5, 2019).

Plastic covers

The plastic covers require a large investment. Currently, none of them are identical. The assumptions was made that the left and right parts were symmetrical, therefore, cutting the costs significantly. The cost price for the plastic covers were estimated by means of an online Cost Estimator (Figure 94).

Shock absorber

The shock absorber used in this graduation project was purchased at a Dutch supplier for around 100 euros per two pieces. A quick online research shows prices ranging from 10 to 40 euros per two pieces (source: AliExpress). It is estimated that when buying 1000 pieces (500 sets), the price per set will be around 20 euros.

Conclusion

Table X provides an overview of the estimated total costs for a complete product. With a batch of 500 pieces the total costs were estimated to be 112.33 euro. Moreover, it required a total investment of around 90.000 euros.

NOTE: for the estimation the tooling costs were written of on a total quantity of 5000 pieces.

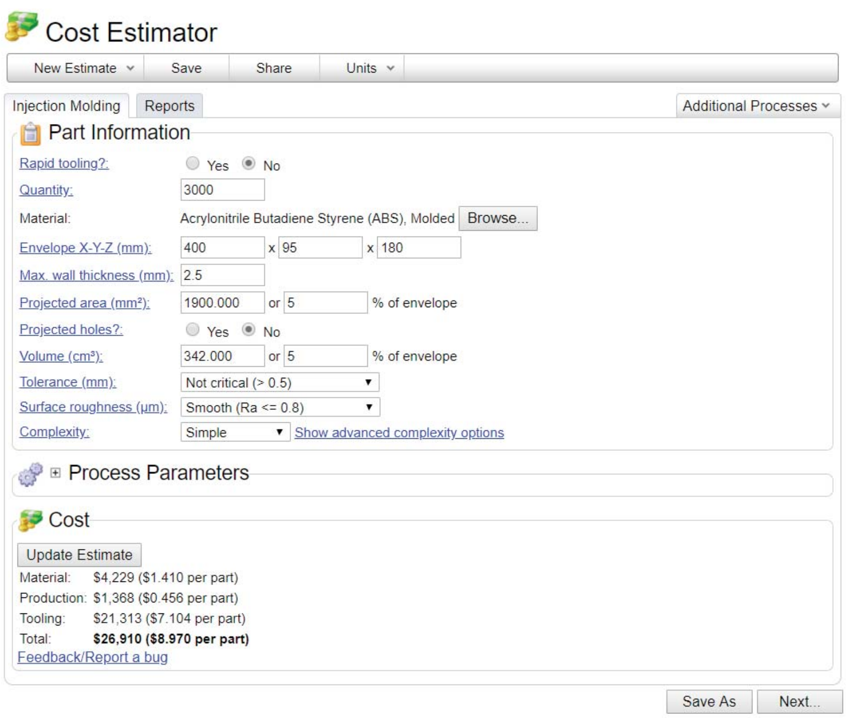


Figure 94: Cost price of the plastic parts estimated by means of an online cost estimator.

Figure 95: Quotation of all the sheet metal parts

Driessen Las- en plaatwerk B.V.
Kuiper 2
5521 DH Eersel
Postbus 195 5520 AD Eersel

Tel: 0497-519898
Fax: 0497-518229
E-mail: admin@driessenlp.nl
www.driessenlp.nl

Offerte: 2018.0381

Voor : Popal Fietsen
t.a.v. : Bart van Driessche
Adres : Huub van Doorneweg 2, 5151 DT Drunen
E-mail : info@bartvandriessche.nl
Datum : 12-10-2018

Geachte heer van Driessche,

Hartelijk dank voor uw offerte aanvraag. Naar aanleiding van uw prijsaanvraag hebben wij hierbij het genoegen u een aanbieding te doen toekomen inzake de volgende werkzaamheden c.q. tekeningnummers:

Aantal	Beschrijving werkzaamheden / tekeningnummer	Stuksprijs	Opmerkingen
1x 2x 25x 50x 100x 250x 500x	Car seat (dure versie)	€ 1285,- € 750,- € 272,50 € 250,- € 240,- € 233,- € 230,-	- *Plaatwerk uitgevoerd in RVS 304* - *Pos 006 uitgevoerd in Sinterbrons olie gesmeerd* - *Pos 007 gedraaid uit vol materiaal*
1x 2x 25x 50x 100x 250x 500x	Car seat (goedkopere versie)	€ 1190,- € 675,- € 206,50 € 186,50 € 176,- € 169,50 € 167,-	- *Plaatwerk uitgevoerd in RVS 304* - *Pos 006 uitgevoerd in RVS* - *Pos 007 gemaakt uit RVS ø18x12mm gelaste buis*

Prijzen : Af-fabriek, Exclusief finishing, Exclusief BTW.
Levertijd: **: In overleg na ontvangst van uw schriftelijke opdracht.**
Betaling : binnen 30 dagen netto.

De geldigheidsduur van deze offerte is twee maanden; prijzen zijn gebaseerd op huidige lonen en materiaalprijzen. Bij wijzigingen zijn wij genoodzaakt deze offerte te corrigeren.

Indien u vragen heeft naar aanleiding van deze offerte kunt u te allen tijde contact met ons opnemen. Bij correspondentie a.u.b. het referentienummer vermelden.

Wij vertrouwen erop u hiermee een passende aanbieding te hebben gedaan en zien uw reactie graag tegemoet. Indien u van deze offerte geen gebruik maakt, ontvangen wij graag per omgaande een gemotiveerde afwijzing.

Met vriendelijke groet,

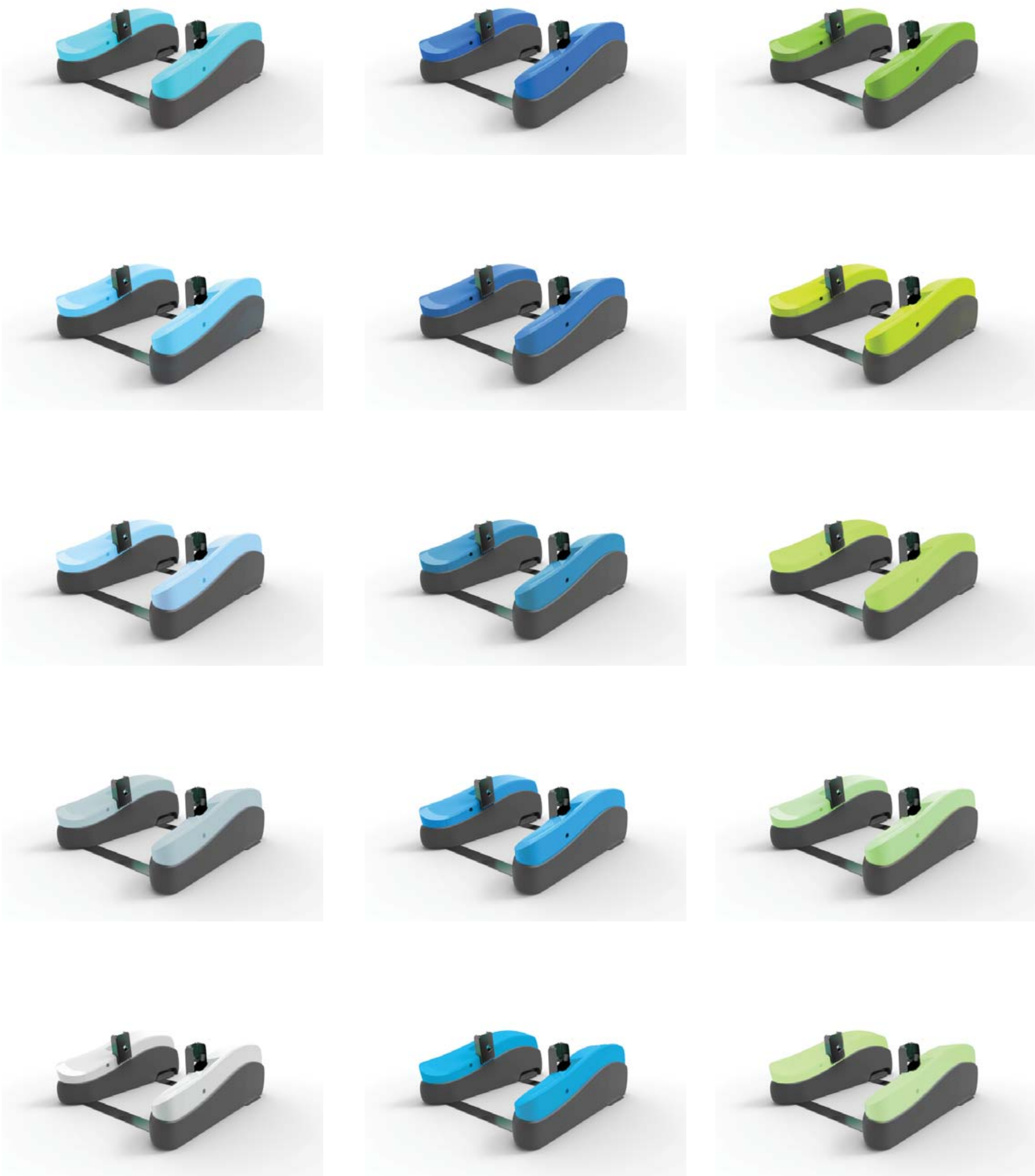
Driessen Las- en plaatwerk B.V.

Table 4: Total cost price of the individual parts and the product as a whole.
Categorized by means of production process or product category.

	Product nr.	Quantity	Description	Price unit
1. Sheet metal	1	1	Car seat adapter L	1
	2	1	Car seat adapter R	1
	3	1	Baseplate	1
	4	4	Diagonal beam	1
	5	2	Baseplate bracket	1
	6	1	Support bracket L	1
	7	1	Support bracket R	1
Total				
2. Steel tubing	8	16	Turning bearing	1
	9	8	Tube	1
Total				
3. Hardware	10	8	hexagon socket head shoulder screw	100
	11	16	Washer 8mm	100
	12	4	Washer 6mm	100
	13	12	M6 lock nut	100
	14	4	Hexagon bolt M6 x 40mm	100
Total				
4. Plastics	15	2	Plastic cover bottom	1
	16	2	Plastic cover top	1
Total				
Tooling costs			Tooling costs (mould)	
5. Damping element	17	2	Shock absorber	1
Total				
Total per unit				
Total investment				

Price	Price per unit	Batch size	Batch size	Batch size (optimized)		
		1	500	500		
€ 95.00	€ 95.00	€ 95.00	€ 13.57	€ 6.79		
€ 95.00	€ 95.00	€ 95.00	€ 13.57	€ 6.79		
€ 190.00	€ 190.00	€ 190.00	€ 27.14	€ 6.00		
€ 42.50	€ 42.50	€ 170.00	€ 24.29	€ 12.14		
€ 65.00	€ 65.00	€ 130.00	€ 18.57	€ 9.29		
€ 175.00	€ 175.00	€ 175.00	€ 25.00	€ 12.50		
€ 175.00	€ 175.00	€ 175.00	€ 25.00	€ 12.50		
					€ 66.00	€ 33,000.00
€ 7.50	€ 7.50	€ 120.00	€ 17.14	€ 6.00		
€ 5.00	€ 5.00	€ 40.00	€ 5.71	€ 4.00		
					€ 10.00	€ 5,000.00
€ 194.50	€ 1.95	€ 15.56	€ 7.78	€ 6.00		
€ 4.97	€ 0.05	€ 0.80	€ 0.40	€ 0.40		
€ 4.23	€ 0.04	€ 0.17	€ 0.08	€ 0.40		
€ 6.75	€ 0.07	€ 0.81	€ 0.41	€ 0.20		
€ 50.20	€ 0.50	€ 2.01	€ 1.00	€ 1.00		
					€ 8.00	€ 4,000.00
€ 2.00	€ 2.00	€ 4.00	-	-		
€ 2.00	€ 2.00	€ 4.00	-	-		
					€ 8.00	€ 4,000.00
						€ 35,000.00
€ 10.00	€ 10.00	€ 20.00	€ 13.33	€ 13.33		
					€ 13.33	€ 6,665.00
		€ 1,209.34	€ 179.67		**€ 112.33**	
						€ 87,665.00

Appendix 41 Color study
















Appendix 42
Prototyping

Part of the design proposal was made out of plastic (the covers). The other part was made out of sheet metal (the suspension frames). The plastic covers were 3D printed. To fit the printing bed of the 3D printer, these parts were split in 5 pieces. Subsequently, each part was 3D printed, glued together, sanded and spray painted (Figure 96).

To guarantee the highest quality, the sheet metal parts (material: stainless steel) were laser cut, bent and welded at an external company specialized in the manufacturing of sheet metal (Figure 97).

41.1 Tolerances

During assembly it became clear that the plain bushings had a loose running fit (H11) for wide commercial tolerances (measured hole diameter: around 8.3mm). Moreover, the M8 hex bolts that served as axes had a body diameter of 7.7 - 7.8mm. As a consequence, hexagon socket head shoulder screws with a precise diameter of 8mm and plain bushings with a locational clearance fit (H7) were used.

42.2 Optimizing for comfort

Firstly, seven different orifice radii were tested. The vibrational transmissibility values of each orifice radii can be found in Table 5. Until radii 1.5 (2x) + 1.25 (2x) mm, the vibrational transmissibility improved significantly. The difference in vibrational transmissibility between orifice radii 1.5 (2x) + 1.25 (2x) mm and 1.5 (4x) mm barely differs: radii 1.5 (2x) + 1.25 (2x) mm worked slightly better. It was assumed that increasing the radii even more, would result in a too high flow rate: the damping would become too low and, thus, the vibrational transmissibility would worsen. In other words, the shock absorber with orifice radii 1.5 (2x) + 1.25 (2x) mm showed the lowest vibrational transmissibility.

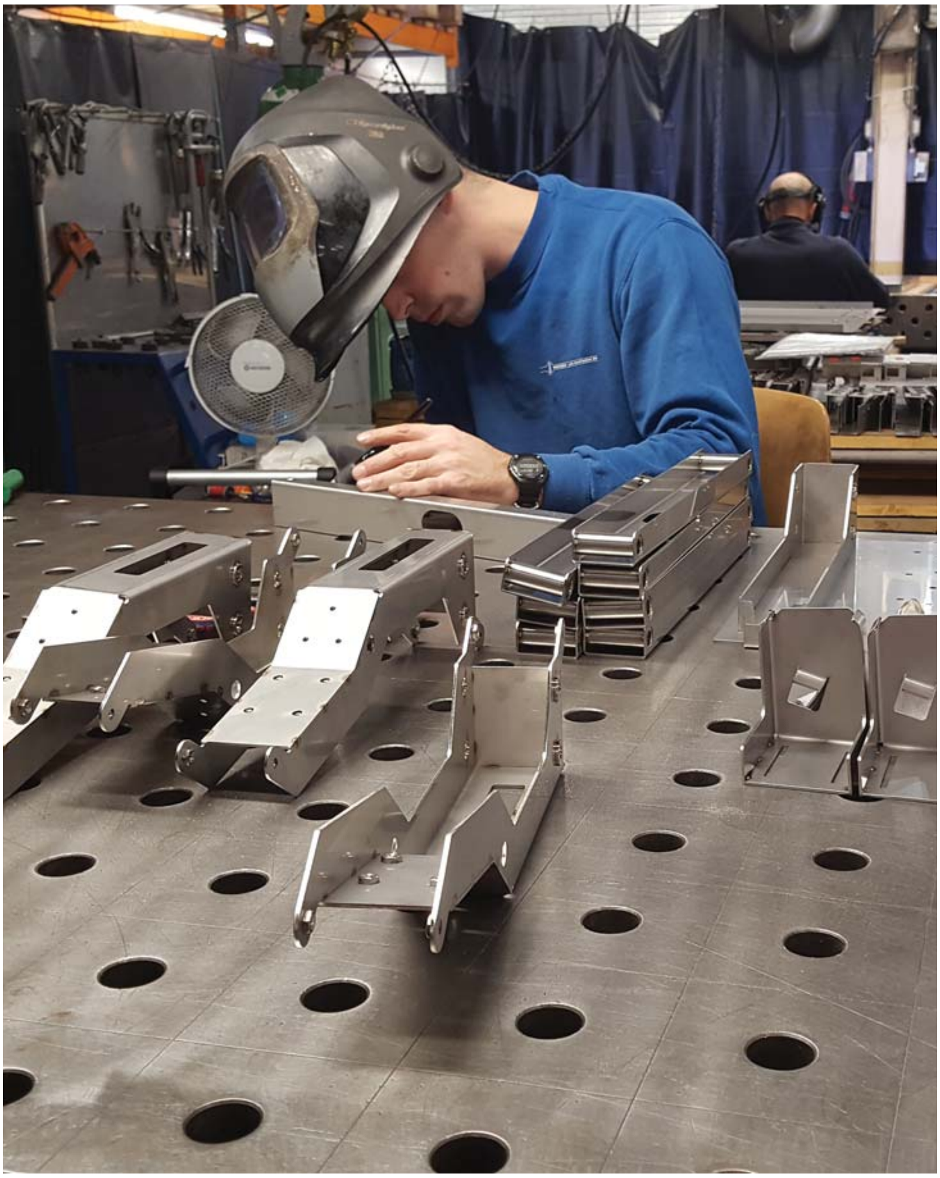
The next 10 pages show the technical drawings that were exported to Driessen Las en Plaatwerk.

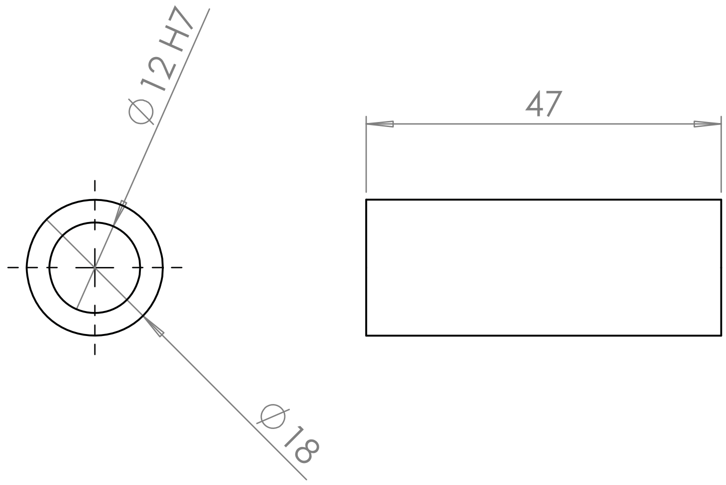
Orifice radii	Vibrational transmissibility		
	x	y	z
0.9 (2x)	212%	97%	128%
1 (2x)	200%	175%	126%
1.25 (2x)	211%	156%	116%
1.5 (2x)	195%	187%	85%
1.5 (2x) + 1 (2x)	345%	198%	81%
1.5 (2x) + 1.25 (2x)	213%	199%	76%
1.5 (4x)	164%	201%	77%

Table 5: Vibrational transmissibility values of different orifice radii for the x, y and z-direction, measured on the test track.

Figure 96: (left) The plastic covers were 3D printed and glued together.

Figure 97: (right) the sheet metal parts (material: stainless steel) were laser cut, bent and welded at an external company specialized in the manufacturing of sheet metal





THIRD ANGLE PROJECTION

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APPV'D			
MFG			
Q.A			

MATERIAL:

WEIGHT:

TITLE:

Tube

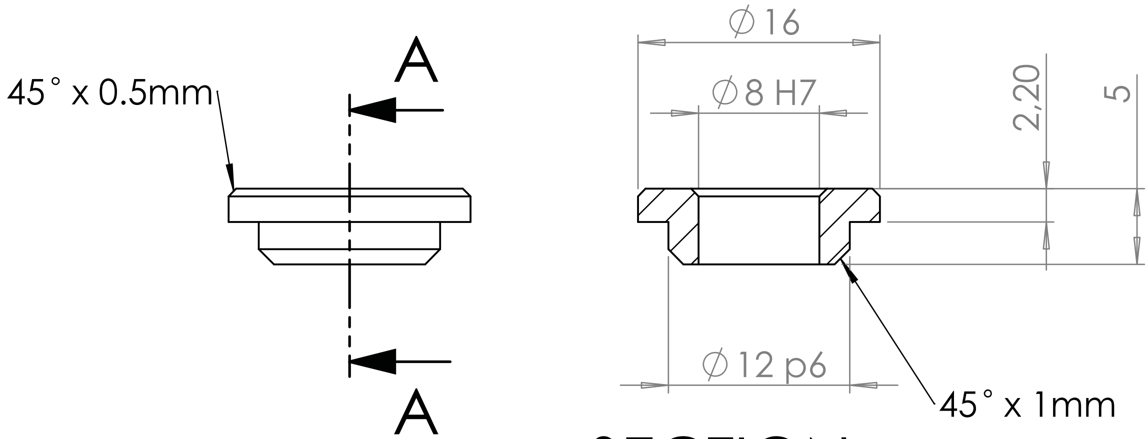
DWG NO.

007

A4

SCALE:1:1

SHEET 1 OF 1



SECTION A-A

THIRD ANGLE PROJECTION

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE		
DRAWN					
CHK'D					
APPV'D					
MFG					
Q.A					

MATERIAL:

WEIGHT:

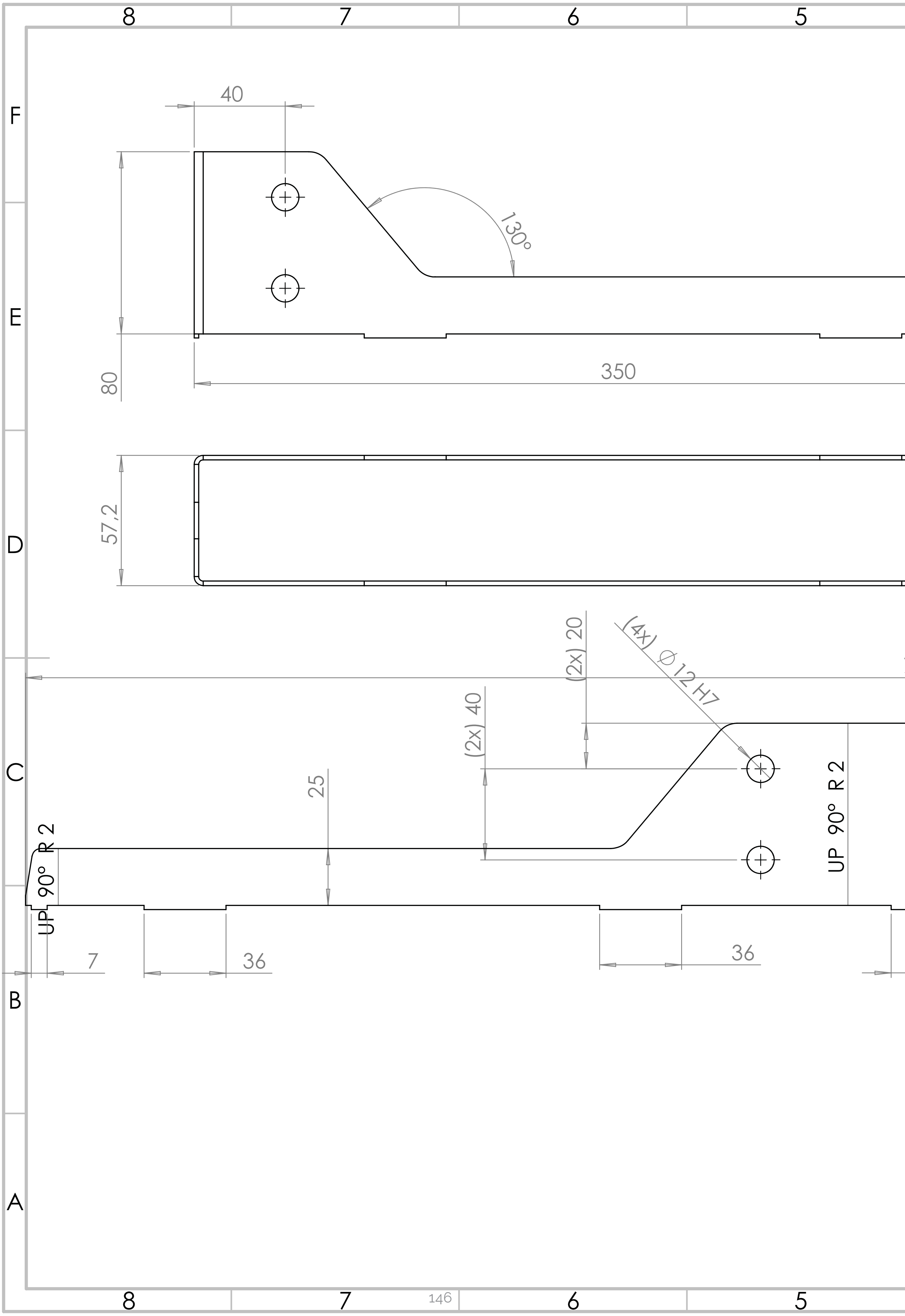
TITLE: Turning bearing

DWG NO. 006

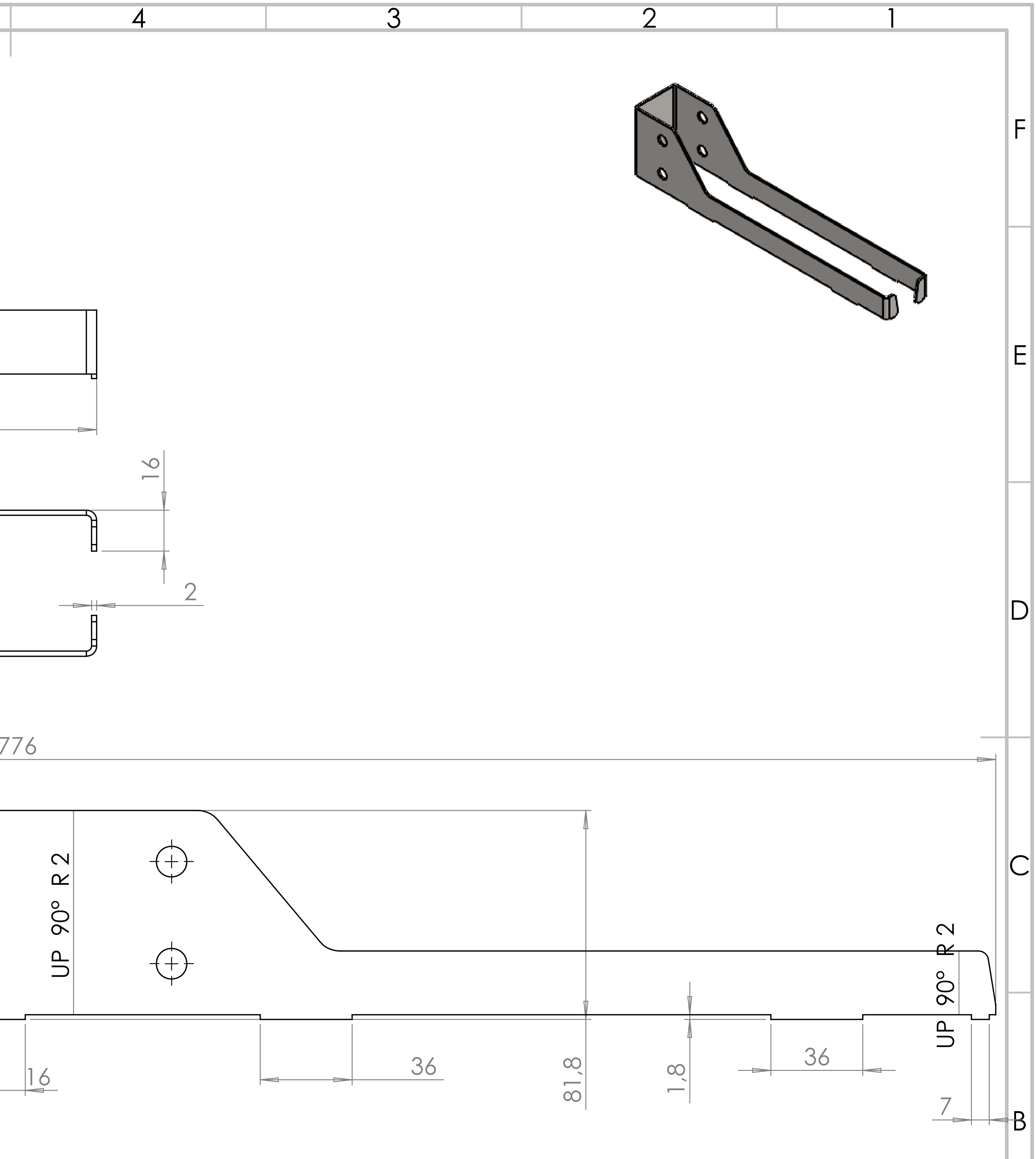
A4

SCALE:2:1

SHEET 1 OF 1



8
7
6
5
F
E
D
C
B
A
40
130°
80
350
57,2
(2x) 20
(4x) Ø12 H7
(2x) 40
25
UP 90° R 2
UP 90° R 2
7
36
36



THIRD ANGLE PROJECTION	FINISH:		DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION

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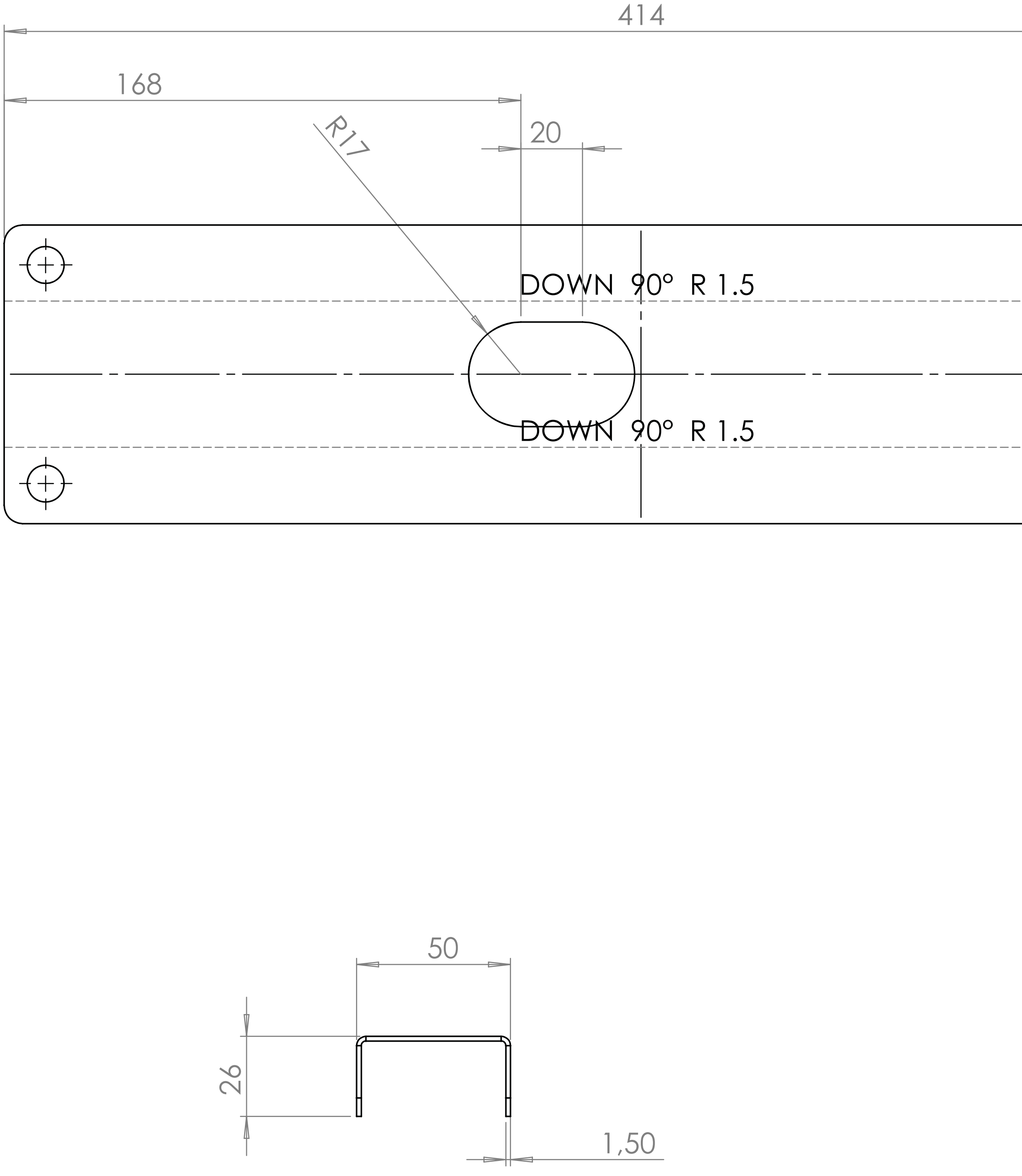
DRAWN					
CHK'D					
APPV'D					
MFG					
Q.A				MATERIAL:	
				WEIGHT:	

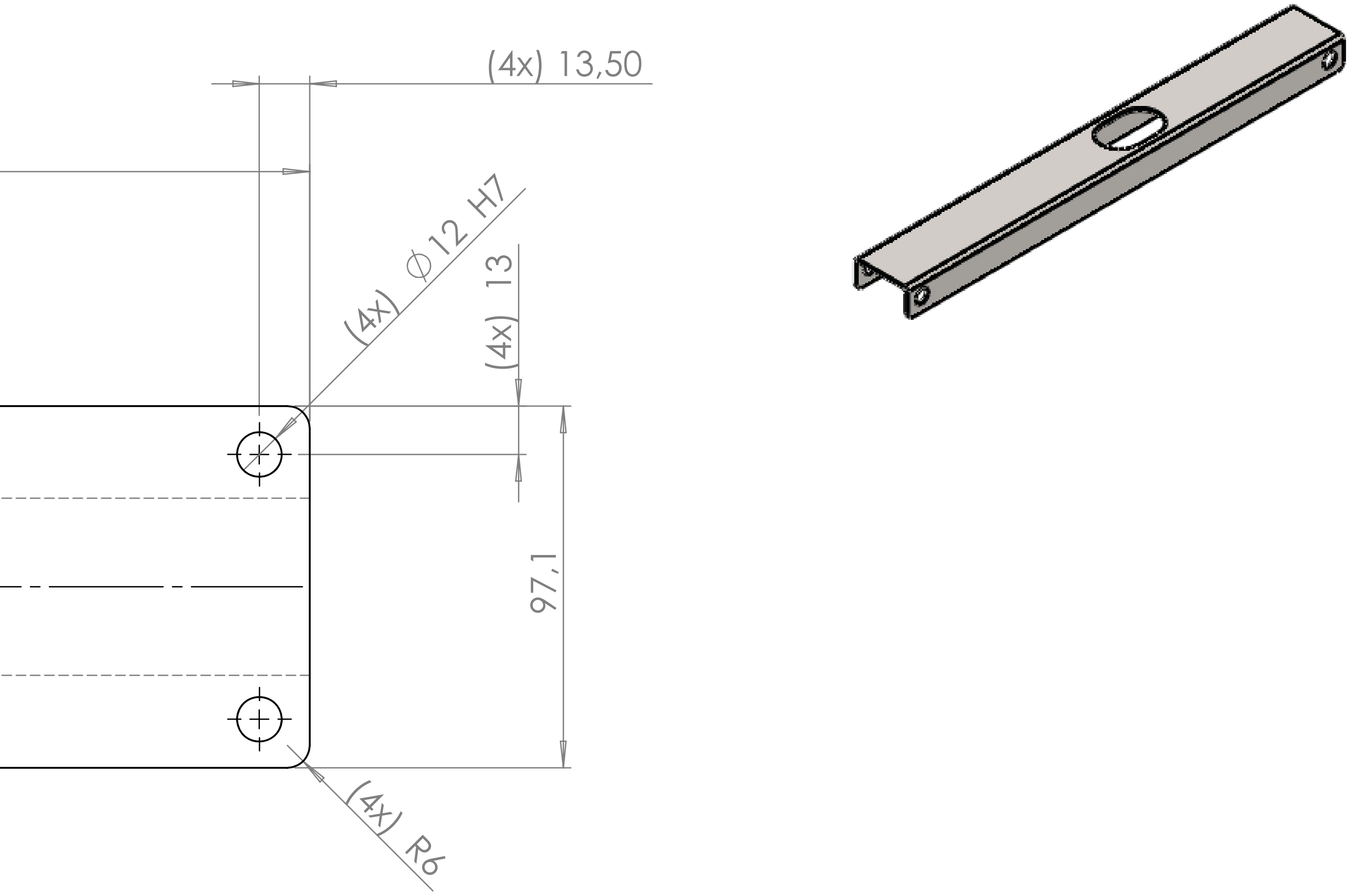
TITLE:
Baseplate Bracket

DWG NO. 004 — A3

SCALE:1:2 — SHEET 1 OF 1



414
168
R17
20
DOWN 90° R 1.5
DOWN 90° R 1.5
50
26
1,50



THIRD ANGLE PROJECTION

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APPV'D			
MFG			
Q.A			

MATERIAL:

WEIGHT:

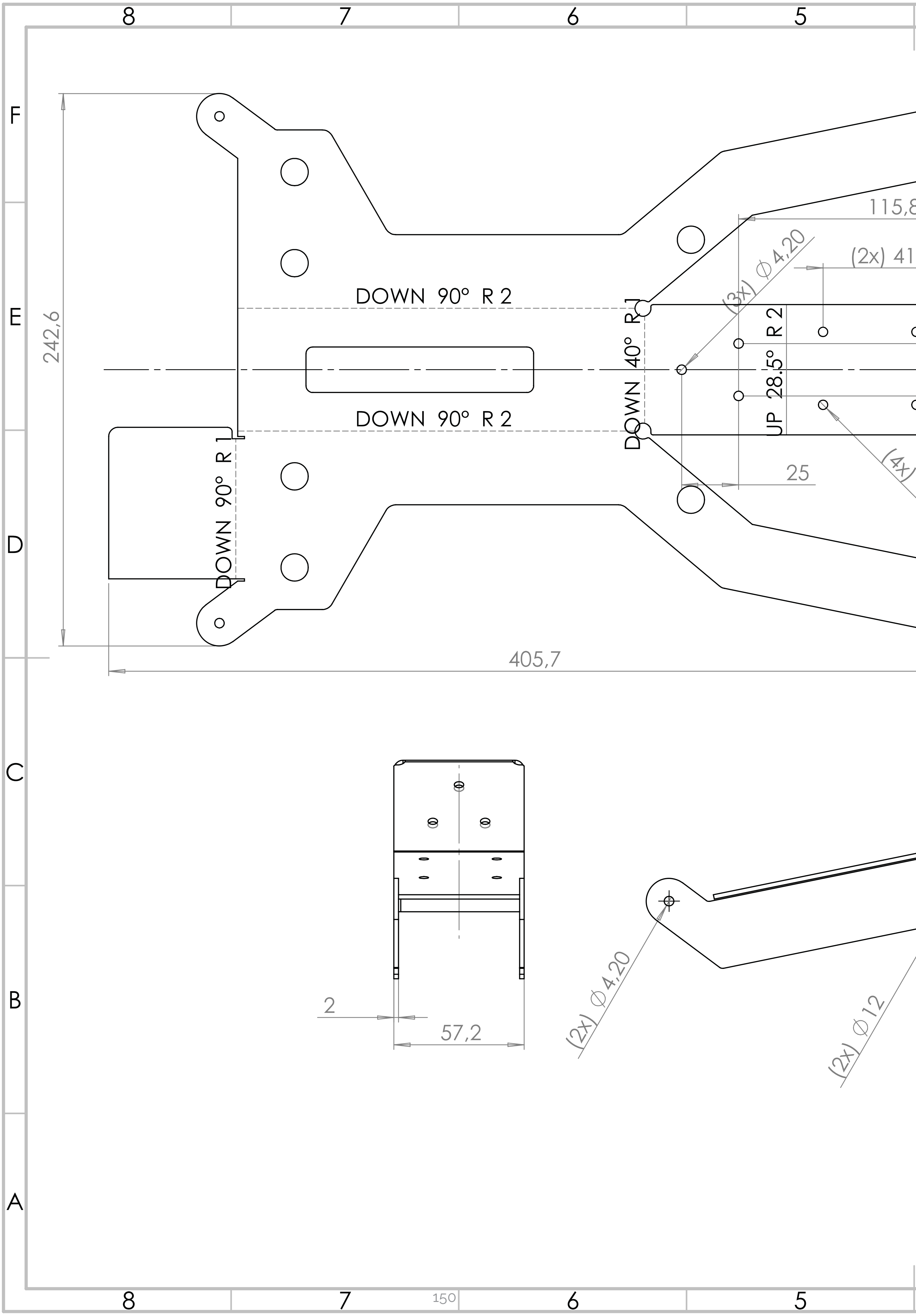
TITLE: Diagonal Beam

DWG NO. 003

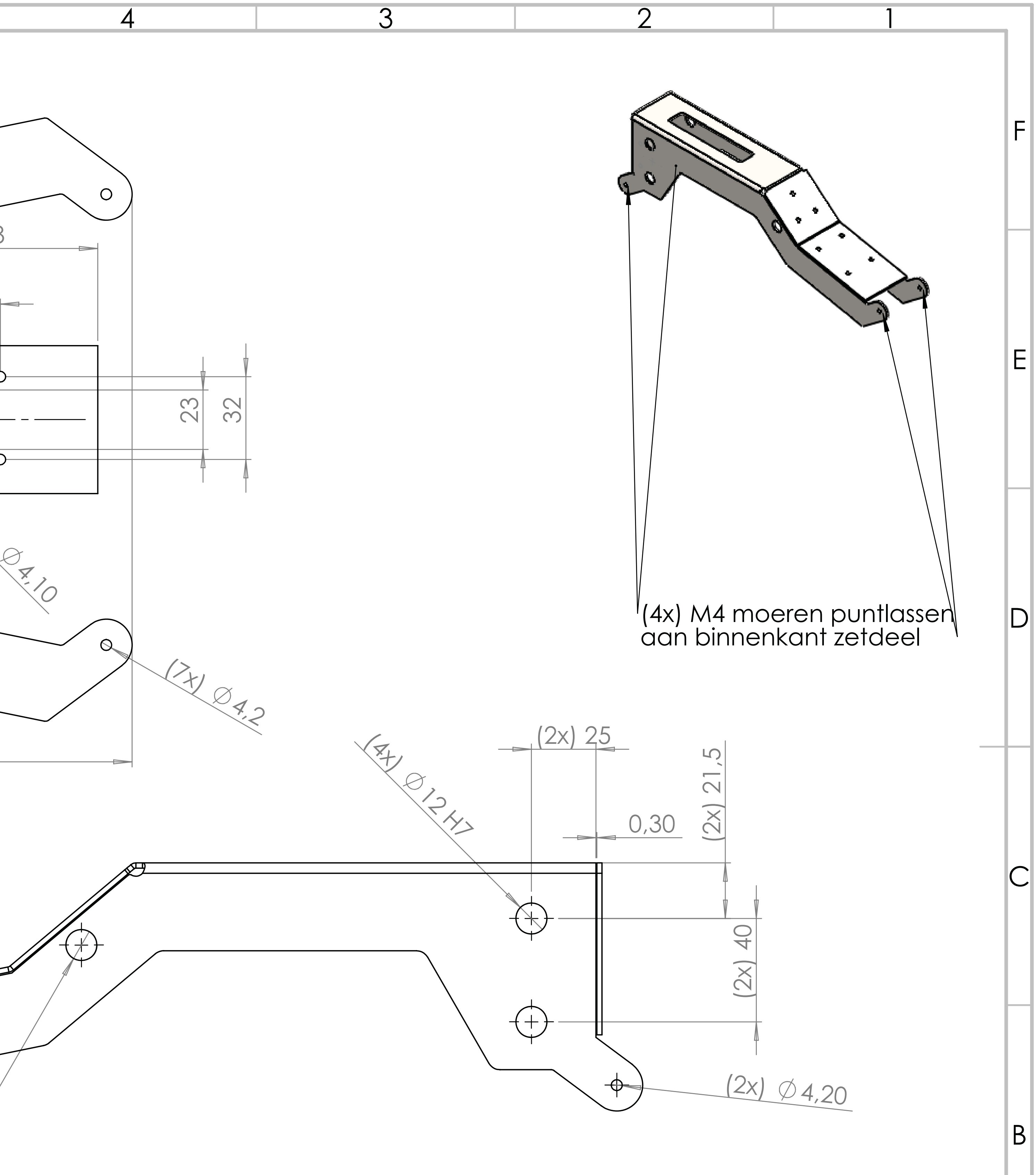
A3

SCALE:1:2

SHEET 1 OF 1



8
7
6
5
F
E
D
C
B
A
242,6
DOWN 90° R 2
DOWN 90° R 2
DOWN 40° R 1
DOWN 90° R 1
UP 28.5° R 2
115,8
(2x) 41
(3x) ∅4,20
25
(4x)
405,7
2
57,2
(2x) ∅4,20
(2x) ∅12



THIRD ANGLE PROJECTION

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APPV'D			
MFG			
Q.A			

MATERIAL:

WEIGHT:

TITLE:

Support Bracket

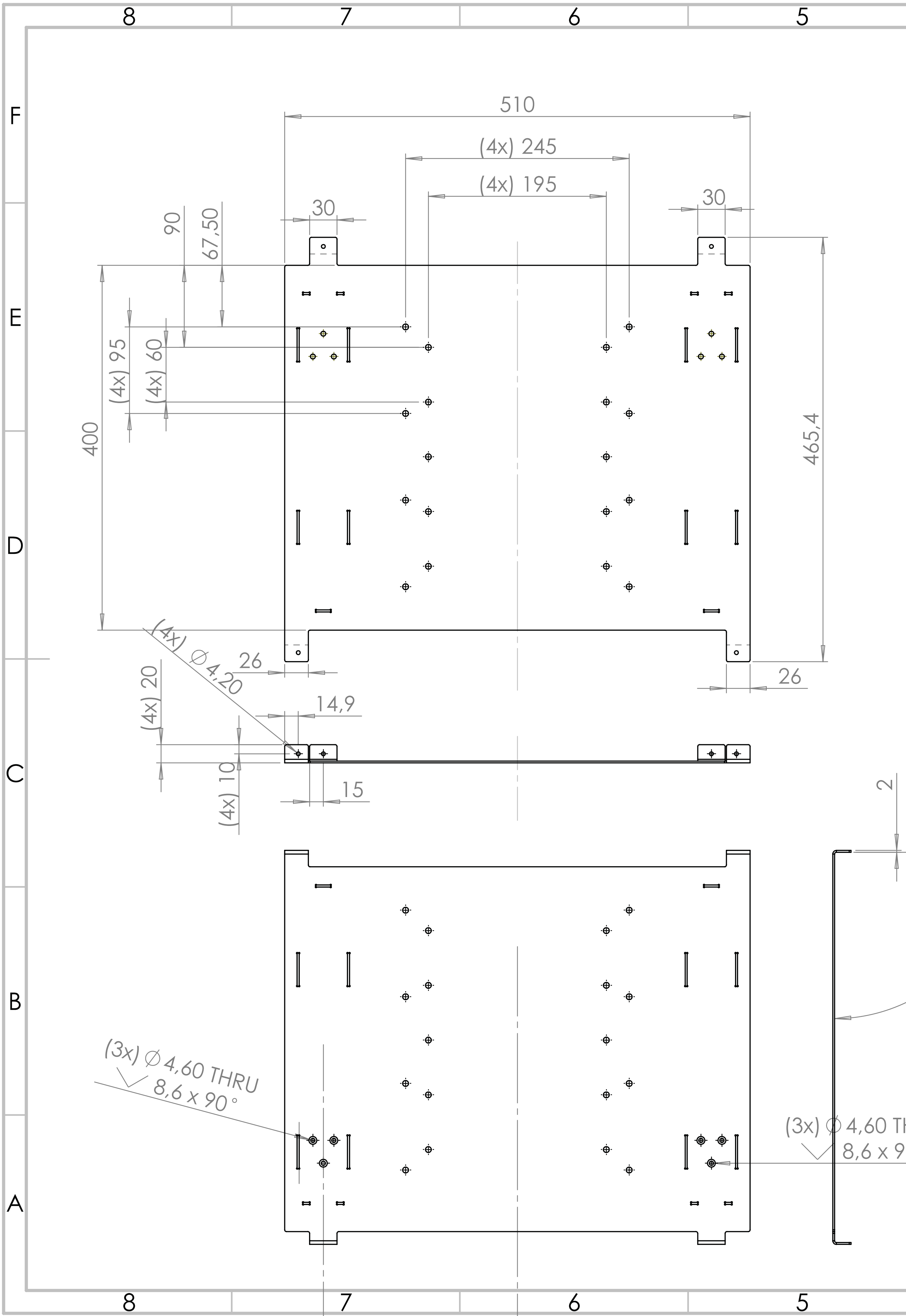
DWG NO.

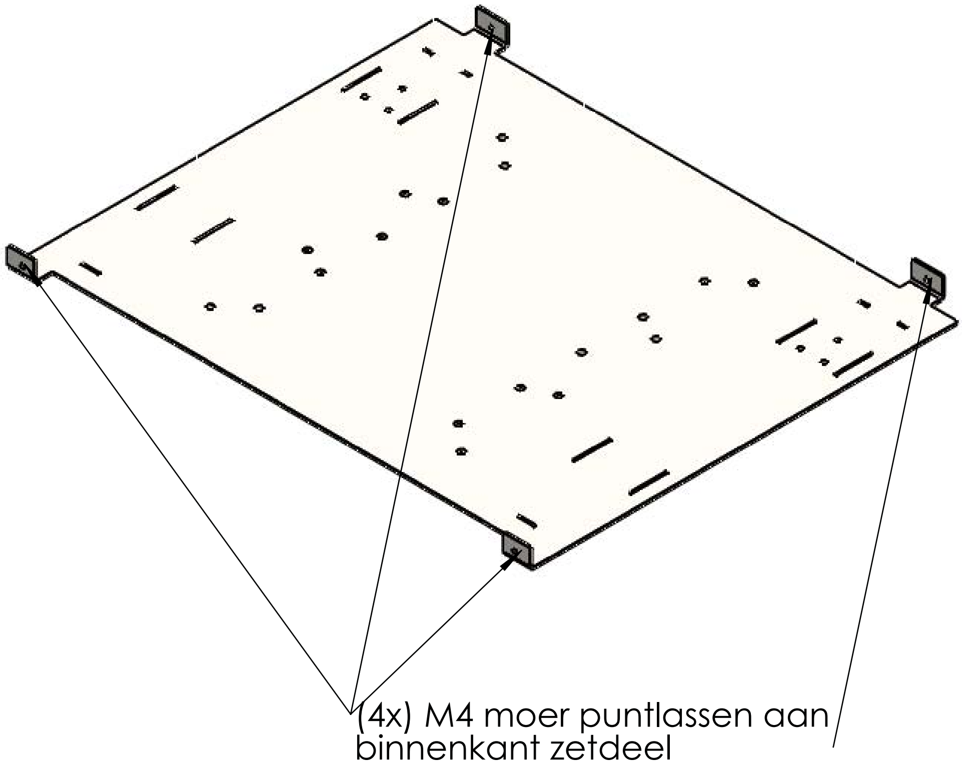
005-V2

A3

SCALE:1:2

SHEET 1 OF 1


8
7
6
5
F
E
D
C
B
A
510
(4x) 245
(4x) 195
30
30
90
67,50
(4x) 95
(4x) 60
400
465,4
(4x) Ø 4,20
26
26
14,9
(4x) 20
(4x) 10
15
2
(3x) Ø 4,60 THRU
8,6 x 90°



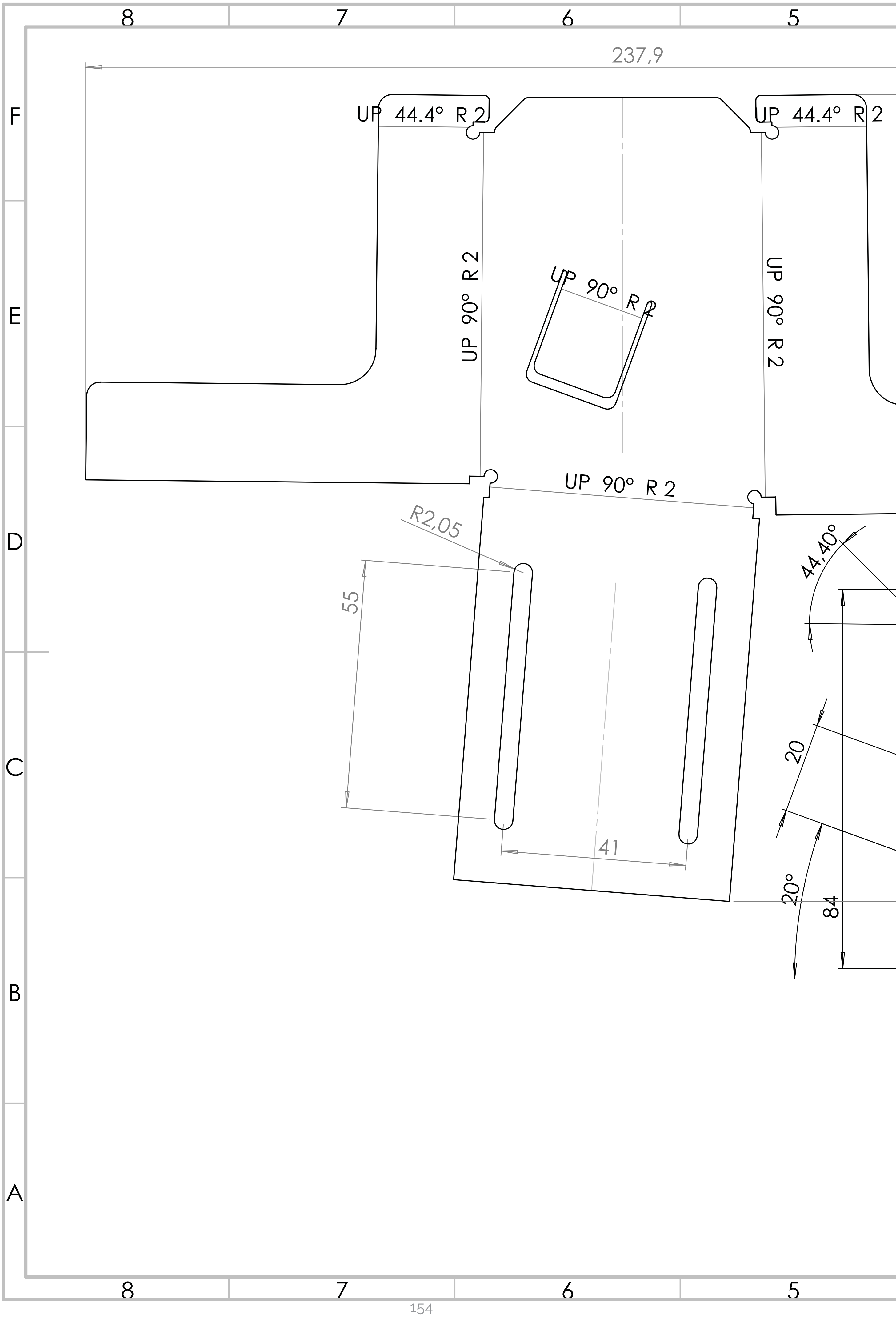
THIRD ANGLE PROJECTION	Finish:	DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION

	NAME	SIGNATURE	DATE	
DRAWN				
CHK'D				
APPV'D				
MFG				
Q.A				MATERIAL:
				WEIGHT:

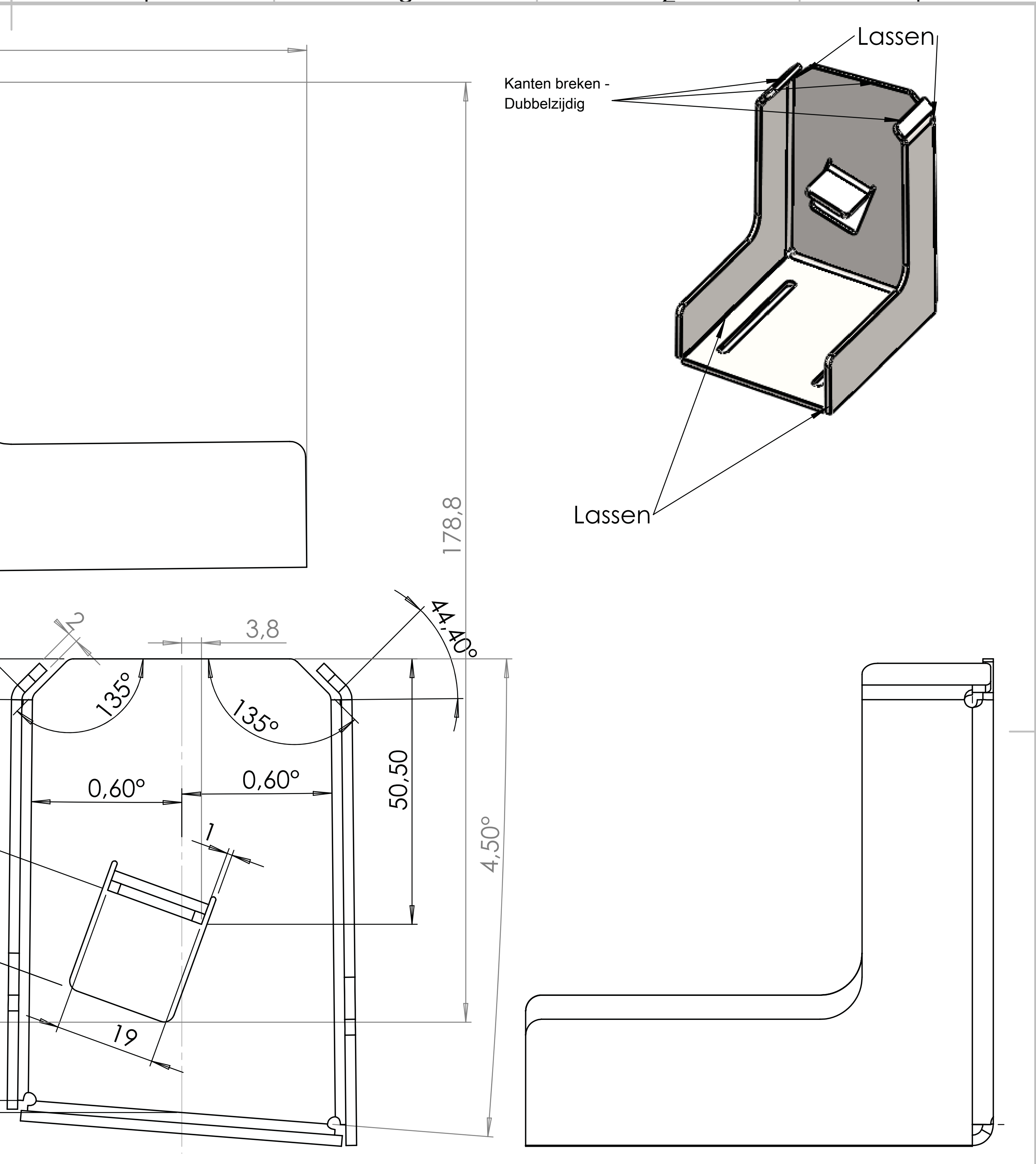
TITLE: **Baseplate**

DWG NO. **002-V2** | A3

SCALE:1:5 | SHEET 1 OF 1



8
7
6
5
237,9
F
E
D
C
B
A
UP 44.4° R 2
UP 44.4° R 2
UP 90° R 2
UP 90° R 2
UP 90° R 2
UP 90° R 2
R2,05
55
41
44,40°
20
20°
84



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:	FINISH:	DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION

	NAME	SIGNATURE	DATE		
DRAWN					
CHK'D					
APPV'D					
MFG					
Q.A				MATERIAL:	
				WEIGHT:	

TITLE: Car seat adapter

DWG NO. 001-V2 A3

SCALE:1:1 SHEET 1 OF 1

Appendix 43

Unweighted r.m.s. acceleration values

Measured on the supporting surface under the head

Weight	Location	Road type Road bricks		
		rmsx	rmsy	rmsz
5 kg	Head	2.934	3.074	3.118

Weight	Location	Road type Road bricks		
		rmsx	rmsy	rmsz
8 kg	Head	3.383	2.685	3.099

Weight	Location	Road type Road bricks		
		rmsx	rmsy	rmsz
10 kg	Head	3.367	2.853	3.107

Weight	Location	Road type Road bricks					
		x-direction		y-direction		z-direction	
		rms	Reduction	rms	Reduction	rms	Reduction
5 kg	Head	1.986	-32%	1.319	-57%	1.883	-40%

Weight	Location	Road type Road bricks					
		x-direction		y-direction		z-direction	
		rms	Reduction	rms	Reduction	rms	Reduction
8 kg	Head	1.544	-54%	1.233	-54%	1.745	-44%

Weight	Location	Road type Road bricks					
		x-direction		y-direction		z-direction	
		rms	Reduction	rms	Reduction	rms	Reduction
10 kg	Head	1.511	-55%	1.216	-57%	1.336	-57%

Weight	Location	Road type Road bricks					
		x-direction		y-direction		z-direction	
		rms	Reduction	rms	Reduction	rms	Reduction
5 kg	Head	1.642	-44%	1.460	-53%	1.776	-43%

Weight	Location	Road type Road bricks					
		x-direction		y-direction		z-direction	
		rms	Reduction	rms	Reduction	rms	Reduction
8 kg	Head	1.968	-42%	1.568	-49%	1.793	-42%

Weight	Location	Road type Road bricks					
		x-direction		y-direction		z-direction	
		rms	Reduction	rms	Reduction	rms	Reduction
10 kg	Head	1.980	-41%	1.595	-49%	1.843	-41%

Table 7: overview of the average unweighted r.m.s. acceleration values for *road bricks* for all three models, for the measurements under the head. From left to right: Steco Baby Mee, the wooden test model and the steel prototype. Next to the r.m.s. values of the test model and the prototype, the exact reduction can be found in comparison to corresponding value of the Steco Baby Mee.

Weight	Location	Road type Concrete tiles		
		rmsx	rmsy	rmsz
5 kg	Head	3.224	2.767	3.371

Weight	Location	Road type Concrete tiles		
		rmsx	rmsy	rmsz
8 kg	Head	3.145	3.298	3.159

Weight	Location	Road type Concrete tiles		
		rmsx	rmsy	rmsz
10 kg	Head	2.142	2.624	2.766

Weight	Location	Road type Concrete tiles					
		x-direction		y-direction		z-direction	
		rms	Reduction	rms	Reduction	rms	Reduction
5 kg	Head	1.473	-54%	1.522	-45%	1.642	-51%

Weight	Location	Road type Concrete tiles					
		x-direction		y-direction		z-direction	
		rms	Reduction	rms	Reduction	rms	Reduction
8 kg	Head	1.430	-55%	1.172	-64%	1.524	-52%

Weight	Location	Road type Concrete tiles					
		x-direction		y-direction		z-direction	
		rms	Reduction	rms	Reduction	rms	Reduction
10 kg	Head	1.323	-38%	1.273	-51%	1.502	-46%

Weight	Location	Road type Concrete tiles					
		x-direction		y-direction		z-direction	
		rms	Reduction	rms	Reduction	rms	Reduction
5 kg	Head	1.523	-53%	1.637	-51%	1.862	-45%

Weight	Location	Road type Concrete tiles					
		x-direction		y-direction		z-direction	
		rms	Reduction	rms	Reduction	rms	Reduction
8 kg	Head	1.420	-55%	1.675	-47%	1.845	-42%

Weight	Location	Road type Concrete tiles					
		x-direction		y-direction		z-direction	
		rms	Reduction	rms	Reduction	rms	Reduction
10 kg	Head	1.327	-38%	1.423	-49%	1.777	-36%

Table 6: overview of the average unweighted r.m.s. acceleration values for *concrete tiles* for all three models, for the measurements under the head. From left to right: Steco Baby Mee, the wooden test model and the steel prototype. Next to the r.m.s. values of the test model and the prototype, the exact reduction can be found in comparison to corresponding value of the Steco Baby Mee.

Appendix 44 Differences between constructions

Difference 1 Mechanism quantity

Wooden test model	Steel prototype
1 (linked, underneath seat)	2 (separate, next to seat)

Description
Having two separate mechanisms might have a detrimental effect on the simultaneous movement of both mechanisms. When oscillating, one side of the mechanism might still travel downwards, while the other side of the mechanism might travel upwards again. Thus, the velocity and acceleration of each side of the mechanism differ. Moreover, a difference in tightening torque might put more or less friction on the pivot points.

Effect
If the mechanisms does not move simultaneously, unwanted lateral rotation (roll) might increase the acceleration values. Consequently, the infant will experience higher r.m.s. acceleration values (predominantly in the x and y direction).

Result
To validate whether the mechanisms moved simultaneously, a transducer was placed on each side of the mechanism (Figure 98-252). Thereafter, the difference between the left and right side was calculated. For the wooden test model, two transducers were placed at the edge of the interface plane (Figure 98).

In the x and y-direction, on road bricks and concrete tiles, the prototype and the wooden test model showed a marginal difference in vibrational transmissibility between the left and right side of the mechanism. In the x-direction, the prototype showed an increase of 4.2% and 1.5% for road bricks and concrete tiles, respectively. In the y-direction, the prototype showed a decrease of -2.7% and -5.0% for road bricks and concrete tiles, respectively.

Though, In the z-direction, the differences were higher, an increase of 9.1% and 8.4% for road bricks and concrete tiles, respectively. This could cause unwanted lateral rotation (roll). It is plausible that this lateral rotation is one of the causes of the higher r.m.s. acceleration values in the x and y-direction, measured on the prototype on road bricks.

	Construction	Road type		
		Road bricks		
		diff. x	diff. y	diff. z
1	Test model	19.8%	7.6%	3.0%
	Prototype	24.0%	4.9%	12.1%
2	Difference	**4.2%**	**-2.7%**	**9.1%**

	Construction	Road type		
		Concrete tiles		
		diff. x	diff. y	diff. z
1	Test model	13.9%	13.3%	7.4%
	Prototype	15.4%	8.3%	15.8%
2	Difference	**1.5%**	**-5.0%**	**8.4%**

Table 8: Row 1 shows the difference in vibrational transmissibility between the left and right side of each construction, for three directions. Row 2 shows the relative increase (+) or decrease (-).

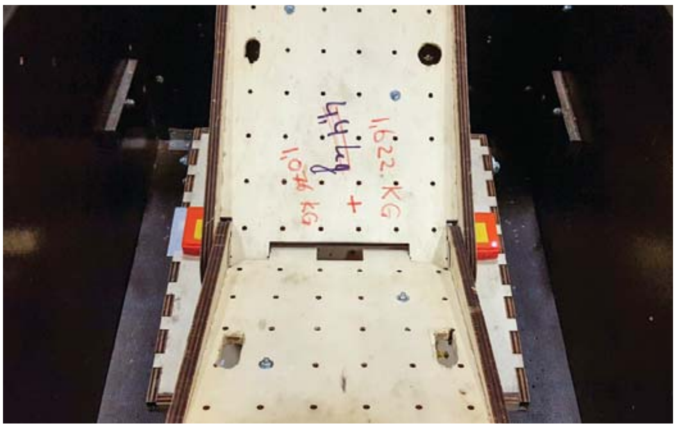


Figure 98: Transducers were placed on each side of the mechanism (wooden test model)

Figure 99: Transducers were placed on each side of the mechanism (steel prototype)

Difference 2 Mechanism material

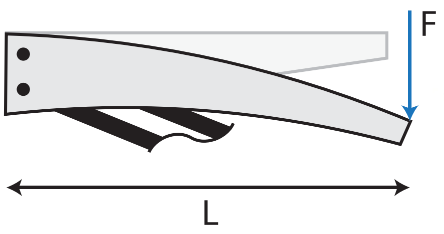
Wooden test model	Steel prototype
Plywood	Stainless steel

Description
The natural frequency of a material depends on the Young's Modulus (Modulus of Elasticity, E). The higher the Young's Modulus, the higher the natural frequency. The Young's Modulus of Stainless Steel is in the range of 189 – 210 GPa (CES, 2018). The Young's Modulus of Plywood is in the range of 6,9 – 13 GPa (CES, 2018). In the example of the free vibration of a cantilever beam and assuming the same cantilever beam dimensions, this means that the natural frequency of a stainless steel beam is 4 to 5 times higher than the natural frequency of a plywood beam.

In other words, the more flexible a part, the lower its natural frequency; the more rigid, the higher the natural frequency (Buscarello, 2002).

Effect
It was assumed that the cantilever deflections from the equilibrium position were very small. In that case, the mechanism material has barely any effect on the difference in vibrational transmissibility values.

Though, to minimize cantilever deflection it is desirable to keep length L as small as possible, since the largest deflection takes place near the free end with a decay to zero at the clamped end.



$$f_1 = \frac{(1.875)^2}{2\pi L^2}\sqrt{\frac{EI}{\rho A}}$$

Figure 100: free vibration of the upper part of the mechanism (set in motion by an external force, F) and its corresponding natural frequency.

Difference 3 Seat (basket) material

Wooden test model	Steel prototype
Plywood - 9 mm	ABS - 2-3 mm thickness

Description
The Young's Modulus of ABS is in the range of 1,1 – 2,9 GPa (CES, 2018). In the example of the free vibration of a cantilever beam and assuming the same cantilever beam dimensions, this means that the natural frequency of a plywood beam is 2 to 3 times higher than the natural frequency of an ABS beam.

Moreover, the plywood seat basket had a much thicker material thickness, making the construction more rigid. It is likely that the natural frequency of the plywood seat basket is higher.

Effect
It was assumed that the difference in seat (basket) material had barely any effect on the difference in vibrational transmissibility values.

Difference 4 Mechanism weight

Wooden test model	Steel prototype
1.3 kg	3.1 kg

Description
The weight of the construction affects the:

1. Moment of Inertia
2. Natural frequency
3. Damping ratio

1. Moment of Inertia

The moment of Inertia (or rotational Inertia, I), of a rigid body, is a tensor that determines the torque needed for a desired angular acceleration about a rotational axis, that is (in the case of a point mass):

I = m*r^2

If the shape of the body does not change, then its moment of inertia appears in Newton's law of motion as the ratio of an applied torque (τ) on a body to the angular acceleration (α) around a principal axis, that is:

α = Σ τ / I

This means, that:

If I = high -> α = low -> more difficult to accelerate angularly;
If I = low -> α = high -> easier to accelerate angularly

Effect (of moment of inertia)
Increasing the mass will result in a higher moment of inertia: the system will accelerate more difficult angularly,

which is beneficial. Yet, once in vibration, the system needs more time to decay to zero to its equilibrium position. On the other side, decreasing the mass result in a lower moment of inertia: the system will accelerate easier angularly, which is detrimental. Yet, once in vibration, the system needs less time to decay to zero to its equilibrium position.

Result (of moment of inertia)
A lighter mass will most likely perform better. Although the system will accelerate easier angularly, this acceleration can be accommodated with by the right spring rate and damping characteristics. In other words, the mass of the wooden test model is beneficial in terms of vibrational transmissibility.

2. Natural frequency

The weight of the construction affects the natural frequency, according to the following equation:

$$Fn = \frac{1}{2\,\pi}\sqrt{\frac{K}{M}}\quad [Hz]$$

Effect (of natural frequency)
The higher the mass, the lower the natural frequency; the lower the mass, the higher the natural frequency. It is desirable that the ratio of the disturbing frequency, fd, over the natural frequency, fn, is as large as possible.

Result (of natural frequency)
To validate the natural frequency of both systems, the cargo bike was placed on top of a wooden beam with a height of 5 cm. A transducer was attached to the mechanism and the cargo bike was pushed backwards. Based on the output signal, the natural frequency of the system was experimentally validated.

The values in Table 9 indicate that the wooden test model had a lower natural frequency in comparison to the steel prototype. The values show a natural frequency of around 2.1 Hz and around 2.7 Hz when loaded with a 5 kg test dummy (damped), for the wooden test model and steel prototype, respectively. When loaded with a 8 kg test dummy, the natural frequencies are around 2.2 Hz and 2.6 Hz, respectively.

Figure 101: To validate the natural frequency of both systems, the cargo bike was placed on top of a wooden beam with a height of 5 cm. A transducer was attached to the mechanism and the cargo bike was pushed backwards.

Wooden test model

Location	Damping	5 kg Fn [Hz]	8 kg Fn [Hz]
Interface	Damped	2.08	2.19
	Undamped	2.25	1.98
	Ratio	-7%	11%
Seat	Damped	2.16	2.19
	Undamped	1.97	2.17
	Ratio	10%	1%

Prototype

Location	Damping	5 kg Fn [Hz]	8 kg Fn [Hz]
Interface	Damped	2.63	2.57
	Undamped	2.28	2.11
	Ratio	15%	22%
Seat	Damped	2.83	2.57
	Undamped	2.48	2.21
	Ratio	14%	16%

Table 9: Natural frequencies of the wooden test model (upper) and the steel prototype (lower) for different weights and damped and undamped conditions.

3. Damping ratio

The weight of the construction affects the damping ratio, according to the following equation:
Effect (of damping ratio)

$$\zeta 1 := \frac{c}{2\sqrt{m \cdot k}}$$

A lower damping ratio implies a lower decay rate, and so very underdamped systems oscillate for long times; a higher damping ratio implies a higher decay rate, and so very overdamped systems oscillate for short times. In addition, making the damping ratio smaller results in a stronger region of isolation (Brown University School of Engineering, n.d.).

Result (of damping ratio)

Table 9 also shows the ratio of the damped natural frequency over the undamped natural frequency. The ratio values of the wooden test model are smaller in comparison to the steel prototype. This might suggest that the wooden test model had a lower damping ratio and, thus, stronger region of isolation.

Difference 5 Seat (basket) weight

Wooden test model	Steel prototype
1.6 kg	3.5 kg

Description
Similar to difference 4.

Difference 6 Seat (basket) attachment

Wooden test model	Steel prototype
Fastened	Car seat adapter

Description
In the steel prototype, the infant safety seat was attached to the car seat adapter. When attached, there was still limited rotation possible. To validate whether the connection between the infant safety seat and the car seat adapter led to an increase in vibrational values, a test was executed in which the infant safety seat was fastened to the construction by means of zip ties.

Effect
No significant difference was found between a 'normal' fit and 'fastened' fit of the infant safety seat (Table x).

Location	Normal			Fastened		
	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
Floor	0.717	0.788	2.350	0.725	0.755	2.603
Head	1.398	1.141	1.474	1.251	1.305	1.615
Vibra, Trans.	194.9%	144.8%	62.7%	172.5%	172.8%	62.1%

Table 10: Vibriational transmissibility and unweighted r.m.s. acceleration values [m/s2] of the normal situation and a situation in which the infant safety seat was fastenend to the construction by means of zip ties.

Difference 7 Center of gravity (CoG, vertical)

Wooden test model	Steel prototype
260 - 320 mm (depending on weight)	145 - 205 mm (depending on weight)

Description
A lower center of gravity increases stability. Moreover, by lowering the CoG, the amplitude of the vibration will decrease too.

Effect
The CoG (vertical) of the steel prototype is better in relation to the CoG (vertical) of the wooden test model.

Difference 8 Center of gravity (CoG, horizontal)

Wooden test model	Steel prototype
100 mm from rear construction pivots, between rear construction pivots and shock absorber pivot	250 mm from rear construction pivots, 75 mm in front of shock absorber pivot

Description
The location of the center of gravity (horizontal) does affect the r.m.s. acceleration values. Increasing the distance of the center of gravity (horizontal), in relation to the rear pivot points (bushings), put additional friction on these pivots. The longer the distance, the greater the moment the bushings have to bear. Additional friction is, therefore, detrimental for the precise reaction to small vibrations.

Effect
To maximize the sensitivity of the construction, proper bushings need to be used that ensure adequate load-bearing. It also helps to make the moment as small as possible (Figure 102). In the wooden test model, the CoG was placed between rear construction pivots and shock absorber pivot: the moment was small. It was assumed that the wooden test model would react precisely to small vibrations.

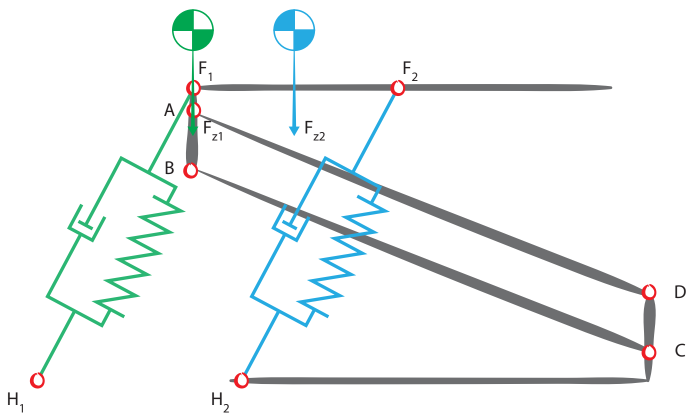


Figure 102: Ideally, the CoG should be placed above the rear pivot points (green) and the shock absorber pivot should be located as close as possible to the rear pivot points as well. This results in no additional moment (personal communication, Dion Wouda, December 6, 2018). However, due to space limitations this option might be impossible. Making the moment as small as possible and placing the CoG between the rear construction pivots and shock absorber pivot (blue), would be a good compromise.

Difference 9 Diagonal length

Wooden test model	Steel prototype
295 mm	387 mm

Description
The shorter the beam, the more rigid, the higher its resonance frequency. The longer the span, the less rigid (or more flexible), the lower its resonance frequency

(Buscarello, 2002).

Effect
Increasing the radius of the diagonals will result in a higher moment of inertia: the system will accelerate more difficult angularly, which is beneficial. Yet, as a consequence, every movement will have a larger amplitude. On the other side, decreasing the radius of the diagonals will result in a lower moment of inertia: the system will accelerate easier angularly, which is detrimental. Yet, every movement will have a smaller amplitude.

Result
A smaller radius will most likely perform better. Although the system will accelerate easier angularly, this acceleration can be accommodated with by the right spring rate and damping characteristics.

Difference 10 Diagonal angle

Wooden test model	Steel prototype
22.9° (minimum weight) 19.1° (maximum weight)	17.9° (minimum weight) 14° (maximum weight)

Description
The start angle greatly affects the vibrational values. The larger the start angle, the greater the total travel distance will be (Figure 103); the smaller the start angle, the smaller the total travel distance will be. In other words, a larger start angle requires more time to react to vibrations and to reach a required vertical travel.

Effect
The tendency to react precisely on small road undulations is greater for smaller start angles. A modular test model was used to test different diagonal start angles. During these test, all other parameters (shock absorber angle, weight and diagonal length) remained the same.

Results
Table X shows the vibrational transmissibility values of the modular model with diagonal start angles of 10, 20, 30, 40 and 50 degrees (horizontal axis as origin). This table illustrates that the smaller the start angle, the smaller the vibrational transmissibility values are.

Difference 13 Shock absorber angle

Wooden test model	Steel prototype
32.9° (topping) 42.2° (bottoming)	18.3° (topping) 19.8° (bottoming)

Description
Shock absorbers are at their highest efficiency when mounted vertically. However, this efficiency can be adjusted by optimizing the flow rate of the oil (adjusting the orifice radii). In addition, the greater the installed angle, the softer the spring rate will be.

Effect
A modular test model was used to test different shock absorber angles. During these test, all other parameters (diagonal start angle, weight and diagonal length) remained the same.

Result
Table X shows the vibrational transmissibility values of the modular model with shock absorber angles of 38, 33, 24 and 19 degrees (vertical axis as origin). This table illustrates that the larger the shock absorber angle, the smaller the vibrational transmissibility values are. In other words, the damping ratio and spring rate of an upright shock absorber would be too high.

Difference 11 Shock absorber quantity

Wooden test model	Steel prototype
1	2

Description
To maintain the same spring characteristics, the spring rate, when using two shock absorbers instead of one, needs to be divided by two.

The same damping ratio can be obtained by optimizing the orifice hole diameter. The radii of the orifices have the largest effect on the flow rate, due to its value to the fourth power.

Difference 14 Tire pressure

Wooden test model	Steel prototype
3.5 bar	3.5 bar

Description
Vibrational transmissibility values might decrease as pressure is reduced, but reducing it after a certain threshold will reduce the cargo bike's control and pose a danger to the infant and parent. The cause of decreased vibrational transmissibility values is explained in appendix 20, section '20.1.6 Tire pressure'

Effect
A test was executed in which the tires of the cargo bike were inflated with 2, 2.5, 3, and 3.5 bar.

Results
Table X shows the vibrational transmissibility values of the tire pressure tests. This table illustrates that the vibrational transmissibility values and the absolute unweighted r.m.s. acceleration values barely differ between the tests. Only the floor measurements in the z-direction increases with higher pressures. This result is likely, since a harder inflated tire does not properly deflect road imperfections: it does not absorb a lot of energy. This outcome suggests that tire pressure does not have a big influence on the measured values under the head when the seat system is installed.

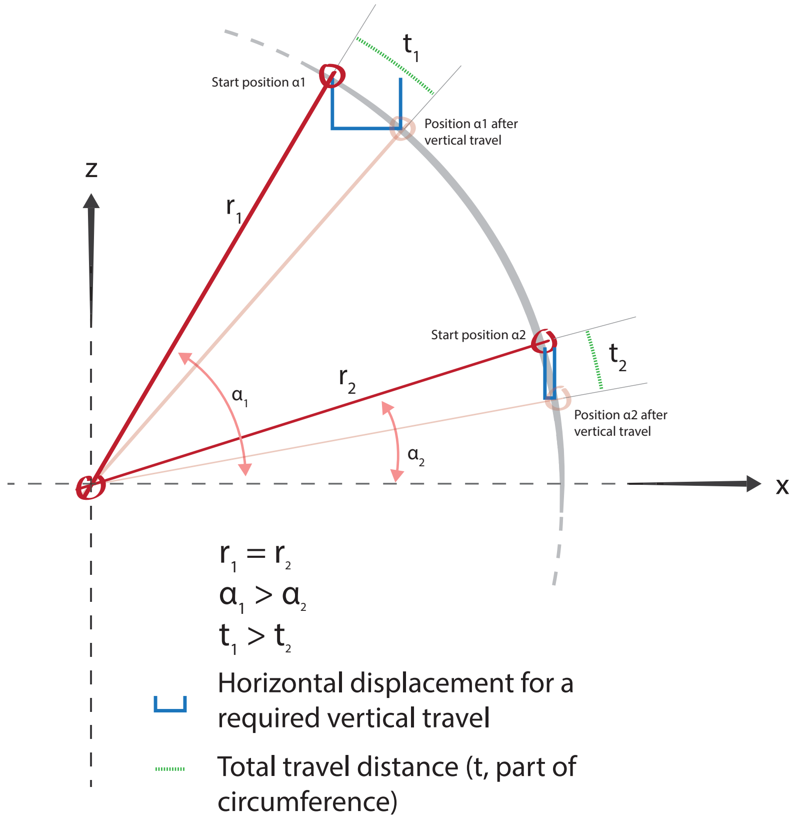


Figure 103: Start angle of the diagonals. The larger the start angle, the greater the total travel distance will be (t1); the smaller the start angle, the smaller the total travel distance will be (t2).

Location	20 degrees			30 degrees			40 degrees			50 degrees		
	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
Floor	0.559	0.809	2.323	0.569	0.711	2.105	0.599	0.775	2.088	0.512	0.700	1.936
Head	0.844	0.736	0.777	0.956	0.856	0.757	1.029	0.811	0.905	1.090	1.000	1.132
Vibra, Trans.	151.11%	90.97%	33.45%	168.10%	120.41%	35.96%	171.67%	104.70%	43.36%	212.81%	142.80%	58.50%

Table 11: Vibrational transmissibility and unweighted r.m.s. acceleration values [m/s2] values of the modular model with diagonal start angles of 10, 20, 30, 40 and 50 degrees (horizontal axis as origin). Measured on the supporting surface under the head.

Location	38 degrees	33 degrees	24 degrees	19 degrees
	rmsz	rmsz	rmsz	rmsz
Floor	2.449	2.559	2.646	2.545
Head	1.064	1.123	1.244	1.332
Vibra, Trans.	43.4%	43.9%	47.0%	52.4%

Table 13: vibrational transmissibility values and unweighted r.m.s. acceleration values [m/s2] of the modular model with shock absorber angles of 38, 33, 24 and 19 degrees (vertical axis as origin). Measured on the supporting surface under the head.

Location	2 bar			2.5 bar			3 bar			3.5 bar		
	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz	rmsx	rmsy	rmsz
Floor	0.622	0.542	2.106	0.689	0.649	2.034	0.630	0.616	2.209	0.605	0.939	2.313
Head	1.149	1.034	1.466	1.045	1.133	1.383	1.100	1.254	1.428	1.326	1.044	1.494
Vibra, Trans.	186.2%	193.7%	69.8%	160.2%	174.5%	68.3%	176.8%	208.3%	65.3%	220.9%	117.9%	64.6%

Table 12: Vibrational transmissibility and unweighted r.m.s. acceleration values [m/s2] of the tire pressure tests. Measured on the supporting surface under the head.

Appendix 45

Unweighted r.m.s. acceleration values

New prototype configuration

Weight	Location	Road type		
		Road bricks		
		rmsx	rmsy	rmsz
5 kg	Floor	1.230	1.243	3.465
	Head	2.113	1.318	1.655
Vibra. Trans.		**171.7%**	**106.1%**	**47.8%**

Weight	Location	Road type		
		Concrete tiles		
		rmsx	rmsy	rmsz
5 kg	Floor	0.954	0.973	4.044
	Head	1.400	1.524	1.607
Vibra. Trans.		**146.7%**	**156.6%**	**39.7%**

Weight	Location	Road type		
		Road bricks		
		rmsx	rmsy	rmsz
8 kg	Floor	1.132	1.139	3.804
	Head	1.509	1.511	1.709
Vibra. Trans.		**133.3%**	**132.7%**	**44.9%**

Weight	Location	Road type		
		Concrete tiles		
		rmsx	rmsy	rmsz
8 kg	Floor	1.275	1.044	3.738
	Head	1.617	1.476	1.687
Vibra. Trans.		**126.8%**	**141.4%**	**45.1%**

Weight	Location	Road type		
		Road bricks		
		rmsx	rmsy	rmsz
10 kg	Floor	1.320	1.575	3.832
	Head	1.586	1.843	1.692
Vibra. Trans.		**120.2%**	**117.0%**	**44.2%**

Weight	Location	Road type		
		Concrete tiles		
		rmsx	rmsy	rmsz
10 kg	Floor	0.932	0.998	3.830
	Head	1.593	1.824	1.696
Vibra. Trans.		**171.0%**	**182.8%**	**44.3%**

Table 14: average r.m.s. values [m/s2] of the new prototype configuration, measured for all test dummies on 'road bricks' and 'concrete tiles'. The last row shows the ratio between the r.m.s. value of the highest vibrational response/output (under the head) and the r.m.s. value of the vibrational input (the floor, highlighted in blue).

Appendix 46

Transient acceleration values

Speed bump

Steco Baby Mee

Weight	Location	Min. acc.	Max. acc.
5 kg	**Floor**	-18.429	24.511
	Seat-back	-18.354	16.547
	Pelvis	-17.997	15.863
	Head	-23.298	**44.804**

Weight	Location	Min. acc.	Max. acc.
8 kg	**Floor**	-19.081	22.247
	Seat-back	-17.476	21.615
	Pelvis	-14.688	21.674
	Head	-44.416	**74.875**

Weight	Location	Min. acc.	Max. acc.
10 kg	**Floor**	-21.165	21.319
	Seat-back	-21.133	23.695
	Pelvis	-13.564	23.590
	Head	-32.076	**78.559**

Prototype
Spring rate 2.67 N/mm

Weight	Location	Min. acc.	Max. acc.
5 kg	**Floor**	-20.369	19.934
	Seat-back	**-25.603**	18.516
	Pelvis	-19.589	20.792
	Head	-21.394	18.852

Weight	Location	Min. acc.	Max. acc.
8 kg	**Floor**	-20.393	17.698
	Seat-back	**-34.546**	29.569
	Pelvis	-27.532	24.749
	Head	-29.983	32.844

Weight	Location	Min. acc.	Max. acc.
10 kg	**Floor**	-25.816	18.415
	Seat-back	-26.257	33.483
	Pelvis	-30.903	21.616
	Head	**-38.287**	16.082

Prototype
Spring rate 3.67 N/mm

Weight	Location	Min. acc.	Max. acc.
5 kg	**Floor**	-23.571	22.618
	Seat-back	**-23.186**	10.623
	Pelvis	-19.756	21.205
	Head	-20.185	17.398

Weight	Location	Min. acc.	Max. acc.
8 kg	**Floor**	-17.099	18.860
	Seat-back	-19.535	17.740
	Pelvis	**-24.350**	18.938
	Head	-20.397	22.267

Weight	Location	Min. acc.	Max. acc.
10 kg	**Floor**	-19.532	19.454
	Seat-back	-24.934	23.914
	Pelvis	**-27.730**	22.306
	Head	-24.140	22.317

Table 15: Average peak acceleration values [m/s2] of the Steco Baby Mee (left) and the new prototype configuration, installed with a softer spring (middle: 2.67 N/mm) and a stiffer spring (right: 3.67 N/mm). The highest peak acceleration values are highlighted in blue. With regard to the new prototype configuration, in 5 out of 6 tests, the maximum values were found at the location of the seat-back or pelvis. This was caused by bottoming or topping.

Appendix 47
Confidentiality statement

De ondergetekende:

1.

Naam: ___________________________ Voorletter(s): ___________________________

Adres: ___________________________

Postcode :________________________ Woonplaats:___________________________

Hierna te noemen *'Participant'*.

En;

2.

Naam: ___________________________ Voorletter(s): ___________________________

Adres: ___________________________

Postcode: ________________________ Woonplaats: ___________________________

Hierna te noemen '*Onderzoeker'*.

Optredend zowel in persoon als namens *Popal fietsen Nederland B.V.,* statutair gevestigd en kantoor houdende te 5151 DT, Drunen, aan de Huub van Doorneweg 2, ingeschreven in het Handelsregister onder KvK nummer 61194654, te dezen rechtsgeldig vertegenwoordigd door *Onderzoeker*.

Komen het volgende overeen:

Artikel 1.
Participant stemt erin toe dat hij door *Onderzoeker*, wordt voorzien van vertrouwelijke informatie (hierna: de Informatie) betreffende:

Een product voorstel van een babydrager, dan wel zitsysteem, voor baby's en/of peuters, dat bevestigd kan worden op een fiets en/of bakfiets. De babydrager maakt het mogelijk een baby en/of peuter mee te vervoeren op een fiets en/of bakfiets.

Het doel van het verstrekken van deze informatie is:

1. Het mogelijk maken van onderzoek
2. Beoordeling van de innovatie op basis van haalbaarheid, vormgeving, constructie en marktpotentie

De informatie kan in elke vorm, mondeling, schriftelijk, in beeldmateriaal en/of fysieke modellen, worden verstrekt. De aldus bedoelde informatie wordt hierna aangeduid als de Informatie.

Paraaf gelezen en goed bevonden bovenstaande

Naam *(Participant)*_____________________ **Naam** (*Onderzoeker*)_______________________

Artikel 2.
Participant zal alle voornoemde informatie die hem door *Onderzoeker* of door haar aangewezen personen is of zal worden verstrekt behandelen als vertrouwelijke informatie die hij derhalve voor derden strikt geheim zal houden.

Artikel 3.
Participant zal de Informatie uitsluitend bekend maken aan zijn of haar levenspartner voor zover deze daarvan kennis moeten nemen voor het realiseren van het bovenomschreven doel. *Participant* zal zijn geheimhoudingsplicht ten aanzien van de Informatie integraal opleggen aan deze levenspartner, die daartoe een afschrift van deze overeenkomst zullen ondertekenen.

Artikel 4.
Participant is tot geheimhouding van de Informatie gehouden voor de duur van *3* jaren na de dag waarop de betreffende Informatie door *Onderzoeker* is verstrekt, of totdat de verstrekte gegevens van openbare bekendheid zijn geworden, buiten toedoen of nalaten van *Participant*. Hij is echter niet tot geheimhouding verplicht betreffende die delen van de door *Onderzoeker* verstrekte Informatie waarvan hij ten genoegen van *Onderzoeker* kan aantonen dat deze reeds van openbare bekendheid waren dan wel reeds in zijn bezit waren voordat deze Informatie van *Onderzoeker* werd ontvangen, dan wel via een derde, niet tot geheimhouding verplichte Onderzoeker in zijn bezit zijn gekomen.

Artikel 5.
Participant verplicht zich de Informatie op geen enkele wijze, in gewijzigde noch in ongewijzigde vorm, in exploitatie te nemen of toe te passen voor enig ander doel dan hierboven omschreven, zonder voorafgaande schriftelijke toestemming van *Onderzoeker*.
Indien het gebruik van de Informatie door *Participant* resulteert in rechten van intellectuele eigendom of soortgelijke aanspraken zal *Participant* deze rechten en/of aanspraken om niet overdragen aan *Onderzoeker*.

Artikel 6.
Participant zal geen octrooi aanvragen noch enig andere aanspraak maken, waar ook ter wereld, met betrekking tot de aan hem verstrekte Informatie en hij zal niemand in de gelegenheid stellen dit te doen, tenzij met voorafgaande schriftelijke toestemming van *Onderzoeker* of tenzij de octrooiaanvrage of de aanspraak betrekking heeft op informatie waarvan *Participant* ten genoegen van *Onderzoeker* kan aantonen dat hij over deze informatie beschikte voordat hij door *Onderzoeker* was geïnformeerd of de beschikking kreeg door een derde, niet tot geheimhouding verplichte Onderzoeker.

Artikel 7.
Onderzoeker is gerechtigd op ieder moment te besluiten geen nadere Informatie te verstrekken en alle reeds verstrekte informatie op eisen. Met inachtneming van het voorgaande is deze overeenkomst aangegaan voor *3 jaren*, ingaande op *04-10-2018* . Na afloop van deze overeenkomst zullen de bepalingen in de artikelen 4, 5, 6, deze zin van 7, 8 en 9 van toepassing blijven totdat de laatste termijn van 3 jaar welke ingevolge artikel 5 tijdens de duur van de overeenkomst is gaan lopen, is verstreken. Voorts zal *Participant* ieder gebruik van de hem verstrekte schriftelijke terstond bij afloop van de overeenkomst staken en de schriftelijk verstrekte Informatie aan *Onderzoeker* retourneren.

Artikel 8.
Indien *Participant* de verplichtingen in deze overeenkomst niet of niet volledig nakomt, zal hij door dit enkele feit per gebeurtenis aan *Onderzoeker* een onmiddellijk opeisbare en niet voor rechterlijke matiging vatbare boete groot €5.000 verschuldigd zijn, onverminderd het recht van *Onderzoeker* op volledige schadevergoeding.

Paraaf gelezen en goed bevonden bovenstaande

Naam *(Participant)* **Naam** (*Onderzoeker*)

Appendix 48

Comfort scale

Pijnscore

A = geen tot lichte pijn <17	B = matige pijn 17 - 24	C = ernstige pijn >24

1. Observaties

Onderwerp	**Kenmerk**	**Score**
Alertheid	Diep in slaap (ogen dicht, geen reactie op omgeving)	O 1
	Licht in slaap (ogen grotendeels gesloten, af en toe reactie)	O 2
	Slaperig (kind sluit vaak zijn ogen, reageert minder op omgeving)	O 3
	Wakker en alert (kind reageert op omgeving)	O 4
	Wakker en hyper-alert (overdreven reactie op veranderingen)	O 5
Kalmte / agitatie	Kalm (kind lijkt helder en rustig)	O 1
	Licht angstig (kind toont lichte onrust)	O 2
	Angstig (kind lijkt onrustig, maar kan zich beheersen)	O 3
	Zeer angstig (kind lijkt zeer onrustig, kan zich nog net beheersen)	O 4
	Paniekerig (ernstige onrust met verlies van beheersing)	O 5
Huilen	Geen huilgeluiden	O 1
	Af en toe snikken of kreunen (nasnikken)	O 2
	Jengelen of dreinen (monotoon geluid)	O 3
	Huilen	O 4
	Schreeuwen of krijsen	O 5
Lichaamsbeweging	Geen beweging	O 1
	Incidentele (3 of minder) kleine bewegingen	O 2
	Frequente (3 of meer) kleine bewegingen	O 3
	Heftige bewegingen met armen en benen	O 4
	Heftige bewegingen ook met romp en hoofd	O 5
Gelaatspanning	Gezichtsspieren volkomen ontspannen	O 1
	Normale spanning van het gelaat	O 2
	Spanning duidelijk in sommige gelaatsspieren (niet aanhoudend)	O 3
	Spanning duidelijk in alle gelaatsspieren (aanhoudend)	O 4
	Gelaatsspieren verwrongen in een grimas	O 5

Totaal score ______

Comfort gedrag schaal

Datum:

Video:

2. Niet gescoorde items

Onderwerp	Niet gescoord omdat:
Alertheid	
Kalmte / agitatie	
Huilen	
Lichaamsbeweging	
Gelaatspanning	

3. Totale indruk van de baby

4. Opmerkingen

Appendix 49

Recommendation

Usage

The infant safety seat can be released from the car seat adapters by pressing two spring-loaded buttons. However, space limitations, the heavy weight and the lack of a proper grip make this operation fairly uncomfortable (Figure 104). Currently, the infant safety seat needs to be placed into the seat system from the front or side of the cargo bike (Figure 105). With this action it is possible to use the handle. To remove the infant safety seat from the seat system, the user needs to stand in front on the cargo bike, press the buttons and lift the infant safety seat out of the cargo bike (Figure 106). Due to the spring-loaded buttons it is not possible to lift the infant safety seat out of the seat system with the help of the handle.

Figure 104: Lifting the infant safety seat from the side was experienced as very uncomfortable. The edges of the box of the cargo bike put stress on the arms and makes lifting very difficult. Moreover, the right hand had to make a very inconvenient and unnatural movement.

Figure 105: (upper) Placing the infant safety seat from the front of the cargo bike.

Figure 106: (lower) Removing the infant safety seat.

Appendix 50

Recommendation

Design for Assembly

It was very difficult to keep the plain nylon washers in place with one hand while moving the diagonal into position with the other hand.


The plastic cover could not be installed when the car seat adapter was fastened. As a consequence, the plastic cover had to be placed before fastening the car seat adapter.
It was very difficult to align the upper plastic cover in such a way that all four mounting holes were properly aligned
The shock absorber bracket could not be fastened in a logical order. Moreover, the shock absorber bracket attached to the upper part was extremely hard to reach.