Nonlinear,
not Necessarily Circular,
Design for Sustainability

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Nonlinear, not Necessarily Circular, Design for Sustainability

Design for carrying loads in urban transportation

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“The assumption that what currently exists must necessarily exist is the acid that corrodes all visionary thinking.”

Murray Bookchin

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Summary

This project has been an exploration into how sustainability is understood and its challenges framed within design. But the reader undertaking the task of going through this document will find more about carrying in urban transportation which has been the area of application.

Probing the underlying assumptions upon which our solutions toward a sustainable future rest, the research identifies the trio of classical social theory, a reductionist approach and domination as an outlook to be at the root of our failure to transform our ways of life. In an attempt to undertake a nonlinear design for sustainability, the project takes the rejection of these assumptions as the basis from which it explores the area of carrying in urban transportation.

Studying the phenomenon of car-dependence, it unveils the perceptions around the notion of carrying that have been shaped over the last decades with the assumption of the car as the default mode of transport within the city. Different groups of people can be ‘carless’ for a variety or combination of reasons; ideology, lack of financial or spatial capacity for owning a car, living in areas without adequate road development, being under-aged for driving, etc. These groups may walk, skate, scoot, cycle, ride buses, trams, trains or monorails to get to places they want to go. Yet with them they carry products that are designed within a picture of the urban setting in which cars are indispensable and indisputable. Thus, by being complicit to this image of transportation, designers are increasingly delegating the control of how we move ourselves, others, objects, and indeed how we organize the urban environment and ourselves as a society, to cars and the unsustainability surrounding them.

The outcome of the project is a two part solution for additional carrying capacity for cycling without imposing an inclusive space on the bicycle or requiring sturdy bags furnished with bulky attachment elements. This outcome is used to sketch out a potential set of elements by which vehicles and carrying products can have a more active relationship with each other and us in order to decouple the wide variety of products and systems in the transport landscape from the ubiquitous influence of cars.

Contents

1 Introduction

Image source: pexels.com/photo/gray-scale-photo-of-metal-fence-3680457/

1.1 Sustainability

Sustainability. One hardly comes across a person unfamiliar with at least some reverberation of discussions around it today. This newfound awareness, while certainly welcomed compared to exhausting closing decades of the 20th century in which the scientists had to debate the reality of human actions' impacting the planet, lives under the a shadow of a bitter reality; an unfailing streak of temperature records being broken annually (NASA, 2020), hurricanes whose escalating devastation doesn't interfere with their intense densification in one season to the point of ousting the alphabet system of naming them (New York Times, 2020), colossally long and brutal bushfires and forest fires covering the most eastern and western continents alike (National Geographic, 2020), coldest winter storms, harshest droughts,... and so the list goes on. We have grown somewhat used to hearing superlative adjectives on the news describing the environmental and climatic situation. All this, while contributing to the gathering awareness, hints at the scale of the approaching catastrophe and the shirking window of time that remains for us to do something about it.

Though mainly portrayed and perceived in the ecological sense, there are many more aspects to the discussion of sustainability as the colourful mosaics of the SDGs (UN, 2015) so cheerfully remind us. The social, economic and political unsustainability of the globalized capitalist world order are inseparable from the ecological crisis and each other.

For instance, there are structures of power and profit that prevent so-called environmental advocates from disclaiming livestock production, which is one of the most significant contributors to greenhouse gas accumulation (FAO, 2021) and shows no sign of slowing down as meat consumption continues to grow aggressively (Guardian, 2018). An industry that consumes astronomical levels of water (thewaterweeat, n.d.) per calories produced as it takes plant-based food items that could solve hunger globally and turns it to meat by the factor of 1/10. It represents one of the most psychologically and physiologically hazardous working conditions (Surge Campaigning C.I.C., 2021) while being responsible for the historical rate at which the largest rainforest of the planet is being stripped down (Guardian, 2019). All the while the so-called model nations of sustainability pursue loopholes in international treaties to allow them to import food items that leaves such scars on nature and humans.

The unyieldingly expansion of the income inequality gap, which levels the wealth of the billionaire class – some 2000 people – with that of 4.6 Billion people (oxfam, 2020). A condition which has only become more preposterous during the covid-19 global pandemic, as the billionaires have found it easy to expose their workers to unsafe conditions (Guardian, 2021) to avoid letting a *good* crisis go to waste. Covid-19 which has swept across the globe has shed light on the unjust, inhumane and unsustainable economic and political models around the world; lack of or underfunded public health systems, the anxiety of paycheck-to-paycheck living under constant threat of hunger and eviction, which during the last year and half has plunged so many people below the poverty line, the physical risk and emotional toll imposed on the essential workers whose life-saving efforts gets negated by politicians who disclaim and mock necessary safety

Figure 1-1 - Brazil Amazon. Aerial view over heavily deforested Amazon rainforest showing new roadways. (source: Encyclopædia Britannica ImageQuest, quest.eb.com/search/300_2267132/1/300_2267132)

Figure 1-2 - Cattle on a pasture in a cleared area, Amazon rainforest between Itaituba and Trairao, State of Para, Brazil, South America. (source: Encyclopædia Britannica ImageQuest, quest.eb.com/search/322_3079825/1/322_3079825) measures under the banner of liberal freedom. And at the time of this writing, as the wealthy nations come out of the crisis through rapid vaccination campaigns, they stand by the power and impunity of pharmaceutical corporations whose intellectual property rights allow them to collect massive profits as people in the global south are left to suffer and die.

Therefore, what is being done to achieve sustainability is not nearly enough. That's in part because we haven't changed the way we look at things. Surely, the mindset that has brought us this perilous multifaceted crisis cannot be the same outlook through which solutions are sought.

1.2 Design for Sustainability

Sustainability doesn't have a long history in design. Its earliest expressions can be found in the works of Buckminster Fuller and Victor Papanek in the late 60s and 70s (Papanek, 1985). To understand and question how sustainable design efforts can be improved or transformed, strategies and approaches within the field have been classified under the four following categories. Far from being a comprehensive analysis, this section only serves to paint a general picture.

The Products, Material and Technology

The majority of what is labelled as sustainable product design usually stops at utilizing biodegradable materials or operating on clean energy. It doesn't come as a shock to know that green, plant-based utensils get produced and shipped halfway across the world for cheap labour and raw material, or that the electricity used by the new generation of cars for instance is in most parts of the world supplied through non-renewable means. But beyond green-washing strategies, the most basic of approaches include using nontoxic, renewable and low impact material and energy sources that are local. Simplifying the production process by reducing the number of steps as well as the variety and total mass composing the product are among other important factors. Furthermore, for decades, the linear systems of production and consumption have been criticized – although not to significant effects yet – and considerations ranging from product design for disassembly, repair, and improvement all the way to cradle-to-cradle standards (McDonough & Braungart, 2002) have been proposed in their place.

The Users, Appropriation and Participation

Increasing user engagement is another sustainability strategy that seeks to challenge the prevailing image of a passive consumer. Empowering the users through involvement in the design, production, assembly and evaluation of products and services to varying degrees falls under this group of approaches. Today, a variety of ways to design for appropriation by the users exist (see Ehn, 2008; Redström, 2008), among the most dominant of which is modular design, where by extending the design of products into the use phase, users are offered a chance to reconfigure and adopt objects to suit their varying and changing needs and environments. Considerations for customization and personalization in design also creates a stronger sense of attachment to products which can significantly lengthen their lifetime (Chapman, 2005) as the termination of product-user relationship often has little or nothing to do with a decline in or loss of the object's ability to fulfil its functions.

The Services, Access and Sharing

More progressive approaches extend beyond the product realm and consider patterns of consumption on a deeper level. By shifting the responsibility of meeting the users' needs from objects owned by individuals to platforms, services and systems that offer access to such functions (Ceschin & Gaziulusoy, 2016), Product-Service-System (PSS) design is one of the most important approaches to sustainability within the field. Thus, access-based consumption which replaces old systems of private ownership with services to rent products, not only reduces the costs of consumption in material and energy terms, but also improves it from a social perspective; encouraging a kind of design that replaces the extreme individualization and isolation of the past decades with strategies of sharing among users.

The Systems, Institutions and Networks

Predictably, focus on services has granted design a more local and situated focus, which has evolved into community-centred approaches to design, at the root of which lies the notion of 'Creative Communities' introduced by Anna Meroni (2007). Within a Social Innovation outlook, people's needs are met by reshaping of the local structures and reallocating resources in new and creative ways, a process driven by and dependent upon those using its outcome (Ibid.). Thus, a new role for the designer has emerged; one of creating relationships and connections between citizens, local authorities, private businesses and civic groups (see Björgvinsson, et al., 2012; Manzini, 2015). This approach requires a cross-disciplinary and cross-sector collaboration to tailor solutions which include the ecological, social, economic and political aspects of reaching sustainability.

More recently, this category has evolved into more comprehensive models known as 'Transition Design' (Irwin, et al., 2015) and 'Socio-technical System Design' (Ceschin, 2014; Gaziulusoy & Brezet, 2015; Joore & Brezet, 2015) which studies sectors that fulfil functions such as transport, energy, health, etc. on a societal level and offer solutions on a multitude of levels to perpetuate paradigm shifts.

Just scratching the surface of research within the field, the progress of design for sustainability is admirable. However, most of the approaches cited above don't have much existence beyond the realm of research and university sponsored projects. The majority of design that is going around, changing (or rather not changing) the world every day, has little regard for sustainability beyond the standards imposed by regulators and public demand for greenness. The response to these usually culminates in legal loopholes and outsourcing to other nations in the background with a greenwashing front to ease concerned citizens.

Furthermore, when the cited approaches do get applied in design, our capacity to achieve transformation through practice remains quite limited. The reason behind this cannot be found in how design for sustainability differs across the four categories of approaches, but rather in how it doesn't. Our complete reliance on the basic ways of understanding that design has been standing upon since its beginning, and the continued lack of discussion around exploring alternative bases for our field, is what maintains its contribution to unsustainability.

1.3 Research Aim

While this project concluded by designing an intervention for the practice of carrying loads in urban transport, the questions that fuelled this journey were not about any specific aspect or function within society. The starting point was an inquiry into how sustainability is understood and its challenges framed. Given all that has been uncovered about this issue, and all the changes that design as a field has undergone, how is it that we continue to design the same things, for the same unsustainable ways of life, within the same picture of the world, supporting the same systems' hegemony? The question was that of probing the underlying assumptions upon which our understanding of sustainability, and in effect our design solutions for it, rest. Notions about the environment, society and ourselves which appear so trivial they are rarely discussed in research and almost never in professional practice. How can designers step beyond these assumptions to see the sustainability challenge in a new light with an actual chance of transforming society towards it? How can we, through our design, also help the rest of society to do the same thing?

1.4 Structure

This document is divided into six chapters. Following the introduction, the second chapter explores three areas of understanding that lie at the basis of how we see sustainability. Respectively, these include domination as an outlook, reductionism as an approach and classical social theorizing. While the timeline of this project limited the development of this part, it is presented here as a work in progress. The findings of the chapter, though a long way from a theoretical framework, have been used as the basis for the design and research process that followed it.

The third chapter takes a detailed look at the sustainability of urban transportation, and in particular the phenomenon of car-dependence, in order to frame the challenge in an effective way and find points of intervention for design. The chapter culminates by drawing attention to the reductive and linear perceptions around various aspects of transportation that have been shaped over the last decades with the assumption of the car as the default mode of transport and selects the carrying aspect as the focus area for further exploration.

The fourth chapter is a rather singular beast. In line with the overall approach of the project, no attempt was made to draw a division between the supposedly separate parts of theory and design, which makes this chapter a mixture of secondary research on carrying and reflections that accompanied attempts to rethink it through design. This section thus documents the different venues explored and multiple design briefs of varying details set along the path.

The fifth chapter, which is a detailed account of the product outcome of the project, illustrates a two part solution for additional carrying capacity for cycling without imposing an inclusive space on the bicycle or requiring sturdy bags furnished with bulky attachment elements.

The final chapter uses the product outcome to sketch out a potential set of elements by which vehicles and carrying products can have a more active relationship with each other, and evaluates the development of the project against the nonlinear approach from whence it set out.

2 The Riddle of Sustainability

image source: pexels.com/photo/photo-of-starry-sky-during-nighttime-1477537/

This section investigates the inertia of our unsustainability through three distinct, though not mutually exclusive, areas of understanding which arguably lie at the root of the issue.

2.1 A Story of Domination

Looking at sustainability from an ecological perspective, the human race had not disturbed the equilibrium of the environment to a significant extent for most of its history. Lynn White's landmark paper in 1967 traces the history of our current ecological crisis, or rather the mild version of it as it stood then. He argues for the basic perception of the relationship between human beings and nature to be at the root of the problem. The relationship which used to be nonlinear, humans as a part of nature rather than separate from or above it during early human societies, started to change gradually with the advent of agriculture, human settlements and cities. However, White (1967) places a particular emphasis on the mid-19th century, when following long developments of natural sciences and technological skills, finally a marriage formed between science and technology, "a union of the theoretical and the empirical approaches to our natural environment" (Ibid., p. 1203). This significant change that produced the Western tradition of science and technology, accepted today as the only *legitimate* kind of knowledge worldwide, granted power to mould nature to the will of men within a dominating perception that was already very much present. Christianity, as White phrases it, is "the most anthropocentric religion" (Ibid., p. 1205), and the West at the time (and still, although to lesser extent) was under the influence of the Christian narrative of the world and its destiny. This portrait, which places man as the steward of nature, and nature as having no other purpose than to serve man, is what most of our modern science and technology is entrenched in.

Therefore, nature was successfully and perpetually objectified, and man departing from its place in the ecological system, assumed the role of its master. This is why White (1967, p. 1206) concludes "more science and more technology" won't save us. Herein lies the difference between the phrases 'environmentalism' and 'ecology' as Murray Bookchin (1982) describes it. While the two are used interchangeably most of the time, the environmentalist outlook sees no problem with humans assuming a dominating position over nature, and hence reduces nature to only a deposit of raw materials, any *harmony* with which is merely "the development of new techniques for plundering… with minimal disruption of the human habitat" (Ibid., p. 22). The ecological outlook, on the other hand, views humans as one piece in the vast and complex web of living and nonliving things that composes nature, and seeks to restore balance to this picture (Ibid.).

Bookchin (1982) expands the man-nature relationship thesis, by arguing that the domination of nature by man is the result of domination of humans by humans. He draws connections between the egalitarian structures of 'organic societies' from preliterate times and their harmonious living as part of their surrounding environment. In contrast, societies today, laden a variety of hierarchical structures, which beyond economic and political hierarchies (class and state) include the domination of "young by the old, of women by men, of one ethnic group by another" (Ibid., 1982, p. 4), are bound to cause this level of ecological unsustainability. In the absence of these structures, notions such as 'freedom' and 'equality' are vacant in organic societies still existing today, as they are implicit in their outlook of life (Ibid., 1982, p. 44).

Domination, hence, as one of the driving forces of the ecological, social, economic and political unsustainability of our existence, hasn't lost or even softened its grip on our efforts for changing the course of human endeavours. This is perhaps best expressed in Arturo Escobar's (2018) critique of the deeply colonial approach of sustainable development undertaken by the wealthy nations of the global north. Sidestepping the knowledge, values and visions of sustainability that don't match that of western modernism and the globalized capitalist world order it serves, he places the current development efforts within an hegemonic 'one-world ontology' and contrasts it to what he calls 'Pluriverse'; a multitude of configurations and approaches to sustainability that hosts many ways of "knowing, doing and being" (Ibid.). Escobar's Pluriverse, is one among a strand of theorization that place autonomy and interdependence at the root of building sustainable societies. Bookchin's concept of 'Social Ecology' (1982) and Wolfgang Sachs's 'Cosmopolitan Localism' which has been expanded upon by various design scholars (see Irwin, et al., 2015; Manzini, 2015), also speaks of decentralization of power and authority, and envisions a diverse yet connected network of communities, towns and regions that collaborate for a thriving human society in harmony with nature.

Design beyond the Outlook of Domination

Taking transportation as an example, the forces that determine how goods and passengers are moved within the city are rarely affected by the people who are directly and intensely influenced by its manifestations. From this perspective, the citizens can hardly be expected to view themselves as part of a mutual relationship with other elements in nature, when they live under asymmetrical and highly distorted power relations in the organization of society. Among the best manifestations of this issue, is the global youth movement of Fridays For Future, which draws attention to how the structure of our political systems does not afford younger generations, whose future is being stolen by the greed of corporate powers, any means of influencing such a crucial course of events.

In this sense, design of a sustainable transport landscape should offer meaningful venues for the citizens to be engaged in the shaping of their surroundings. Furthermore, the decision-making process in such an approach should have a degree of decentralization that can grant more autonomy to the people of each area by acknowledging and utilizing their knowledge and experiences, and thus create more diversity and situdeness within the elements of the system. Moreover, as designers take on the role of facilitators, it is important to shake off the myth of neutrality. To maintain long lasting collaboration with the public, it is important to develop ways to incorporate different and at times contrasting values, preferences and interests of user groups. Such a design approach which can cater a system better suited to local needs, necessarily requires a level of dynamism and feedback loops, which aligns with the following section.

2.2 Anything but Complex

Half a century ago science was introduced to Chaos. On the forefront of this development were physicists and mathematicians, but its effects broke across the boundaries of scientific disciplines (Gleick, 1987). Chaos split the scientific approach in two; reductionism and emergence. In Robert Sapolsky's (2011a) description, prior to this revolution all Western style scientific knowledge was reductionism, pursuing understanding of the whole by breaking systems into their composing elements and analyzing them. The emergence side, however, counters this by acknowledging that the interdependence of components and subsystems at lower levels can give rise to novel features at the macro level, thus rendering the reductionist understanding insufficient for explaining the system as a whole (Ibid.). Put simply, the concepts of chaos and emergence, which are more commonly referred to as complexity theory, offer a way to solve nonlinear problems which reductionism utterly fails at.

2.2.1 Complexity from Simplicity

James Gleick (1987), in his thorough account of the chaos revolution in the 20th century, selects the perfect example to explain nonlinearity; the Lorenzian waterwheel (see figure 2-1). The flow of water enters the system at the top, filling the buckets and causing the wheel to turn. The buckets have holes at the bottom which allows the water to empty on their way back to the top. The speed of the wheel, determined by the flow of water, which indicates the amount of water left in each bucket as they reach the top, is at the same time affected by the water left in the buckets. The interdependence of these two parameters makes the equation describing this system a nonlinear one.

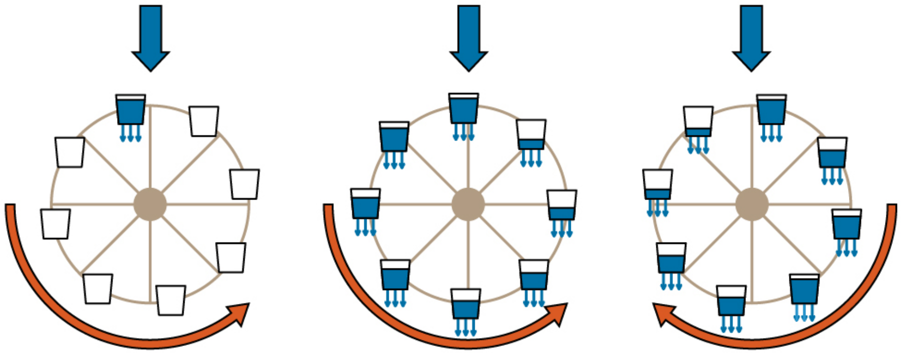


Figure 2-1 - the Lorenzian waterwheel (illustration based on Gleick, 1987, p. 27)

Reductionist science is only able to explain the behaviour of the waterwheel under low flows, where the system exhibits a periodic behaviour; buckets emptying before reaching the top and the wheel turning in one direction. At higher flows, however, the speed of the wheel does not allow the buckets enough time to empty before reaching the top, and the wheel changes direction, which under continuation of the flow will change speed and direction many times more. This baffled the scientists, leaving them to believe it was a chaotic system, incapable of being solved. Before complexity theory, physicists were educated to believe nonlinear systems could not be solved (with minor exceptions) and usually work their way around solving such problems (Gleick, 1987, p. 42). Thus, nonlinearities such as friction were treated to be "noise in data" (Ibid., p. 41) until complexity theory revealed the hidden structures behind what was assumed to be chaos; showing that the noise was, in fact, the system.

The trajectory of the graph in figure 2-2 maps the speed and direction of the waterwheel and is known as a 'Strange Attractor'. These new types of order show a behaviour that is aperiodic but not chaotic as in lacking rules. They are aperiodic but nevertheless deterministic systems which are different from and much more interesting than lawless chaos, making them locally unpredictable but globally stable (Gleick, 1987, p. 48). Looking closely, the next point on the graph cannot be predicted with any degree of certainty as the trajectory never repeats itself. Yet, looking at the bigger picture, the behaviour of the system is stable and quite predictable.

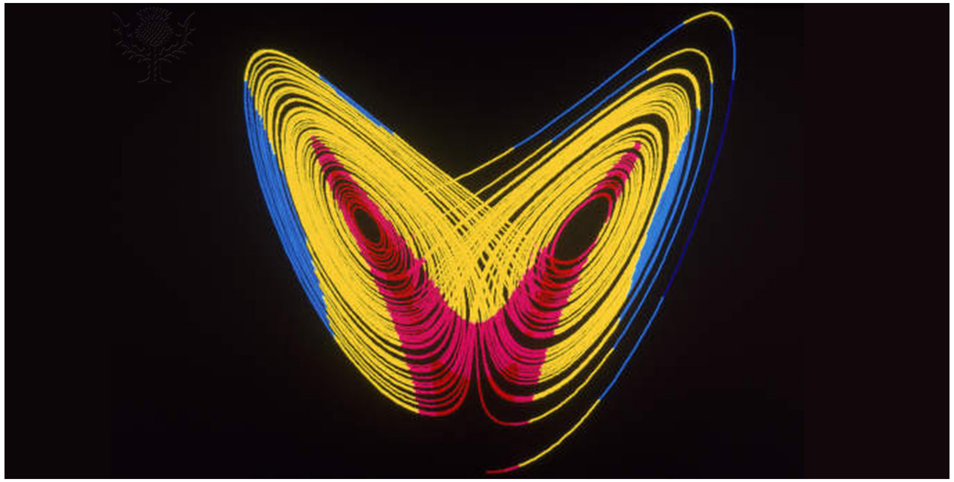


Figure 2-2 - Lorenz Attractor (source: Encyclopædia Britannica ImageQuest, quest.eb.com/sear ch/139_1915122/1/139_1915122/cite

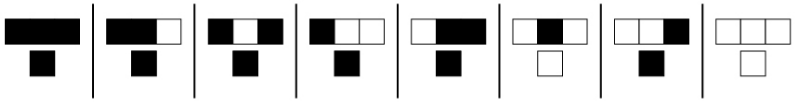


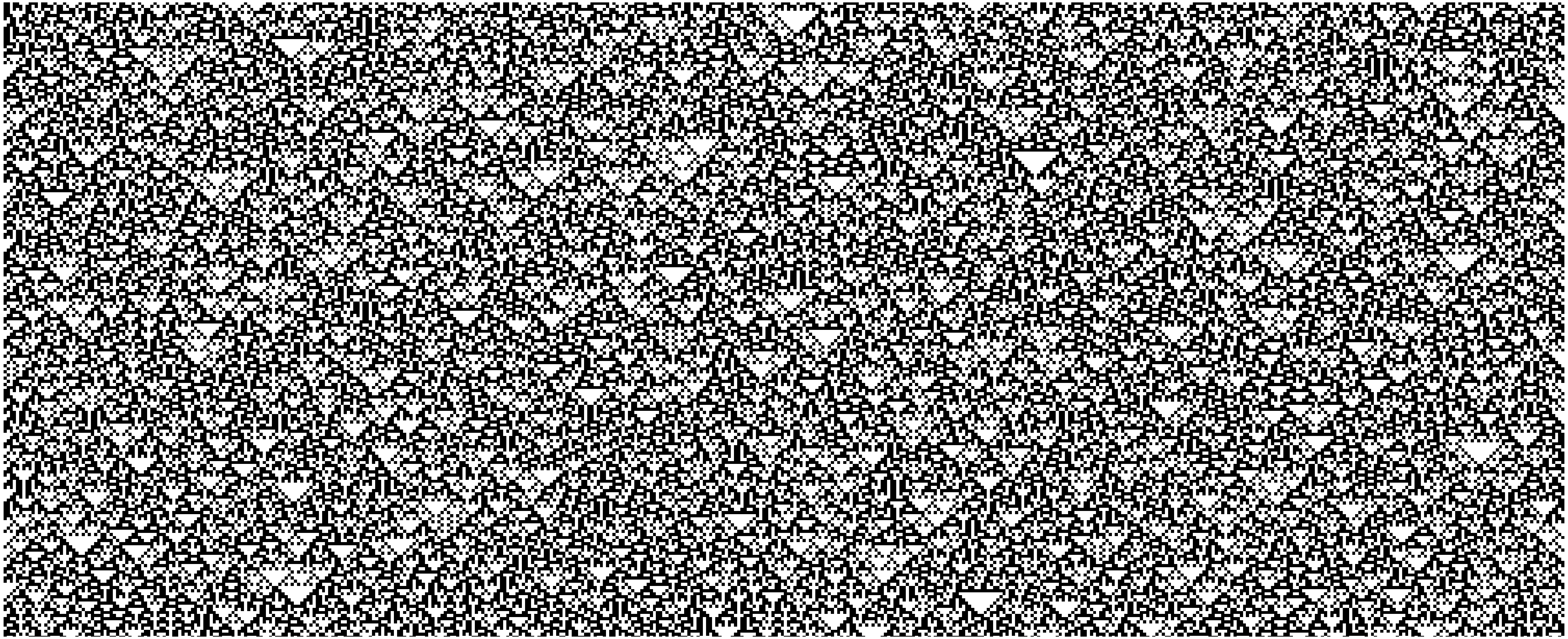
Figure 2-3 - Cellular Automata, code 90 (illustration based on Wolfram, 2002, p. 25)

Through this new approach to nonlinearity, Chaos showed that complex behaviour did not necessarily arise from a complex blueprint and that simple rules can give rise to infinite complexity. One of the most beautiful manifestations of this fact can be found in 'Cellular Automata'. In his painfully heavy yet visually astonishing book, Stephen Wolfram (2002) explores varying levels of complexity rising from this form. A cellular automata starts with a grid and has a set of eight simple codes that determine what the colour of each square is going to be, black or white, based on the neighbouring squares in the previous row.

Cellular Automata can produce repetitive or even uniform (all black/white) results, yet an example of the level of complexity some codes produce is shown in figure 2-4, which is not orderly as it does not repeat itself but also not chaotic since it shows local structures interacting with each other. All this complexity, and only eight simple codes behind it.

This new outlook unlocked many secrets of nature. Ants, for instance, can collectively do immensely complicated tasks with amazing accuracy (Sapolsky, 2011b) such as regulating the temperature of the colony or building structures with their bodies. No overall blueprint exists for these actions, and no single ant knows what the structure looks like or where in it they are situated. Instead their actions are guided by a series of simple local rules, the interdependence between the outputs of which gives rise to the complex behaviour observed at macro level (Ibid.).

Figure 2-4 - an example of Cellular Automata (source: commons.wikimedia.org/wiki/File:R090_rand_0.png)



2.2.2 A Symmetry of Scale

The rules behind a complex system are what transmit information across scale, and connect the levels from micro to macro in a dynamic manner. This was revealed by later studies of strange attractors which showed a fascinating similarity across different levels (Gleick, 1987, p. 261). This "symmetry of scale" as Mandelbrot calls it (cited in Gleick, 1987, p. 95) is the basis of 'Fractal Geometry', the most famous example of which is the Koch Snowflake (see figure 2-5). The Snowflake starts with an equilateral triangle, and the rule at each step is to build another equilateral triangle on the middle third of all edges of the previous triangle. Thus, while the snowflake is limited to a finite area, it can grow to infinite complexity. Fractals are self-repeating scale-free geometries that can produce complex patterns by just one or a few simple rules. They have been referred to as our window to perceive infinity (Ibid., p. 98) as the rule of a fractal defines not only the overall shape but also its details down to the smallest level.

Fractals are evolution's answer to the problem of complexity and limited resources. In the case of our circulatory system, for instance, there is no cell in the human body that is more than five cells away from a blood vessel, yet the entire circulatory system composes five percent of the body's mass (Sapolsky, 2011b). The challenge here is double sided. Not only does this immensely complex network have to be packed in a finite space, but also the structure of it has to be coded into the genome, which without the fractal logic doesn't have enough genes to program the circulatory system let alone anything else (Ibid.).

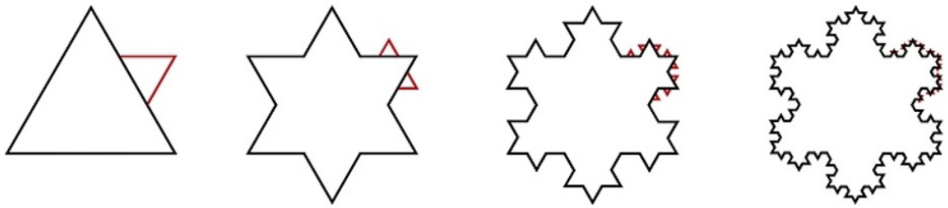


Figure 2-5 - Koch snowflake fractal, artwork (source: Encyclopædia Britannica ImageQuest, quest.eb.com/search/132_1469555/1/132_1469555/cite)

More than half a century has passed since the foundation of science was shaken by notions such as these. To this day, discoveries of complexity continue to be made in physics, biology, meteorology, geology, etc. Disciplines that were headed toward increasing specialization are being brought together by chaos breaking across boundaries of scientific territory as it represents the universal nature of systems (Gleick, 1987, p. 5). The world around us is complex and nonlinear, yet the systems upon which our daily lives depend are still being built based on a reductionist understanding of the world, and the colossal failure of reductionism in understanding this complexity is what continues to reproduce the crisis we are in. However, nonreductive systems and forms of organizations are being propelled by grassroots action, the manifestation of which cannot escape anyone online. Wikipedia, as a marvellous success story, has proved that without a central authority and predefined blueprint the contributions of thousands of people, building on each other's input and modifying it, can produce results that come within breath-taking proximity to that of scientific Encyclopaedia Britannica (Giles, 2005).

Design beyond a Reductionist Approach

In design, complexity theory has been gaining much acceptance for the past decade, with the Design Research Society even holding a conference around complexity in 2010. For instance, design scholars are making references to complexity theory in their work on transforming landscapes of sectors or regions by designing governance systems and collaborations (See Irwin, et al., 2015; Kossoff, 2015; Manzini, 2015), building resilient and adaptive infrastructure such as food networks (See Baek, et al., 2015), and design of and through social engagement and dynamic controversy mapping (Venturini, et al., 2015). However, as promising as this trend is, it still stands a long way from the kind of transformation in our approach to problems that can remake how we design the world around us. It is precisely because of this distance that the notions presented in this section were selected from the most basic concepts of complexity theory, to draw attention to the root of the perceived *default* way of thinking

The often indispensability of reductionism to how we design systems, i.e. creating complexity through complex blueprints, means changing them, whether to override their heavy ecological disruption or renew resemblance to the people for and the times in which they are operating, is quite difficult. Complexity theory offers a view of systems in which startling detail and variety at lower levels does not contrast a stable and harmonious whole. However, the use of complexity theory should not translate to harvesting the 'collective intelligence' of vast numbers of atomized, isolated individuals in a centralized system of decision making. As the short overview shows, it is not just the quantity of inputs that creates emergent features. But rather the interdependence between the elements and their ability to build on each other's actions that transmits their effects up the levels and changes the system as a whole. Naturally, adaptiveness is inherent to such an approach which helps keep the system in sync with its context. In this sense, systems we design should not have separate structures of authority working behind the scenes but should in themselves act as spaces in which the public interacting with it provides feedback to its working in a diffused and interdependent pattern that has a direct influence on how it changes.

2.3 Placing the Blame

How we understand social action has a significant impact on how we approach sustainability and the changes needed in its direction. Yet, among the variety of approaches to sustainable design, almost all subscribe to a very narrow strand of thought within social studies. This lack of discussion around what the 'social' is and how it changes, is a limitation designers share with people of various professions and backgrounds as the hegemony of classical modern thought continues to stifle the plurality of other theories falling outside its bounds. This section paints a general picture of social theories in relation to approaching design for sustainability.

2.3.1 Classical Theories

Expanding on the analysis of Reckwitz (2002) and Shove (2010), classical theories of action can be discussed around two dualities; technology vs. society and structure vs. agency (see figure 2-6).

Technology-Society Divide

On one side of this line are those who believe the answer to sustainability is in technological advancement. Arguing that society changes as the result of changes in technology, the proponents of 'Technological Determinism' grant little focus to the actions of people in the way of change, and instead advocate for cleaner and more efficient products and systems (Shove, 2010). In opposition to this view stands the social[1] view on change, which argues humans and their manner of organization to be where the fault lies and ultimately the solution needs to be deployed.

Structure-Agency Divide

The second divide exists within the social side and represents the classical question of social studies. The first side is the economics school of thought (Reckwitz, 2002) and it holds the individual responsible by viewing their 'agency' as the sole source of action in society. Using the language of 'choice', 'attitude' and 'behaviour' (Shove, 2010) this argument sees the path of sustainability in persuading the individual to change. In stark contrast to this, is the school of social psychology (Reckwitz, 2002), which renders individuals as submissive to 'structures' which determine the course of action in society and are where change needs to be administered. These structures can range from public institutions, regulations, formal or informal roles to norms, values and visions. These two sides represent two different theories; a purpose-oriented and norm-oriented theory of action (Ibid., p. 245) the use of which can be found in various design for sustainable behaviour strategies and the restructuring of local resources, networks and institutions discussed in social innovation literature and socio-technical system design.

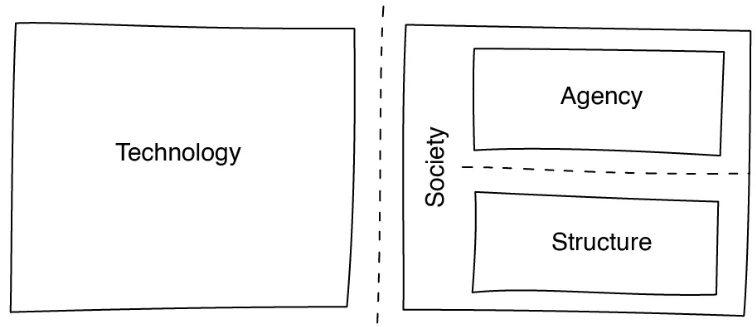


Figure 2-6 - the dualities within classical social theory

2.3.2 Cultural Theories

Yet beyond the bounds of classical social theory, which represent most of what is done under design for sustainability, there is a vast and diverse selection of theories that has been developing within social science since the 1970s. Andreas Reckwitz (2002) provides a detailed account of the contemporary landscape of social studies, which places these 'Cultural Theories' in contrast to classical schools of thought (Ibid., pp. 245-6):

> "The newness of the cultural theories consists in explaining and understanding actions by reconstructing the symbolic structures of knowledge which enable and constrain the agents to interpret the world according to certain forms, and to behave in corresponding ways. Social order then does not appear as a product of compliance of mutual normative expectations, but embedded in collective cognitive and symbolic structures, in a 'shared knowledge' which enables a socially shared way of ascribing meaning to the world."

Reckwitz (2002) goes on to categorize these theories into the four groups of Mentalism, Textualism, Intersubjectivism and Practice Theory, the primary difference between these four being where each view locates the 'social'; the mind, discourse, interactions or practices. Identifying with practice theory, he argues how the intellectualization of culture stemming from the other groups' basis in very specific entities (Ibid., pp. 258) such as discourse or communicative action which try to explain institutional complexes in this regard, has been resolved in practice theory at the expense of lacking concrete theoretical ground, which has made it somewhat more practical in fields such as organization, gender and science studies (Ibid.) as well as design.

1 Here, 'social' is used in its conventional meaning; relating to people.

Practice Theories

Theories of practice are a family of theories rooted in the writings of Wittgenstein and Heidegger (Reckwitz, 2002; Shove, et al., 2012), which began taking shape with Bourdie's 'Praxeology' and Giddens's 'Theory of Structuration' (Reckwitz, 2002; Chaffee & Lemert, 2009; Shove, et al., 2012).Their thesis can be summarized as the rejection of both norm-oriented and purpose-oriented theories of action which places the social in the dynamic relationship between structures and the agency of individuals (Reckwitz, 2002). In other words, accepting that our action as agents does not take place inside a vacuum and is affected by structures. However, the existence of these structures is dependent on agents to reproduce and transform them through their actions.

Practice theory thus sees practice as the locus of the social which is defined by Reckwitz as "routinized type of behaviour which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge" (2002, p. 249). The notion of 'individual' is of secondary importance in practice theory as the focus is on 'carriers' who are "bodily and mental agents" performing the practices (Ibid.). Yet as a result of each agent carrying a multitude of different practices, 'individual' appears at the "unique crossing point of practices" (Ibid., p. 256).

The adaptation of practice theory in design, which began through the work of Elizabeth Shove (2006, cited in Scott, et al., 2009) from the field consumer studies, is gaining a lot of acceptance. The model for practices put forth by Shove and colleagues (2012) is among the most cited which constitutes of three elements "meaning, material and competence" or in the writings of Scott and colleagues (2012) "image, stuff, skill"(see figure 2-7). In a growing movement across the fields of product design (Ingram, et al., 2007; Kuijer & de Jong, 2012; Shove, et al., 2012), human-computer interactions (HCI) design (Pierce, et al., 2013; Redström, 2013), design for product-service-systems (PSS) (Mylan, 2015) and codesign (Scott et al., 2012; Pink 2015), researchers are taking practices, in their irreducibility to their constitutive elements (Reckwitz, 2002), as the unit of analysis and design (Ingram, et al., 2007; Kuijer, et al., 2013; Pierce, et al., 2013).

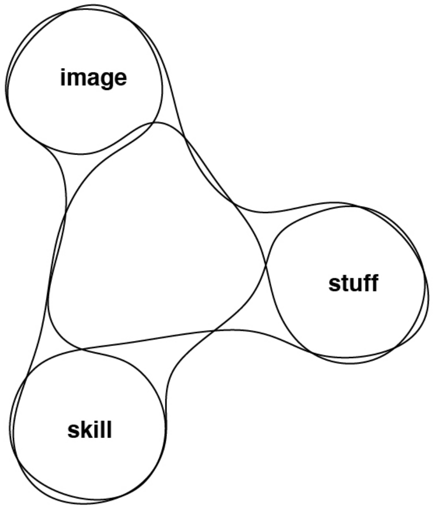


Figure 2-7 - the three elements of practices (illustration based on Scott, et al., 2012)

Actor-Network Theory

One of the most well developed cultural theories which Reckwitz (2002) places in close proximity with theories of practice is actor-network theory. Actor-network theory which was developed within the field of Science and Technology Studies by Latour, Collin and Law in the 1980s subscribes to the same rejection of dualities in describing the world as "made up of hybrids, assemblages, and collectives that are composed of human and nonhumans that act and organize together, sharing the delegation of power and agency" (Forlano, 2016, p. 47). However what sets it apart from other theories is the extension of the notion of 'agency' to nonhumans (Mützel, 2009; Sayes, 2014). That is not a return to the technocratic view on social change, but rather an argument consistent with practice theory in challenging the centralization of individuals that has been happening for the past decades (Forlano, 2016) and instead shifting focus to the dynamic interplay between humans and nonhumans.

Agency defined as "the capability of the individual to 'make a difference' to a pre-existing state of affairs or course of events" (Giddens, 1984, p. 14) has thus been dehumanized by actor-network theory through decoupling from criteria such as intentionality and consciousness (Sayes, 2014). Therefore, nonhumans, which can be material structures, artefacts, animals, natural phenomena, etc. are considered to possess agency as they can make a difference. Bruno Latour views agency along a spectrum between absolute causality and mere existence, meaning objects can "authorize, allow, afford, encourage, permit, suggest, influence, block, render possible, forbid, and so on" certain functions (Latour, 2004, p. 226, cited in Sayes, 2014).

In this view, designed objects and spaces are intended to make certain practices easier, more efficient or safe by distributing the agency of the users onto things (Yaneva, 2009). Latour exemplifies this delegation of action in the design of car seatbelts by introducing three levels of agency assigned to the object for ensuring the safety of the users (1989-92, cited in Sayes, 2014). In these scenarios, failure to fasten the seatbelt (i) result in sonic consequences, (ii) blocks the ignition, or (iii) Is not possible, the last being a design that automatically straps the user upon getting seated (Ibid.). Thus in each case, by making use of an object we are delegating varying levels of control to them, which comes into close proximity with the element of 'competence' in practice theory, and how historical development of designed objects and environments have pushed certain skills and know-how out of existence as they seized to be necessary.

There is a growing body of work in design that draws on actor-network theory which can be traced back to Latour's 2008 keynote at the Design History Society conference. These works stretch across fields such as architecture (Yaneva, 2009; Forlano, 2016), participatory design (Bannon & Ehn, 2013), HCI and political design (DiSalvo, 2012) and communication design (Venturini, et al., 2015).

Design beyond Classical Social Theory

Attitude of users, which thus far had been regarded as a critical factor in changing to sustainable patterns of living, thus came under heavy scrutiny. The latent yet complete hold of classical theory in how the root of certain issues are looked for in design was startling to realize. It is important to note that any comparison between social theories is not a matter of absolute correctness or falsehood. To quote Reckwitz, these are "vocabularies" (2002) to help us understand, explain and discuss social phenomena. What this comparison hopes to reveal is the destructive hegemony of classical thought in how we think about society and radical efforts for changes toward sustainability.

Design theory and practice is laden with the vocabularies of classical theories. This often results in sustainability discussions revolving solely on a technological hinge as people await the break-through that will wipe away all the ecological disruption, or placing the blame on individuals who if only choose not to use the unsustainable systems that the designed world is saturated by, everything would be transformed. These narratives, and in effect the solutions developed under their influence, fall dangerously short of representing the complex dynamics of social change as individual choices (or rather lack thereof) end up having little to do with attitude, and no technological innovation can deliver a sustainable system as long as it operates within the existing unsustainable structures.

2.4 A Relational, Nonlinear and Holistic Design for Sustainability

Far from being a comprehensive review of these topics, the three aspects discussed in this chapter are obstacles to a much needed holistic, plural and dynamic understanding, without which we cannot hope to escape the mistakes we continue to make in new clothes. The outlook of domination, the trivialness of reductionist thinking, and comfort of classical dualities have for so long hung above our sustainability efforts, holding us back from producing significant transformation. While design has made promising progress toward changing its perspective in each of these areas, they remain limited and largely confined to the academic community with little representation in design practice, which is another duality and linear way of thinking in need of change.

The answer to sustainability is cleaner and more efficient technologies. It is about information campaigns, and about reform to our social, economic and political organization. But it is also much more than that. There are ways of assigning meaning to the world that have been such an integral part of design for most of its existence, that without intending to or indeed knowing so, we reproduce them every day through our designs. These narratives can be traced across the levels and aspects of design's role in society, from large multi-disciplinary multi-sector initiatives to the design of small products. Our continued failure to challenge these assumptions, reproduces their hegemony over the way we frame issues, and that is arguably the chief determinant of design's conservative unsustainability.

2.4.1 Designing for Transportation

These insights, which were gathered rather dispersedly throughout the early phases of the project, were used as a rudimentary sketch to carry out a nonlinear kind of design for sustainable transport. The process of research and design documented in the following two chapters, respectively involving transport and carrying, took the rejection of domination, reductionism and classical social theory as the basis from which the exploration set out.

3 Transport

image source: pexels.com/photo/view-from-back-of-tram-at-the-city-2498551/

3.1 Sustainability of Transport

Mobility is one of the most essential aspects of human life everywhere. So many dimensions of our lives are related or dependent on our ability to move ourselves and goods from one place to another. Transportation affects our access to jobs and education, influences our socializing and recreation practices, and determines the availability and affordability of necessities such as food, clothes, medicine as well as services such as health care, making it essential to the wellbeing of society.

However, the dominant ways in which people and goods are moved around our cities and the globe are highly unsustainable as they consume monstrous amounts of energy and material, usually non-renewable ones, and leave heavy footprints of greenhouse gases and waste. According to IPCC, the transport sector in 2010 was responsible for 23% of total energy-related CO2 emissions (IPCC, 2014, p. 603). Since 1970, this sector has seen an increase of 250% to its CO2 footprint worldwide, far beyond the rate of any other sector (Mattioli, et al., 2020). In EU-27, transport is the sole sector whose GHG emissions has risen from the 1990 level, of which 71.7% percent belongs to road transportation (Mattioli, et al., 2016).

Beyond the ecological destruction, transportation furthers social and economic inequalities. While people living in the urban centres and those with high income levels enjoy a multitude of options and receive the bulk of infrastructure development, populations of small towns and rural areas, and specially low income groups are excluded from the fruits of this new age of mobility. However, such inequalities pale in the face of what Elliott and Urry (2010) call 'The Globals'; the rise of a new global elite whose membership depends on speed of mobility and the flexibility granted by the weightlessness of the info economy. The cost of their fluid movement is borne by the poorest sections of the global populations, faced with a deteriorating environment and an increasingly hostile climate, who cannot escape the worst of the impacts as they are the least mobile.

Creating sustainable solutions for such an imperative aspect of life is very important and not at all straightforward. Yet the fact that we are still even occupied by discussions such as electrifications of cars is a witness to how dramatically we have strayed in defining and tackling the challenges of sustainability within this sector. As a starting point, urban transportation was selected for this project. That is not to claim the existence of clear boundaries or the separability of urban aspects of transportation from regional or international ones. But urban transport was selected as it accounts for a large share of the environmental impact, 40% of all energy consumption (IPCC, 2014, p. 605), in a relatively focused and thus more easily, promptly and locally malleable space. Furthermore, while high income groups may enjoy international mobility, urban mobility remains a daily necessity for all sections of the population, and its significance increases as more and more people are residing in cities worldwide, which by UN's projections will be 68% of global population by 2050 (UN, 2018). Finally, while much of international or even regional travel has been halted during the covid-19 pandemic, urban transport has seen various changes everywhere which should not go uninvestigated.

3.2 Urban Transport

Modes within urban transport differ greatly based on the economic situation, geography, culture, etc. Generally, however, five basic modes can be recognized within the transportation systems of cities (Anke, et al., 2021; Schiller, et al., 2010); (i) walking and (ii) cycling, which are the two active modes of transport, (iii) private motorized vehicles or the most common form of them, cars, (iv) buses, trams and streetcars as short-range and (v) trains, metro and subway as long-range public transportation. These five modes correspond to four general types of users; pedestrians, cyclists, drivers and transit users.

The variation across responses to issues of urban transportation can be summed up in two debates (based on Schiller, et al., 2010, p. 192); (i) modal competition, the frontiers of which are drawn between cars on one side and a mixture of walking, cycling and public transit on the other, and (ii) freight versus passenger mobility, one side advocating for deregulation and globalization of trade and the other for personal mobility and localization. The position of policy and planning around these two issues has produced a spectrum of sustainability within different parts of the world based on the paths undertaken during the second half of the 20th century when most developments picked up pace (Ibid., pp. 69-73). Based on the historical account provided by Schiller and colleagues (2010) the following contrasting scenarios can be represented to describe the differences:

Global, Segregated, and Car-oriented

Globalization of freight in this view, is prioritized over passengers' mobility. Resource flows of unnecessary length stretch across the planet to access cheap labor and raw materials by transoceanic vessels, which are then channeled through the city by delivery trucks to be sold at large stores for higher profit. These stores, like many other services such as education, healthcare and recreation, are segregated within the city in a low-density urban plan which forces citizens to travel long distances from their residence to meet basic needs. These practices are supported by and induce more demand for cars, which is necessary for undertaking larger, less frequent loads of shopping for instance. As cars become indispensable, public funds are directed for development of more roads within urban areas as well as regional highways.

Local, Mixed and Car-free

In contrast to this is the more sustainable way of organizing urban transport; re-urbanization and mixed-use city planning which places the variety of services people access on a daily or weekly basis within very short distances of where they live. Strategies known as 'pedestrianization' and 'traffic calming' in this view allocate the space and funding formerly claimed by cars to sidewalks, car-free zones, bicycle and public transit infrastructure, making a combination of walking, cycling and public transit a sufficient and easy way to access different urban spaces and services.

Thus, rather than the ubiquitous access of a single mode, i.e. driving, focus is shifted on 'multi-modal and inter-modal' infrastructure (Schiller, et al., 2010, p. 88) in a connected ecosystem of different mobility options. The latest developments in this regard are the research on mobility as a service (MaaS) and intelligent transportation system (ITS) (See Giesecke, et al., 2016). Furthermore, this scenario improves the sociability and security of urban communities (Schiller, et al., 2010, p. 92) by increasing the presence of people in the streets, on top of which is the physical and mental wellbeing benefits of active and public mobility compared to driving.

3.2.1 Mobility and Covid-19

As mobility is one of most tangible aspects of our lives which has been heavily influenced by the covid-19 pandemic, it is worth taking the learnings from it into account, noting also the remarkable amount of research that has been done over the past year.

Information and Communications Technology

For those able to shelter-in-place, which depends on type of occupation, economic security and access to services, the past year has replaced most driving, cycling, walking and commuting practices by screens; teleworking, online shopping, food delivery, Netflix, virtual lectures and workshops, and video calls to family and friends. Advancements in the field of internet and communication technology (ICT) has made it possible to easily shift many practices to the virtual side, with some companies even re-evaluating the necessity of business travels after the pandemic is over.

In general, the relationship between ICT and travel behaviour is disputed in the literature. According to Ozbilen and colleagues (2021) there are two opposing views that dominate the discourse; (i) substitution, as in virtual practices replacing the need to travel, and (ii) complementarity, where the use of ICT creates further travel needs. Being a complex and multifaceted relationship, it is not easily analysed. However, in more defined and narrow fields of practice, e.g. teleworking and online shopping, ICT is commonly perceived to be environmentally beneficial, as people no longer drive cars or ride the train to go to places. This perception has been sharply disproved. ICT replacing physical travel for these two purposes has an enormous environmental rebound effect (Freire González & Vivanco, 2020), both in energy and material footprint, which in the case of Sweden for instance comes close to 200 % (Ibid.).

Changing Modal Split

The modal split is the share of each mode of transportation of the total mobility within an area. The pandemic has put a halt to two categories of transport modes (Anke, et al., 2021): car sharing, which can be neighbourhood carpooling or services provided by companies, and public transit, which in many parts of the world is under the threat of bankruptcy (Honey-Rosés et al., 2020). This is in part balanced by the overall reduction in mobility of people under lockdowns, stay-in-home orders and curfews. That considered, the travel demand left unmet by those modes has shifted across the modal split differently according to context. Based on Anke and colleagues' (2021) study on German mobility, in urban spaces, most of the increase has been taken up by walking and cycling, while in contrast rural areas have seen most of the increase absorbed by private cars. This disparity is furthering a gap already present in the patterns of transportation development in urban and rural areas (Ibid.). As city dwellers who have more options and smaller distances to cover show a trend toward sustainable transport, residents of rural areas, burdened by longer distances for need satisfaction and lack of infrastructure beyond roads, sink deeper into their dependence on cars.

For urban spaces, there is a lot of optimism in relation to the pandemic, viewing it as a chance to claim back street spaces for active modes of transport. Measures have already been taken by governments in parts of the world to facilitate walking and cycling during the pandemic, such as pop-up bicycle lanes, car-free zones and adjustments to traffic signal timing (Anke, et al., 2021). Therefore, when it comes to urban transport, there is only really one obstacle (though a massive one and far from singular), managing to surpass population figures in some countries with others not far behind (World Economic Forum, 2015); cars.

Figure 3-1 - traffic Jam (source: pexels.com/photo/road-traffic-street-car-4212617/)

3.3 Cars

While the destructive impacts of cars on our environment is clear and the price too high, car-dependence as a “testimony of the difficulty of moving away from the car system, despite the increasing awareness of the negative externalities” (Mo.Ve. Association, 2008, cited in Mattioli, et al., 2016) keep them in place. To investigate possibilities of intervention, this section looks at cars from two perspectives.

3.3.1 Car: An Urban View

Sustainable transport literature contradicts the motorists’ mobility to the interest of pedestrians, cyclists and commuters (Schiller, et al., 2010). The autonomy and convenience of cars, which often gets associated entirely with the vehicles’ features, mainly comes from the extensive network of routes that often cripple other modes’ share of public funding and space in the city.

According to Mattioli and colleagues’ (2020) remarkable review of the political economy of car-dependance, before the reign of cars, the streets were a commons, accessible to different types of users like pedestrians, cyclists, horse riders, strollers, animal-drawn wagons and carriages. They attribute streets, as we have come to know them today, to a physical and social reconstruction of city streets propelled by a coalition of urban motorists, auto and road construction industries in the early 20th century. A development that started in US with intense car lobbies, e.g. Ford, and were later adopted by the rest of the globe. In this regard, Norton (2007, cited in Ibid.) provides an account of how the initial problem of cars in the city, which was collisions and casualties followed by calls for regulating them, was reframed by influence over policy to regulate the presence of “other users”. Thus, cars became the primary and default users of the streets, open to others only under “carefully defined restrictions”, and the infrastructure created to ensure the safety of the pedestrians, like zebra crossing and traffic lights, were really created to safeguard the unchallenged supremacy of cars over urban spaces (Ibid.).

While the debate around the use of cars too often stops at fuel discussions, it is important to acknowledge that even with a green car and 100% clean fuel we would still be spending monstrous amounts of energy and time getting around (Schiller, et al., 2010, p. 115), given that the majority of cars’ ecological impact doesn’t come from their use, but the possibility of it as we continue to build our cities around spaces to drive and store them (Ibid., p. 96). The “near-universal” (Mattioli, et al., 2020, p. 1) access of cars comes at the expense of other modes infrastructure, access and safety, reducing the usefulness of active and public transportation in satisfying mobility needs (Schiller, et al., 2010; Mattioli, et al., 2020).

Historically, the rising car industry of the 20th century and the campaign of ‘Urban Sprawl’ or low-density planning in the West went hand in hand (Mattioli, et al., 2020), creating a vicious cycle; cars allowed settlements further from city centres and required more space to be stored in large suburban housing patterns while living on the outskirts increased demand for car manufacturing. Yet in conceptualizing what the city could look like without the mass of car routes infiltrating every corner of it, it is important to discuss what sustainable urban planning means, as recent research has proven the common perception to be defective.

Figure 3-2 - comparing density in urban planning; low density(left - source: pexels.com/photo/aerial-photography-of-gray-houses-1486785/) and high density (right - source: commons.wikimedia.org/wiki/File:Residential_buildings_along_a_road_in_San_Francisco.jpg)

Urban Density

There are different views about what the most sustainable urban form is. Holden & Norland (2005) provide a thorough account of the research in this regard which shows how the dominant theory for decades claimed a dispersed city or low-density planning caused high levels of energy consumption in transport, while arguing compact or high-density planning to be the most efficient form. These scholars, however, investigate a theory known as the ‘Compensatory Mechanism’ which means people living in compact urban areas, who travel short distances for daily purposes, make up for it by frequent weekend travels by car, and long leisure trips by plane so that the overall energy consumption, is nearly at the same high level. While this can

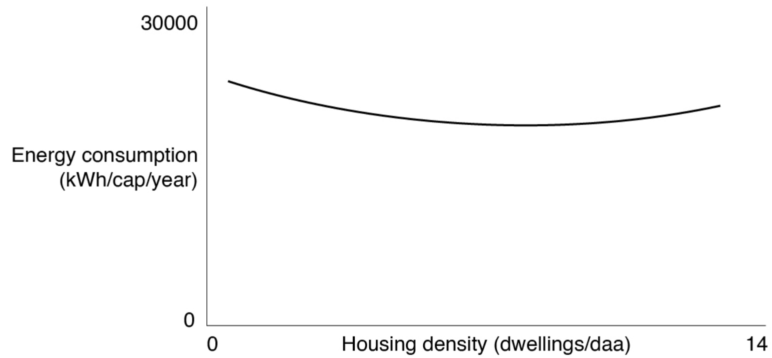


Figure 3-3 - energy consumption for housing and transport in relation to urban density, based on a study in Norway (diagram based on Holden & Norland, 2005) arguably be limited to those with a certain level of economic security, the challenges posed to the wellbeing of citizens by ultra-high density planning enabled by skyscrapers affects all. Holden & Norland's study on Norway verifies the compensatory mechanism and shows an in-between optimum; meaning people who live in less compact areas which allow access to open spaces, like gardens and parks, consume the lowest overall energy for mobility.

Therefore, density in urban planning is double sided; low and high levels create the same unsustainable outcome, and there is a medium level at which energy efficiency is achieved. More recently, research in this area has been focusing on a middle option between the two opposing views known as 'Decentralized Concentration' (Holden & Norland, 2005), which argues for decreasing centralization and zoning of cities, so more people can live closer to service areas in a mixed-use planning pattern which at the same time requires urban greening and expansion of open spaces in the city. In this view, investment in active and public transport infrastructure can support the mobility of citizens, thus keeping the benefits of a compact city (low daily travel and more efficient housing patterns) while also getting rid of the compensatory mechanism (Ibid.).

Urban density and Covid-19

The discussion of urban planning and the optimum density for cities can never be viewed in quite the same light after the Covid-19 global pandemic. Higher density will obviously not be an option, and neither will centralization (Honey-Rosés et al., 2020). The city must decentralize functions across different aspects, for instance a network of dispersed green spaces available to communities across the city rather than one giant park, which would not only slow the spread of a pandemic compared to a highly centralized city but can also be used as make-shift hospitals and repose centres should the need arise (Ibid.).

3.3.2 Car: A Product View

In a remarkable analysis of car-dependence Mattioli and colleagues (2016) argue for three distinct levels to the phenomenon, summarized as the following:

- **The Macro**
  On a macro level, there are structures such as built environment and institutional arrangements that force cars as a means of transport on the users (ibid., p. 58). Cars, for instance, have an intense lock-in mechanism which is supplied by overproduction and the constant decrease in their value as well as their multifunctional design (Mattioli, et al., 2020, pp. 4-5). Thus, once purchased, cars get used for trips on an insane spectrum of different duration, range and velocity; from five-minute trips to a store a few hundred meters away all the way to months long inter-province, -nation and even -continent trips.

- **The Micro**
  On a micro level, there are two types of dependence (Ibid., p. 57): first being conscious one, referring to users who have alternatives but chose not to use them, and the second a structural dependence of people who cannot use other modes, due to disability for instance.

- **The Meso**
  The third level, which sits in between and also connects the two others while remaining mainly understudied, is car-dependent practices. The link between the car and some of our practices has become so integral that removal of the car would implicate substantial changes to their time, frequency, destination and the competence required to perform them, which in many cases may result in abandonment of the practice altogether (Ibid., p. 59). In relation to competence for instance, the difference is not limited to the use of other modes of transportation since by allowing us to carry tools we might not be able to take otherwise, cars also impact the performance of practices at the destination (Ibid., p. 59).

Thus, from an actor-network theory perspective (refer to Latour, 2004; Yaneva, 2009; Sayes, 2014), so much of the control over our movement has been delegated to this single product over the century of its presence in human society. It is therefore important to understand the changes that the perception of this product has undergone during this time period. While in early decades, the car was a symbol of freedom, speed and class (Mattioli, et al., 2020, p. 11), its image today can be discussed around three aspects of its use:

- **Cocooning**
  To Mattioli and colleagues (2020, p. 11) the most significant "selling point" of the car today is the privacy and safety aspects of it as a mode of transport; the car offers protection against weather conditions like rain, wind and UV, is a shield from environmental factors such as (ironically) heat, noise, pollution and most recently viruses, and it separates the passengers from undesirable social interaction or crimes in the street.

Figure 3-4 - cocooning aspect of the car (source: pexels.com/photo/panel-with-buttons-on-contemporary-car-door-4150584/)

- **Escorting and Group Travel**
  Cars are obviously favoured for offering the ability to escort individuals with limited autonomy of movement (Mattioli, et al., 2016), such as the elderly, children, physiologically or mentally disabled individuals, etc. Furthermore, cars are also an easy solution to mobility of multiple individuals as a social unit, in both professional and recreational trips.

Figure 3-5 - escorting aspect of the car (source: pexels.com/photo/happy-asian-kids-traveling-in-car-4473498/)

- **Carrying**
  The next aspect is the car's supporting feature for transporting heavy and or bulky loads with ease (Mattioli, et al., 2016). Be it groceries, golf clubs, small furniture items or musical instruments, cars have a significant advantage over other modes when it comes to carrying capacity.

Figure 3-6 - carrying aspect of the car (source: flickr.com/photos/29233640@N07/3342093669)

Acknowledging the difficulties imposed on the "carless" (Mattioli, et al., 2016) in a car-oriented spatial and institutional infrastructure, any attempt to improve the usability of active and public transportation modes, means not only rethinking the allocation of space and funding along the modal split in a wider reassessment of city planning, but also enhancing these aspects of mobility that maintain the dependency of our practices on cars. The perception of these aspects has been shaped over the decades around the assumption of cars as the default mode of transport, which is a strong manifestation of the reductive kind of thinking that fuels the unsustainability of our patterns of living across different aspects of society.

To start with cocooning, the reductive and linear conception of the car's space which shields the passengers from heat, noise and pollution, continually disregards the fact that the car heavily (if not solely) contributes to the problem it protects the passengers from in the space beyond it. Even in the case of the latest, hostile and lethal environmental factor, covid-19, the safety offered by the interior of a car, means people with cars are less conscious about physical distancing in places they cannot help but share with others. These are boundary spaces like parkings, elevators and hallways as well as public spaces like stores. In contrast, a holistic and nonlinear conception of space practiced by pedestrians, means rather than closure to focus is on the distance from and the relation to other actors in the space.

With regards to group travel, cars are reductive compared to active and public mobility which are constitutive and relational as the velocity and direction of a group's movement as an entity is the result of all members' mobility. Cars, on the other hand, are not an egalitarian mode of group mobility as only one person can drive the car. This also extends to the escorting aspect of the car. Driving a person around in a car is hardly an empowering method of escorting them as opposed to the role one can fill in going along with them on a bus or by walking.

Finally, the reductionism governing our perception of mobility comes into full catastrophe with carrying. Being a society of plastic bags and shrinkwraps, almost everything we want to carry gets enclosed within another shell. Which itself most likely goes inside another one, followed by yet another to leave us with the convenience of only dealing with the last shell. Groceries, themselves ranging from zero to multiple levels of packaging, get shoved into bags, which if the shopping session is voluminous enough have to be enclosed within much bigger bags for easier handling, and those finally get thrown into the trunk of a car. These endless layers, on a large scale and over an extended period of time, amount to catastrophic effects with regards to material, time and energy wasted to produce and dispose of them. It is important to note that the influence of a reductive conception of carrying doesn't stop at the boundary of transportation. For instance, given that cars allow us to carry equipment and tools easily, they undermine efforts for shifting from ownership and individualization toward systems of access and sharing.

3.4 Design of, by and for Cars

The underlying ways in which we perceive how we move ourselves, others and objects, and relate to our surrounding environment, have a significant influence over efforts at creating a sustainable transport sector. These perceptions which like many other aspects of our lives are reductive and linear, owe much of their current form to the decades long prevalence of cars in the mobility landscape. In a vicious cycle, these images and the cars' unchallenged infiltration of our cities have reinforced each other over the last century to produce the unsustainable urban scene and mobility patterns we have come to know.

The need to decouple our practices and perceptions from cars is evident, however, a motion toward challenging the status quo isn't necessarily limited to the design of transportation modes. The resistance of cars to being changed and replaced is supported by what Shove calls an 'ecology of stuff' (2003, cited in Scott, et al., 2012). The plethora of objects and spaces that are designed every day for the urban setting, take their point of departure from the image of the car as something default and ubiquitous, and thus define their place in our lives around this fact. As such, product designers of all spheres, not just those working for the auto industry, constantly contribute to car-dependence through their designs by upholding and strengthening the reductive perceptions and images within a car-oriented mobility landscape. Therefore, every design that doesn't negate these types of understanding, further intertwines cars with more aspects of our lives.

3.4.1 Initial Brief

As the cover of this document has indicated, the carrying aspect was selected as a case study to connect these findings to possible changes through design intervention. Thus, the following chapter contains research and ideation process around this question:

How can carrying practices within urban transport decouple from the unsustainability of car-dependence?

The following chapter does not focus on a specific problem within the carrying aspect of a definite mode of transportation. Instead the aim was to probe the practice of carrying in general. Making it an attempt to understand how we carry things, how the things we carry affect our mobility and that of others, and the implications of carrying for the overall sustainability of transportation.

4 The Way We Carry

image source: stocksnap.io/photo/baggage-luggage-IFK3M3WSV4

4.1 Do We Still Carry?

It appears quite futile at first to be designing for such an outdated and apparently dying practice as carrying. Such patterns of action seem to be on their way to eradication with all the ICT developments and the virtual and online take-over – seemingly another material aspect of our lives that will soon belong in the history books. That is of course history e-books. To argue otherwise, this section looks at three distinct areas of development most relevant to carrying.

4.1.1 Digitalization

The relation between digitalization and carrying is not as simple as it may seem at first. On the one hand, digital technology has relieved us of the need to carry a vast array of loads on a daily basis or significantly reduced the volume and weight of them. Instead of paper and coin money we mostly carry a credit card with us. Instead of keys to various entry points of our houses and workspaces we carry electronic key cards. And phones, laptops and tablets have erased the need to carry documents, books and music physically, which together with the extensive reach of the internet, most of the time means we don’t even carry the digital bits with us and simply access them online.

However, this picture is double sided as this trend constantly produces new patterns of behaviour and products with it that we carry around. We almost always carry our laptops or tablets with us and are literally inseparable from and completely dependent on our phones. With headphones (and at later stages virtual reality goggles) we are invited to carry our own sensory environment around with us, undistributed by what goes on in the surrounding space.

This opens a path to another question relating to carrying. Do these new products limit or expand our mobility? At first glance there is the weight of the backpack containing our laptop which potentially limits the range and velocity of our trips, and the volume of it on our back which limits the movement of our arms. The same goes for the smartphones, the perpetual increase of whose dimensions have long passed the threshold at which they comfortably fit our pants pockets. But on a wider spatio-temporal view, these devices significantly expand our freedom of movement. Giving us more temporal flexibility, the ability to change plans and be spontaneous, and almost do anything anywhere; listen to books while jogging, attend a conference while sitting on the beach or work on the train.

4.1.2 Disposition, Ownership and Access

The rampant pace of production-consumption-disposition cycles in the consumer society of today is another aspect relevant to the study of carrying. Single serving and disposable products are everywhere; from single portion coffee creamers, packaged snacks and ready-made food to cups, plates and utensils, to tissues, paper towels and razors. Everything one might have once needed to carry in relation to food, eating and personal hygiene is now within your reach at the places of work, study or leisure – just around the corner in a supermarket or better yet vending machines. This development has gone on to the point where they have become more convenient to use at home as well and the practice of cleaning and caring for durable versions of them belongs to a bygone era.

While the dominant approach frames the question as one of waste, the unsustainability of these products is far more severe. Making them from low impact and biodegradable materials is more destructive than helpful as it induces more consumption by putting a thin sustainable disguise on them, a phenomenon known as “green consumerism”. No matter if it is composed of plastic, paper, bamboo or what have you, the cups keep piling up in the trash can next to water coolers while we easily disregard the time, energy and labour that goes into their production, and reproduce the social and economic unsustainability of consumerism at the same time.

In contrast to this trend, which has been ruthlessly expanding into more and more aspects of daily life for more than half a century, are the two rather opposing notions of (i) individualism and personal ownership and (ii) collectivism, sharing and access-based consumption, whose relationship to carrying is somewhat complex. This relationship is laid out here through three examples:

- First is the case of tools and equipment that are needed to perform certain activities. The two opposing scenarios here are to privately own and thus carry equipments to the destination at which a task takes place, or to make a multitude of them available to a group of individuals accessing that space. This can be shoes in a bowling alley, rackets in a gym facility, tools in a workshop or grills in a park.

- The other example is that of services one can outsource, but stretch beyond the space they are performed at, which in contrast to the previous example creates the need for carrying. Take the case of laundry. It is unsustainable for each household, which is a continually shrinking living arrangement of individuals, to own a laundry machine which may be used from once to a few times a week. Yet sharing access to a series of machines with the people of one’s floor, building or block means there is a need to carry loads of clothes to and from these facilities.

- The third example is that of the most infamous disposable item, the cup. In contrast to disposable cups, the relatively new trend of personal water bottles is certainly welcomed; more time, material and energy is used to produce a single unit, but it has a far longer life span. On the sharing side of this argument resides the provision of a multitude of durable cups, to be accessed by people sharing a space, like an office, who will collectively clean and care for them. Yet as this solution only works for certain spaces and determined destinations, and one usually makes stops at a variety of spaces during a normal day in the mobile lives of today, the bottle might be a better option as it also erases the need for purchasing bottled water outdoors.

4.1.3 Delivery and E-commerce

The last discussion, which probably has the most tangible relation to carrying is that of home delivery and e-commerce, which has soared during the covid-19 pandemic (Ozbilen, et al., 2021). Some of the well-known problems of shopping online are being addressed with the development of ICT. For instance the possibility provided by virtual and augmented reality technology to try on the clothes one is about to purchase. Another example is the connection of large transnational retailers with networks of local producers to add fresh produce to their list of deliverables, which more often than not is an imposition which forces the locals to sell their products on these platforms and decrease their earnings as they are unable to compete.

Still, most of the products purchased through these services (food items or not) reach the consumers after traveling irrationally long distances; extracting raw material from one place, producing in another and selling halfway across the globe. A practice made not only rational but immensely profitable by globalization policies and tax breaks for corporations everywhere. However, beyond the ecological destructiveness of exporting and importing nearly equivalent quantities of the same product type in and out of a country, and the inhumane conditions for the warehouse workers who have been specially exposed to risk during the past year, these services also have negative implications for the consumers. These include reducing the social mobility of their living spaces as well as stimulating health hazards relating to immobility such as obesity and heart problems.

The unstoppable growth of online retail giants considered, people still get out of their houses, go to local stores and markets and do much of their shopping in person; be it for the carefully designed experience of shopping in supermarkets and malls, or the failure of virtual tools to match the experience of being there and examining what one purchases, or the motivation to be sustainable which is manifested in a growing package-free shopping trend.

4.2 What Do We Carry?

With the more basic question settled, it is imperative to have a glance at what we carry. The different loads we carry have a significant impact on our mobility patterns. They limit or sometimes determine the means by which we can get to our destination. In the urban context, the loads we carry with us vary greatly based on the time (of year, week or day), geography, culture, profession, socioeconomic status, gender, etc. To paint a general picture, figure 4-1 displays the spatio-temporal scale of loads carried by passengers in urban scenarios. Starting on the left are the smallest and lightest of urban loads, ones we rarely leave indoors without, such as keys, phone and wallet. Then there are objects which are small and carried frequently but based on weather conditions, such an umbrella or a jacket. Further to the right are loads of higher mass and volume that we interact with on a weekly or monthly basis, those are groceries and shopping items, exercise equipment and clothes, dry-cleanings, etc. Finally, at the end of scale are the heaviest and bulkiest loads which include suitcases, furniture or appliances which we may not need to carry for months or years apart.

Wallet Cell phone Keys Glasses Headphones	Water bottle Laptop (and charger) Documents, files, folders Bike helmet Medication Stationary Food (lunch, snacks) Sunblock Cosmetics Umbrella Daily groceries Purse Shoulder bag Backpack Fanny pack Baby wear Exercise equipment (shoes, rackets, yoga mat) Weather condition clothes (jacket, gloves, hat, scarf)	Large backpack Weekly-monthly shopping (food, clothing, furniture items) Dry-cleanings Recreational items (board games, packed food and drinks) Musical instrument Overnight bag	Stroller Suitcase	Furniture Appliances

Figure 4-1 - the spatio-temporal scale of carrying in urban transport

The items on the scale are of two fundamentally different types; (i) the object one actually wants to carry, such as water, money, laptop or clothes, and (ii) the object one uses to carry it with, meaning a bottle, wallet, backpack, and suitcase.

4.3 How Do We Carry?

In every instance of urban load carrying, three categories of elements can be recognized:

1. the object(s) – the item(s) in need of relocation
2. the mobile body – the body causing the motion, which can be a vehicle or a human
3. the bearer – the ‘something’ that links the previous two together, which can be a bag, box, container or case

These boundaries get blurred when the bearer is an integral part of the mobile body, such as a car truck, bicycle basket or the overhead compartment in a train.

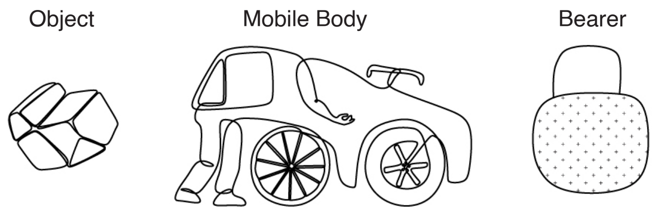


Figure 4-2 - the three elements of carrying

Excluding the industrial freight context from this analysis, almost all bearers within urban mobility have two components:

a. the holder – primarily tasked with holding the object(s), e.g. the pouch of a bag
b. the connector – primarily tasked with relating to the mobile body, e.g. the handles

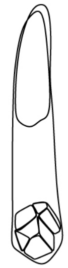
Figure 4 3 - the two components of a bearer (sources from left:
1. Yellow plastic carrier bag. Encyclopædia Britannica ImageQuest. quest.eb.com/search/118_804370/1/118_804370/cite
2. commons.wikimedia.org/wiki/File:Ghost_Backpack.jpg
3. Red suitcase, artwork. Encyclopædia Britannica ImageQuest. quest.eb.com/search/132_1559584/1/132_1559584/cite)

4.3.1 The First Part of the Story: Object(s) and Bearer(s)

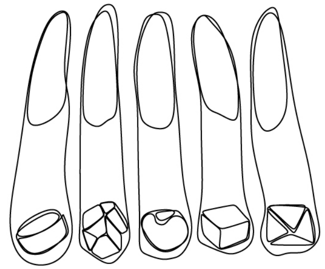
The following section probes into the relationships between objects and bearers, and in doing so attempts to unveil the perceptions behind carrying.

Object(s) – Bearer

The most common way of carrying objects is to throw them inside a closed or semi-closed space that *holds* them by the means of inclusion. The convenience of inclusion solely lies in the ‘s’ following the ‘object’. If the object was only a single item, would a bag be necessary or even a convenient way to carry it? Granted the item isn’t disproportionately large or heavy, it could simply be held in one hand, which is why the illustration on the right looks odd.

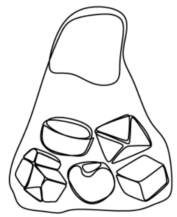


Yet it seldom happens that we have only a single object to carry. Assuming there are five objects to carry, it seems odd to imagine using five separate bags to carry them in even though the five bags perfectly fulfill the functions of (a) holding the objects and (b) connecting them to the mobile body, i.e. the hands.

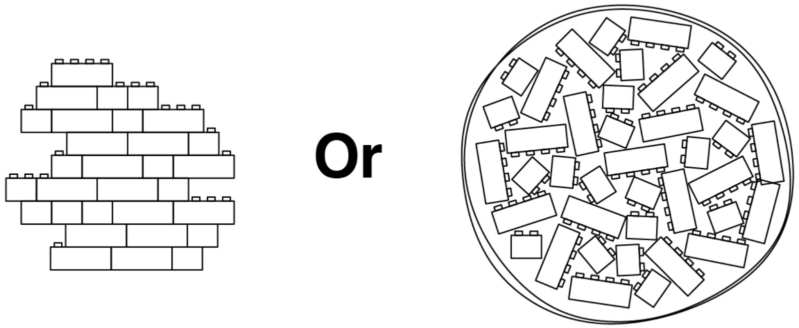


Object – Object

The convenience of carrying multiple objects in a single bearer has little to do with the connection to the mobile body and much with the attachment it creates between those objects. It’s hard to imagine scenarios other than this as the hypothetical objects used here have no means of relating to each other on their own.



To make this point more clear, Lego bricks can be used instead as objects. This makes it possible to either use inclusion by a bearer as the means of indirect attachment between the bricks, or connect the bricks directly to each other and form a new entity, which can be carried on its own.



This example shows that the convenience of inclusion as the *holding* task of a bearer, lies to a great degree in creating an attachment between objects which otherwise would be difficult to connect. In a hierarchy of carrying, this means the only thing connecting two objects in the same level is having a common superior; i.e. being enclosed by the same bag.

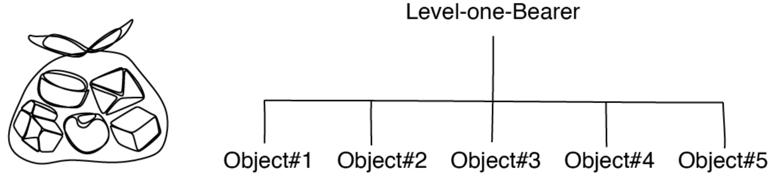


Figure 4-4 - the hierarchy of carrying, two levels

This perception suits the common understanding we have of hierarchies which is influenced by a reductionist frame of thought. Gibson and colleagues (2000, p. 218) make a distinction between three types of hierarchies:

1. Inclusive - higher level entities contain lower level ones within them, e.g. jurisdictions
2. Exclusive - higher level entities are placed above lower ones in a ranking system, meaning lower level entities are not in any way part of higher ones, e.g. military ranking systems
3. Constitutive - higher level entities are the emergent outcome of interdependence between lower level ones, e.g. cells of an organ of a body

Exclusive type hardly being relevant to our context, most of the carrying happens in an inclusive hierarchy.

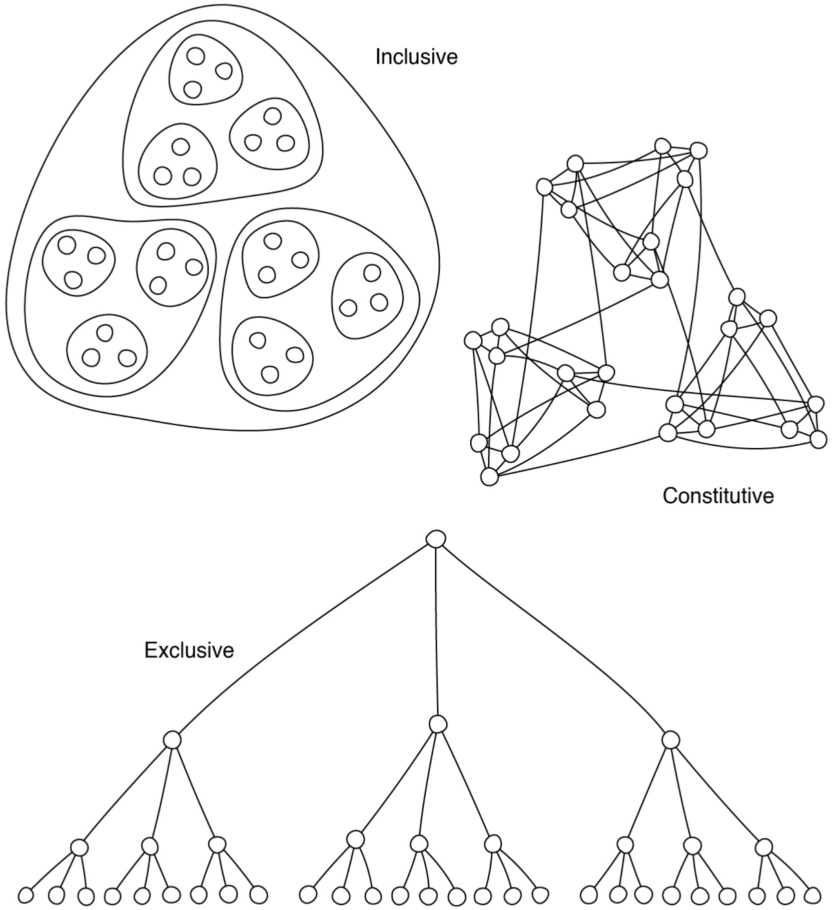


Figure 4-5 - the three types of hierarchies

Bearer – Bearer

This inclusive feature is present at various levels of the hierarchy of carrying. Bearers become objects in relation to next level bearers along the hierarchy where inclusion by the bigger bag servers as the attachment between the lower level bags.

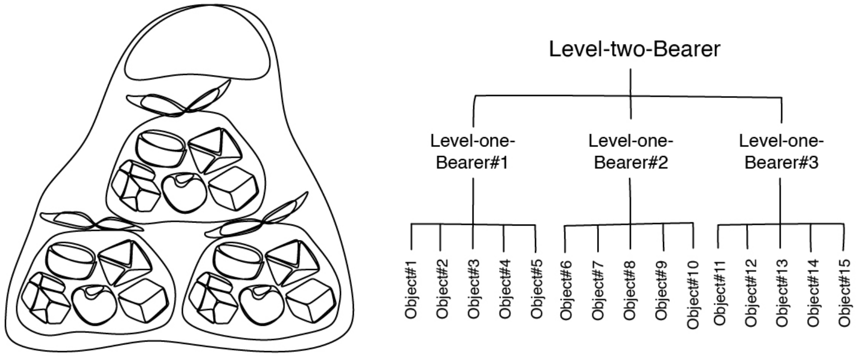


Figure 4-6 - the hierarchy of carrying, three levels

In the context of urban mobility, this hierarchy can translate to the levels of a normal load of grocery shopping: individually wrapped candy, within a larger package, that goes into a plastic bag, which likely goes into another bag if the shopping load is large enough. This inclusive hierarchy through which we perceive objects, bearers and the linear relationships between them, leads to a spatially ‘closed’ design. In this sense, the design of products rarely seems concerned with any space beyond which it immediately occupies. This makes the carrying relationship almost always a linear one as it places the responsibility of the connection onto the higher level entity, requiring it to encompass the lower ones.

The constitutive hierarchy, which represents the nonlinear way of thinking about this issue, is mainly absent in the design of urban products. However, examples of it can be found in specialized carrying gear for hikers, climbers and military equipment. There are a multitude of options such as daisy chains, gear loops of webbing, elastic cords, etc. considered in the design, which not only offer faster and easier access for items to be carried outside the bag, but also accounts for scenarios that push the use beyond the inclusive capacity of the bag. Instead of solely relying on inclusion, these ‘open’ features allow bags and objects to relate to each other in a mutual way.

Figure 4-7 - relational capacity on a hiking backpack (left, source: Hikers carrying backpacks at Crater Lake, mountain landscape, Chilkoot Trail, British Columbia, Canada, North America. Encyclopædia Britannica ImageQuest. quest.eb.com/search/322_3863427/1/322_3863427/cite) and a military backpack (right, source: commons.wikimedia.org/wiki/File:Molle_Rucksack_NG0805_1179.jpg)

4.3.2 Design Brief 1: A Constitutive Bearer

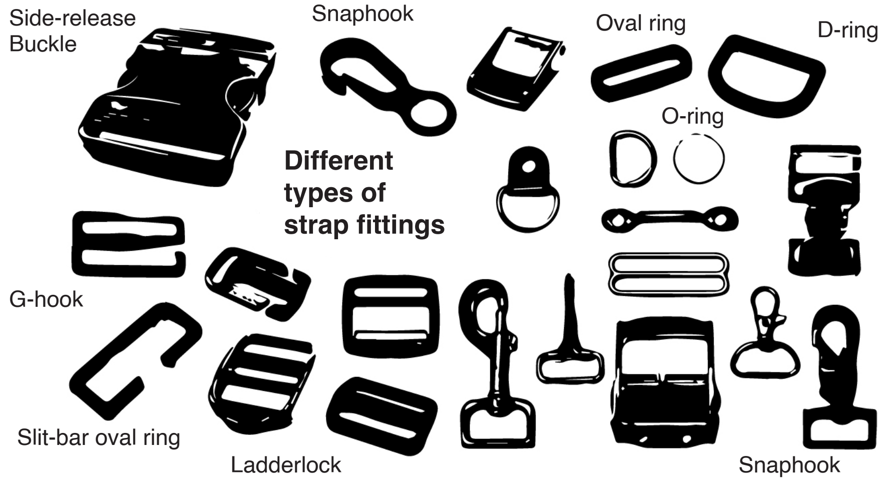
The insights from the object-bearer relationships led to the first design brief:

> Designing a nonlinear configuration for bearers that doesn’t rely on inclusion as a means of holding the objects

This process started out by considering designed points of attachment on objects and assigning the role of the bearer to a tension agent such as a rope, twine or strap. Starting off, the concepts heavily revolved around ropes and making use of knots as a means of attachment, however straps or webbing were finally selected as a form. Webbings are quite strong compared to their low cost and simple production. They are soft and easily bent, handled and coiled. Additionally, their flat profile can diffuse pressure in areas of contact with objects as well as mobile bodies.

Straps, like ropes, are used on a variety of levels and across many areas, from small bags all the way to load securement in industrial context. However, unlike the rope, they are more common in various urban products which presents a degree of familiarity for the users; straps of leather, nylon and other fabrics can be found in backpacks, bags, holsters and clothing items.

Figure 4-8 - straps used on variety of levels and different uses (sources from left:
1. commons.wikimedia.org/wiki/File:XXth-conference-of-Gazprom%27s-young-scientists_02.jpg
2. Gym bag. Encyclopædia Britannica ImageQuest. quest.eb.com/search/118_821235/1/118_821235/cite
3. commons.wikimedia.org/wiki/File:Ergo_Ratsche_mit_langem_Hebel..jpg)



Thus, building on long standing interactions with this form, winding was selected as a method of creating tension in the strap, discarding the prior idea of utilizing knots. The reason being that knots require competence and have human errors to consider. In addition, they are time consuming, and depending on their type, can be quite difficult to untie after being loaded. Winding, which uses friction to create tension, is theoretically scale-free. From coiling huge ropes on ships around single bollards, double bits and cleats to small everyday uses we make when we wind our backpack straps in double rings and ladderlocks, the same function applies: with enough friction, the load can be secured.

A simple study was carried out on different types of strap fittings, such as buckles, ladderlocks, rings, snaphooks, G-hooks, etc. to better understand how winding the strap in a pattern around a number of bars can create sufficient tension. The idea thus became for the bearer to be a sling of strap, which having multiple fittings along its length, can be used to grip and connect various objects by looping around them.

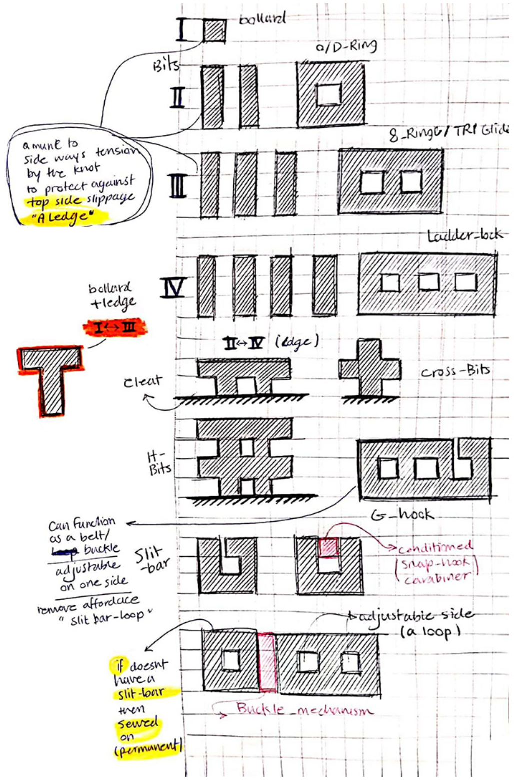
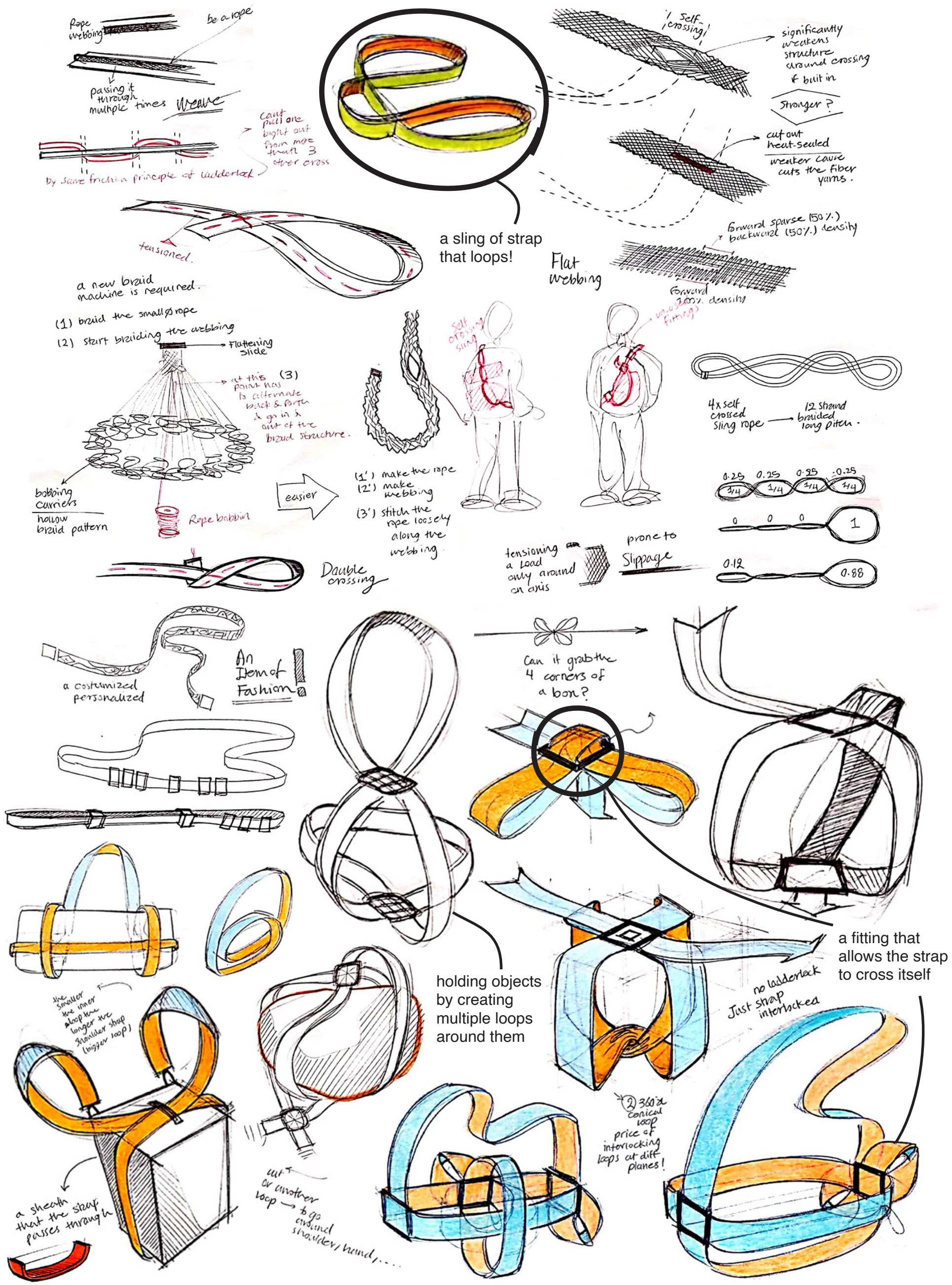
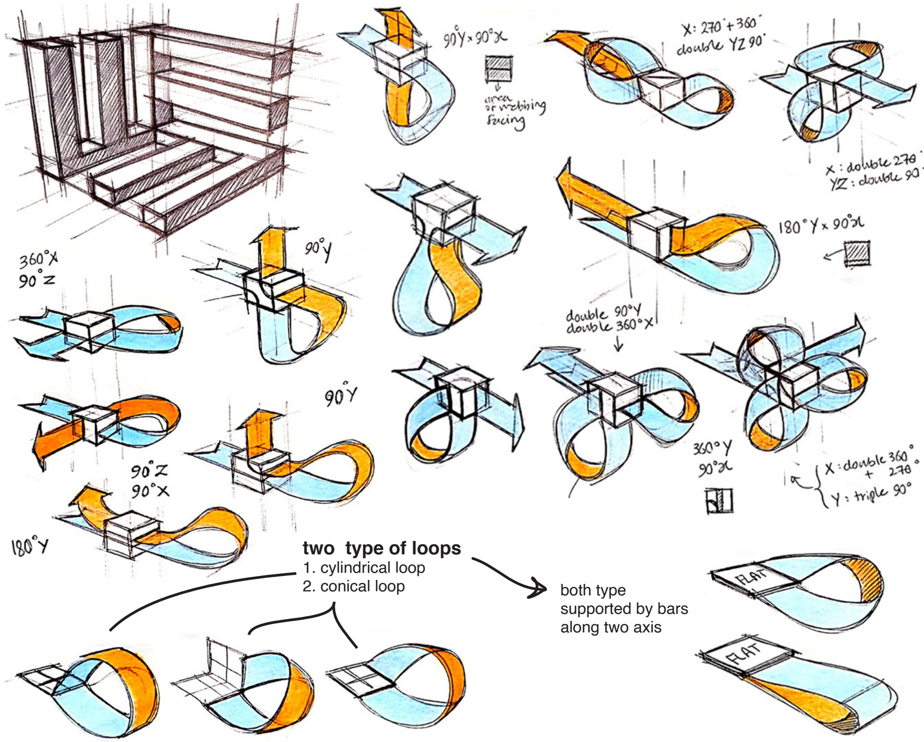


Figure 4-9 - winding as the method of creating tension across scale, from ships to backpacks (sources from left:
1. Cargo ship mooring line. Encyclopædia Britannica ImageQuest. quest.eb.com/search/132_1496723/1/132_1496723/cite
2. Boat in the Soo Locks, Michigan, USA. Encyclopædia Britannica ImageQuest. quest.eb.com/search/132_3127946/1/132_3127946/cite
3. commons.wikimedia.org/wiki/File:Adjustable_boarding_stirrup_PA200107.jpg)

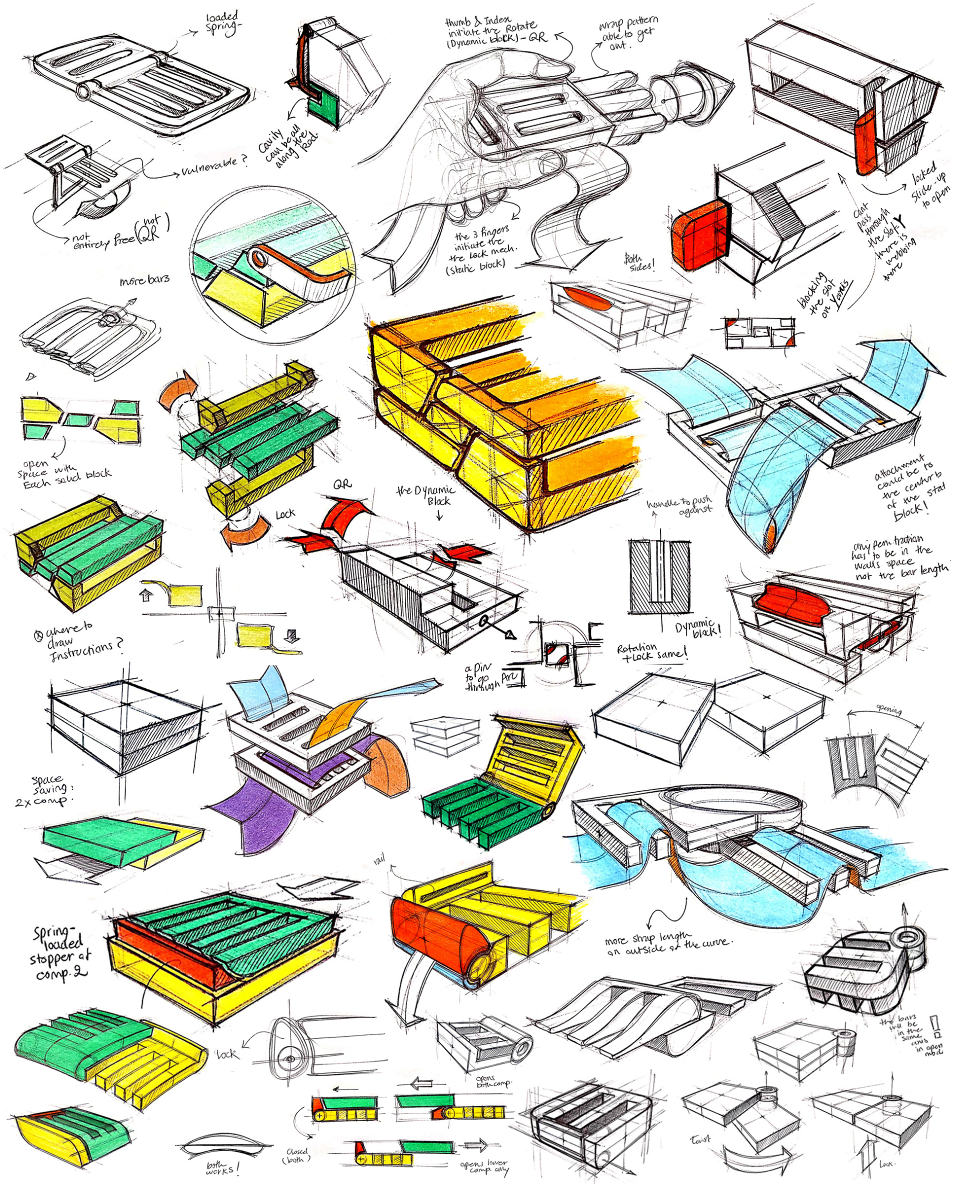


Given that multiple loops along the strap would be necessary for gripping items of various shapes and combinations, the function of the fitting is to allow the strap to cross back on itself. To offer maximum spatial possibilities with this 'self-cross' feature, the bars of the fitting around which the strap winds to create tension, should not be confined to a single axis, as normal ladderlocks are.

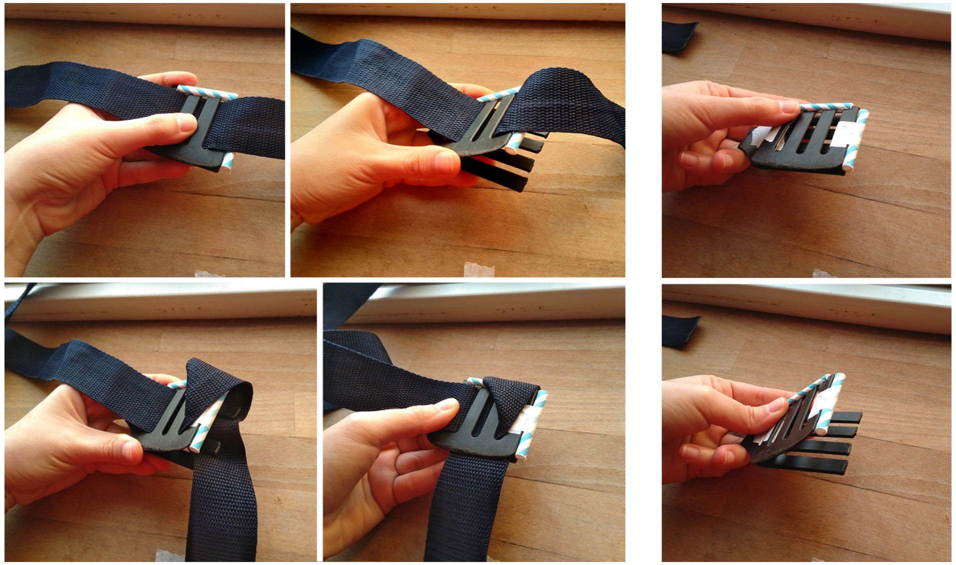


Starting off, bars along three axes were supposed to be necessary. However, after a simple study on the different ways in which a strap can cross its initial point again, two general types of loops were discovered; (i) the cylindrical loop, in which the strap exits and enters the fitting at the same edge, and (ii) the conical loop, where the exit and entrance edge are perpendicular to each other. These two types would both be supported by bars along two axes, which unlike the prior assumption can afford a rather flat product, making it easier to apply a number of them along the strap.

With this conclusion, the design of the fitting began to shape around its second important feature which is having a quick-release mechanism. To be feasible for urban uses the fitting has to function quickly and easily, not requiring precision or even two hands to release the tension.



The main idea behind quick-release was to utilize ‘slit bars’, meaning the mechanism would turn a closed set of bars (a ladder) into one that has an open side (a comb). This way the zigzag pattern of the strap through the bars can easily and quickly exit from the open side without having to go through the bars, loosening and undoing the winding. The fitting thus became a two component object. Two sets of bars perpendicular to each other moving in relation to one another to open and close the sets of bars for quick-release.



Reflection

This process of ideation was abandoned as a result of recognizing the inefficiency of eliminating inclusion, finding it instead necessary at least for the first level of the hierarchy. Inclusion by a bag is the most effective way of *holding* objects if they are numerous, small or have irregular shapes, which they often do. It offers protection against environmental factors such as temperature, UV, moisture and airborne particles, and also enables easy organization of multiple objects. Therefore, while the design of a self-crossing, quick-release strap fitting might be of use in hiking gears, the sling solution in general is not feasible in the urban context.

That said, it must also be acknowledged that most secondary and above layers of inclusion can and should be evaded. Setting a definite threshold is not an easy task as some primary levels of inclusion are so basic that they should be and are treated as objects; for instance a water bottle. Beyond those, unessential levels of inclusion cause significant material waste, but having multiple secondary level bags rarely happens in the urban context, with the exception of grocery shopping, which is explored further in the following section.

4.3.3 The Second Part of the Story: Bearer(s) and the Mobile Body

The relationship between the bearer and the mobile body can be of two types:

> **1. Passive / linear** – a relation through the 'holder' part of the bearer; inclusion by a closed or semi-closed space of the mobile body
> **2. Active / nonlinear** – a relation through the 'connector' part of the bearer; one part of the bearer attaching to a part of the mobile body

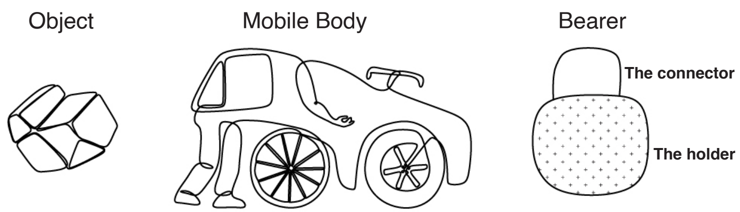


Figure 4-10 - the three elements of carrying and the two components of a bearer

With this distinction, a general picture of how carrying differs across urban transport modes can be painted. This analysis is limited to the three modes of walking, cycling and driving, leaving out different forms of public transit such as bus, tram and subway as they are very closely represented by the relations and bearers discussed under the walking mode.

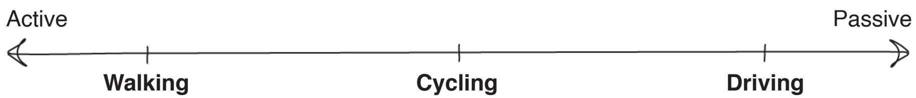


Figure 4-11 - the spectrum of load carrying across three urban transport modes

Walking

On one end of the spectrum resides walking which involves the most active relationship with bearers. Most of the bearers we use in the urban setting have connectors that interact with some part of our bodies. The shape of the connector and the corresponding body part result in two different types of relationship with bearers. The first group are bags that are *worn*: the double straps of a backpack that go around the shoulders, the single strap of a messenger bag worn over one shoulder, the belt of a fanny pack, the harness of a holster and small bags whose connectors go around the neck, wrist or arm, etc. The second group are bags that are *carried*: the handle of a hand-bag or the handles of a plastic, paper or cloth grocery bag. However, there are exceptions. Bearers such as handleless boxes and paper bags don't have an active relationship with the body, making it solely the responsibility of the body to relate to them, which often translates to being enclosed by one or both arms.

Figure 4-12 - different bearers with active and passive relationship to parts of the body (sources from left-first row:
1. pexels.com/photo/man-wearing-black-backpack-704805/
2. pexels.com/photo/woman-in-white-tank-top-and-black-pants-carrying-black-sling-bag-3577288/
3. pexels.com/photo/woman-carrying-gray-tote-bag-standing-beside-red-bookcase-2078019/
4. pexels.com/photo/man-in-pink-crew-neck-t-shirt-wearing-black-cap-4665730/
Second row:
5. pexels.com/photo/anonymous-elegant-ethnic-businesswoman-with-laptop-bag-walking-on-zebra-crossing-6000119/
6. commons.wikimedia.org/wiki/File:Leather_Fanny_Pack.JPG
7. pexels.com/photo/young-sportswoman-listening-to-music-in-park-3776837/
8. pexels.com/photo/happy-woman-with-carton-box-in-bedroom-4247730/
9. pexels.com/photo/happy-woman-with-flowers-in-paper-package-5410146/)

Driving

On the other end of the spectrum, cars stand as advocates for a passive relationship with bearers. Different spaces within the car, such as the trunk, the back seat, the front passenger seat, the floor or even the glove compartment, can carry bearers (or objects) by enclosing them within their space, which make the transportation of handleless boxes and paper bags easier with cars.

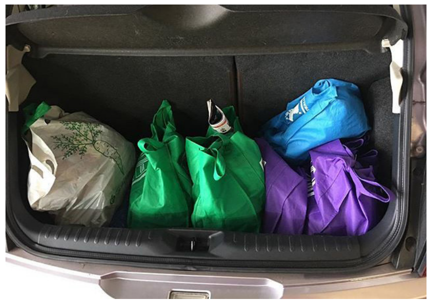


Figure 4-13 - passive relationship between bearers and the trunk of cars (sources: flickr.com/photos/moodlegal/45626834111/)

The majority of bearers, however, have some type of handles that are designed to support the weight inside of them, even if they are only used in boundary stages of car trips; from the store to the car or from the car to the house. Hence, in the passive relationships promoted by the car as a mode of transport, these handles go unused most of the time.

Cycling

The third and middle mode is the bicycle. The most common solutions for carrying objects and bearers with a bicycle are of the passive type. These entail varying degrees of closure; encompassment by the semi-closed space of a basket or cargo container, closed space of a fixed pannier, or being pressed between the surface of the rack and a spring-clamp, bungee cords, straps or nets.

Figure 4-14 - different carrying solutions for bicycle that encompass bearers (sources from left-first row:
1. commons.wikimedia.org/wiki/File:Bicycle_2.jpg
2. commons.wikimedia.org/wiki/File:Danish_bicycle_cargo.jpg
3. https://commons.wikimedia.org/wiki/File:Bay_State_Bike_Week_2011_(5556311070).jpg
second row:
4. https://www.flickr.com/photos/barriesutcliffe/3862006200/
5. https://commons.wikimedia.org/wiki/File:Bike_rack.jpg)

However, there are also a wide variety of solutions that make use of the relational capacities offered by different parts of the bicycle. While they are widely adopted and indeed necessary for bicyclepacking, their use within the city is comparatively limited.

Figure 4-15 - extensive use of active bags in bikepacking (source: ridefar.info/2021/04/the-varied-definitions-of-bikepacking/)

On the active side of cycling, there are bags that have extra straps to go around the bicycle frame in various points, trunk bags that slide and clip on a railing installed on the rack or pannier bags with multiple hooks that attach and detach from the rack frame (the next section looks into these solutions in more detail). And in the absence of these considerations, there is always the option of attaching bags by their handles to the steering bar which entails a degree of discomfort and limited motion for the cyclist.

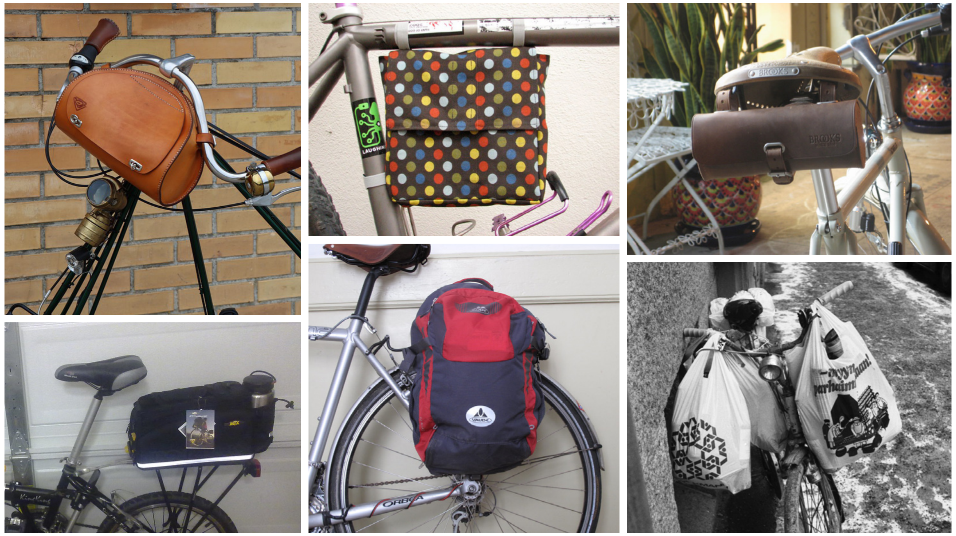


Figure 4-16 - urban examples of bags' active relationship with the bicycle (sources from left-first row:
1. pixabay.com/photos/bike-pedersen-velo-4930903/
2. https://www.flickr.com/photos/lenore-m/2864380344
3. https://www.flickr.com/photos/ubrayj02/4250024103
second row:
4. https://www.flickr.com/photos/sudoshift/5932822180
5. https://www.flickr.com/photos/7394371@N06/3974023151/
6. https://commons.wikimedia.org/wiki/File:Meritullinkatu_25_-_Helsinki_1986_-_ser860330_-_hkm.HKMS000005-km0000nv5l.jpg)

By this analysis, the dominant perception of the relationship between bearers and vehicles is arguably passive, which aligns with the passive and linear relationship of bearers to objects they encompass. This passivity, which represents the reductive way of thinking, creates a vicious cycle in the ecology of products in our unsustainable urban transport landscape. Bags are designed to have passive relationships to cars and bicycles that are used to carry them, and in return vehicles are designed with large, inclusive spaces to encompass them. This perception of carrying is certainly among the elements that sustains our dependence on cars. And the seemingly disconnected acts of designing various kinds of bags, though not consciously subscribing to this view, reinforce it by failing to envision alternatives.

4.3.4 Design Brief 2: Decoupling Bicycle from Passive Carrying

Creating an urban ecosystem of shared and public transport, connected to provide a seamless experience of mobility within cities, cannot be completed without active transport modes. The bicycle then becomes of critical significance. It is the most sustainable form of transport for local trips such as shopping as it consumes lower energy levels compared to walking the same range (Schiller, et al., 2010, p. 92), not to mention the higher velocity and carrying advantages. In addition, bicycles can be used by a wide range of age groups as they are simple to handle, and their minimum mechanism makes them durable and easily maintained.

Thus, the bicycle plays a key role in leaving car-oriented cities behind. This opens a space to challenge the image of the bicycle as a mode of transport. Is it a downgraded version of a car or an upgraded version of walking? Bicycles already contrast the reductionism inherent to cocooning and group travel by cars through being relational in those regards. So the question becomes:

> can the carrying aspect of a bicycle represent the same nonlinear logic?

Grocery Shopping

Grocery shopping, as the most relatable instance of urban load carrying, was selected as the specific area to probe this question. It is done frequently and often is large enough or undetermined enough to potentially cause difficulty without a car, as opposed to carrying a laptop to school or a set of clothes to the gym, which are predetermined and small loads. The selection of this area is by no means a praise of the supermarket style of shopping which induces unnecessary consumption, disposable packaging and over-packaged products. What remains essential is the practice of purchasing necessities (food and non-food items) which takes place on a daily or weekly basis.

Acknowledging the unsustainability of reliance on disposable bags, no matter what their material is, the solution should embrace the growing movement of personal durable bags for grocery shopping. The most successful versions of these products are the ones that don't impose a bag of sturdy structure no matter how aesthetically pleasing they are. The ability of these bags to be folded or rolled up into extremely compact forms has been a critical factor in the wide adaptation of durable bags, especially among young adults.

Figure 4-17 - durable grocery bags (sources from left:
1. pexels.com/photo/fashion-person-woman-texture-6786665/
2. Reusable shopping bag. [Photography]. Encyclopædia Britannica ImageQuest. quest.eb.com/search/132_1216165/1/132_1216165/cite
3. pexels.com/photo/person-holding-orange-fruits-in-white-net-3737624/)

Thus, simple unfastened bags were selected as the base for the inquiry that followed. These bags can be of different material and forms: bags with a surface made of cloth, various types of polymers, woven or nonwoven, or a mesh of similar material variety. These compact and widely adopted bags, however, when not in use on the body, rely solely on the assumption of the passivity offered by cars' inclusive space. In this approach, solutions such as cargo-bikes for carrying them are fundamentally futile as they subscribe to the same perception, and in doing so turn the bicycle into a mini car. Rethinking the image of bicycles will no doubt entail changes in how we organize ourselves. In relation to shopping, the practice of doing massive volumes of shopping once-a-month has to be abandoned. Trying to keep these practices alive by mimicking cars in the design of bicycles, reproduces the same segregated and centralized city plans and temporal patterns that fuel car-dependence.

Furthermore, creating an active relation for simple bags is preferred to expanding on existing pannier bags and trunk bags cited in figure 4-16. Those bags while having an active relationship with the bicycle don't afford the transformation of their carrying capacity into a compact space when not in use. In addition, those bags are specifically designed for the mode of cycling, which means more complexity and cost of production as well as elements installed on the bag which require hiding when not attached to the bicycle. This may be an understandable cost to pay for leaving cars behind, but specialization is not the only way to go. Indeed creating a seamless shared and public transport landscape requires generalization across the modes people will inevitably shift between to gain access to different spaces.

4.4 Carrying by Bicycles

4.4.1 The Place of Solution: The Bicycle

Baskets

In the urban context, the most common way to carry loads by a bicycle is baskets which can be installed in front of the steering handle, on top of the rear rack or on the side of the back wheel. Baskets have five faces, making them a semi-closed space that affords passive carrying. Compared to a rack, which has only one face, this semi-closed space can be quite limiting when it comes to grocery shopping, a number of bulky items or even two regular size bags filled with groceries meet their limit. This issue very often leads to scenarios outside supermarkets in which people try to fit items in their backpacks, attach bags to steering handles, or even hold bags in one hand and cycle with the other.

Figure 4-18 - different positions for baskets on bicycles (sources from left:
1. commons.wikimedia.org/wiki/File:Pashley_wicker_basket.jpg
2. commons.wikimedia.org/wiki/File:Bicicletas_en_Jap%C3%B3n_(14757269742).jpg)

Figure 4-19 - limited carrying capacity when shopping by bicycle (sources from left:
1. commons.wikimedia.org/wiki/File:Woman_on_a_bicycle.jpg
2. China Tackles Pollution Caused By Plastic Bags. Encyclopædia Britannica ImageQuest. quest.eb.com/search/115_2702736/1/115_2702736/cite)

Cargo Containers

Setting the image of the bicycle aside, cargo-bikes are theoretically the perfect solution to this problem. But one is more likely to encounter the scenarios cited above rather than cargo-bikes. Apart from their relatively high cost, which is far more intense in their electronic versions, the failure of cargo-bikes in achieving wide acceptance can be attributed to their large size and the limitation of movement it entails. For people whose use of the cargo function is limited solely to shopping, this downside is quite a burden as it also represents challenges with regards to parking space. There are, however, detachable trailers which can be taken off when not needed, but those are even less adopted since they cannot support spontaneous trips to the market.

Figure 4-20 - cargo-bikes and trailers (sources from left:
1. commons.wikimedia.org/wiki/File:Butchers%26Bicycles,_Mk1,_2015,_white_06.jpeg
2. commons.wikimedia.org/wiki/File:Bicycle_cargo_trailer.jpg)

Fixed Panniers

The size of a cargo container is too large for the majority of cases described, as shopping trips don't usually involve such volumes. In this case, a more appropriate solution is offered by fixed panniers which are installed on both sides of the back wheel and offer a larger capacity compared to baskets. What is meant by *fixed* here is that the panniers themselves don't leave the bicycle and carry grocery bags by encompassing them. Usually installed on the rack by straps on multiple points, their attachment and detachment is not easy enough to be a recurring

Figure 4-21 - a fixed pannier (source: commons.wikimedia.org/wiki/File:Pretty_Kewl_Bicycle,_White_Frame.jpg) function like that of pannier bags (which are covered in the next section). Nonetheless, fixed panniers come with a lesser degree of both problems: what fits the grocery bags may not fit the dimensions of the pannier, and having a rigid pannier on the bicycle at all times is a spatial burden. The latter has been solved by baskets and panniers that fold or collapse when not in use.

Figure 4-22 - a collapsible basket (source: flickr.com/photos/99247795@N00/5621255686)

The high spatial cost of a decent carrying capacity for a bicycle is a problem rising from the passive perception. To explain, once placed inside the inclusive space of a basket or pannier, the physical properties of the grocery bag which are designed to withstand the weight while used by pedestrians, get disregarded. The pouch of the bag provides sufficient securement for the items inside which doesn't need encompassment by another space whose limited dimension often fails to hold full bags.

4.4.2 First Concept: An Active Grocery Bag

These early insights led to a process of ideation for an active type of relationship between a simple unfastened grocery bag and the bicycle. Assuming the pouch of the bag sufficient for carrying the items, the aim was to create a new relationship to the bicycle that doesn't entail inclusion. Starting off, the bag was reduced to its most basic elements: a pouch and two handles. Moreover, the rear rack as the most convenient part of the bicycle for its purpose was taken as the starting point. In comparison to a rack installed on the front wheel, this has the advantage of more space while any load placed on it will not interfere with the steering of the vehicle in any way.

Figure 4 23 - a simple rear rack (source: flickr.com/photos/geiranders/4763374112)

The Steps to Carrying

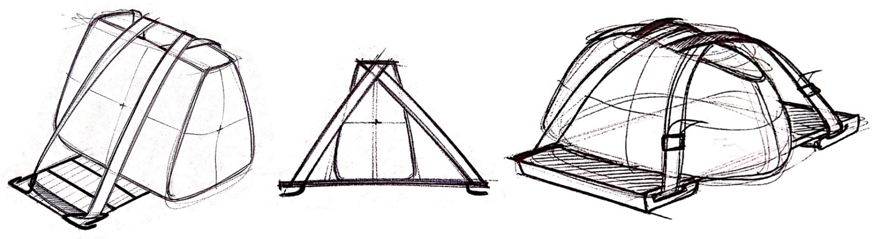
Three steps to carrying a simple bag on the rack were recognized: closure, attachment and tensioning.

- **Closure**
  Grocery bags of the simplest kind, don't have any definite means of closure for their open side at the top. However, they have two handles on their facing sides, which upon grip by a hand or placement on a shoulder, come together to create what can be called a 'partial closure' of the bag. This feature, while being perfectly sufficient for the walking mode, is absent in carrying the bag on a bicycle. In the case of baskets, this doesn't present a problem as inclusion by the space of baskets offers securement. For the rack, however, leaving the top open results in items falling out.

Figure 4-26 - partial closure of grocery bags

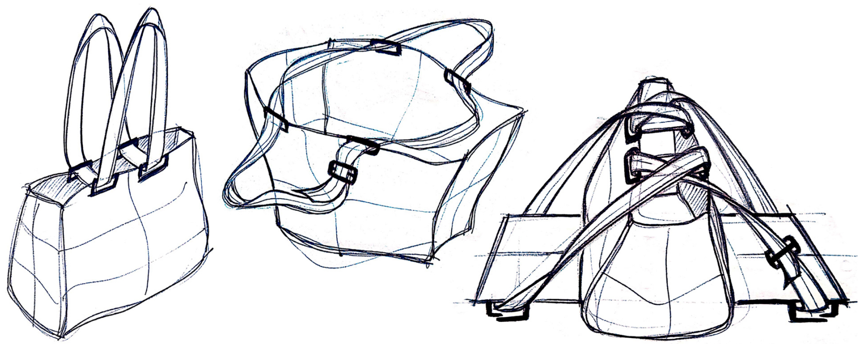
One of the easiest answers to this is knotting the handles together, which for overflowing bags may also be done in baskets. But using the handles in this way eliminates the possibility of using them to create attachment and tension.

- **Attachment**
  To make the most use of the bag's valuable handles, the elements of closure and attachment were combined into one motion. Crossing the handle of each side over the other and then attaching it to the rack, not only closes the top but also provides four points of attachment to the bicycle.



This solution entails changes to the rack as well. To offer easy and fast attachment, four snaphooks can be installed on the corners of the rack for the straps to go through.

- **Tensioning**
  For tensioning, the handles need to have some type of fitting, e.g. a ladderlock, which allows their length to be adjusted. Thus once attached to the rack, the two handles can be shortened to create sufficient tension for the bag to stay on. To make this interaction quicker and easier the two handles can be interdependent. Instead of two separate pieces of strap attached to the top edges, four oval rings can be placed there through which a single sling of strap passes. This one-sling, two-handle solution means after attachment to the rack, only one ladderlock has to be adjusted for tensioning.



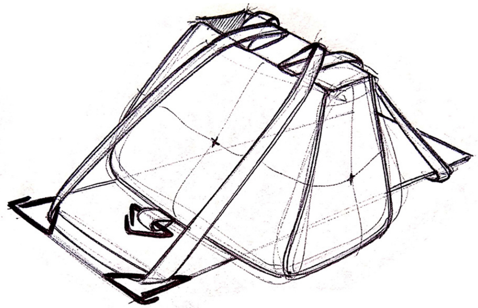
The Direction of Gravity

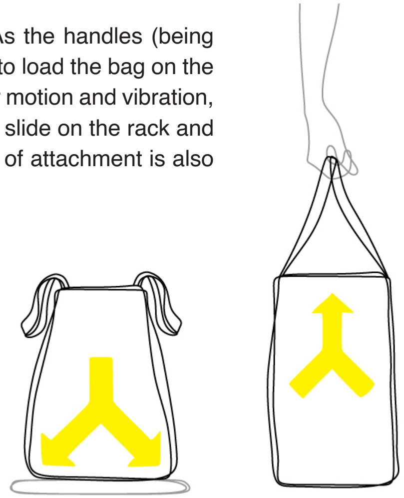
Using the handles of the bag for attachment to the rack, revealed a contradicting feature between the modes of walking and cycling; their relation to gravity.

- **Anti-gravity**
  When walking, and accordingly gripping the handles by hand, the direction of tension is in the middle of the bag and upwards as carrying is against the force of gravity.

- **Pro-gravity**
  When placed on the rack, however, that surface acts against gravity and thus the tension needed for carrying is downward to secure it in relation to the rack. Moreover, these downward tension points should be farthest apart to offer maximum stability.

This disparity represents a problem in the design. As the handles (being made for walking) are located at the top, using them to load the bag on the rack only fixes the top side of the bag. Meaning under motion and vibration, the bottom side, as it is not attached in any part, can slide on the rack and destabilize the tension altogether. Therefore, a point of attachment is also needed at the bottom.

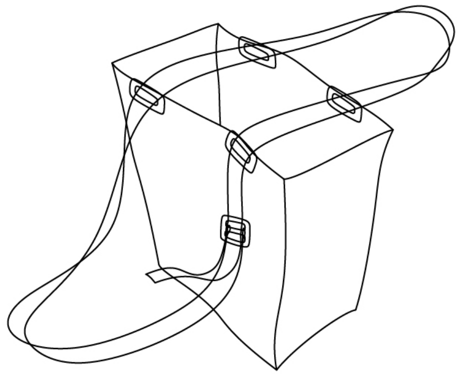




Pro-gravity Anti-gravity

Length Adjustment

With the overall configuration in hand, the next important issue was how the tensioning took place. The interdependent handles concept was created to solve the problem of two-step adjustment, one per handle. But having a single fitting imposes an order to the activity of loading as it confines the tensioning capacity to one handle. To explain, the four oval rings block the fitting from being exchanged between the sides of the bag and therefore the fitting-possessing handle has to be last to get attached to the rack. This problem of 'symmetry in use' can be solved by having two fittings, which again means two steps for tensioning.



Thus far, the length adjustment of the handles was assumed to happen through a simple ladderlock. But using such fitting represents a problem with the requirements mentioned above. To use a simple ladderlock, one end of the strap has to be sewn in a small loop around its middle bar, and the other after going through a zigzag pattern to sustain tension, exits the fitting as the 'free end' of the strap. Shortening the length is done by pulling on this end. Using a ladderlock would either require the tensioning capacity to be confined to one side, which is a problem of 'use symmetry', or to have two separate handles, which doubles the adjustment steps in the interaction sequence.

These two requirements led to the design of a new fitting. Basically it differs from a ladderlock in that the adjustment happens through pulling the middle of the strap rather than the end of it. In rope terms, this is called a 'bight': a double section taken from the middle of the rope that doesn't cross itself (Padgett & Smith, 1987, p. 36). Calling the new fitting a 'bightlock', it needs to allow adjustment easily while at the same time keeping the length fixed under tension. Moreover, to be convenient it should have a quick-release function for relieving tension by letting the excess strap into the main sling.

Inspired by the simple and low-tech design of quick-release ladderlocks, this solution was also designed without any moving parts to achieve durability and cost efficiency. In a

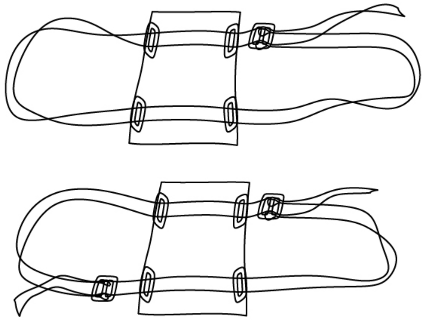


Figure 4-25 - the issues with using a simple ladderlock; tensioning capacity confined to one side (top), two step for adjusting the length (bottom)

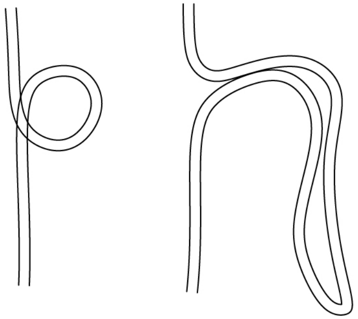


Figure 4-26 - comparison between a loop (left) and bight (right) on a rope (illustration based on Padgett & Smith, 1987, p. 36)

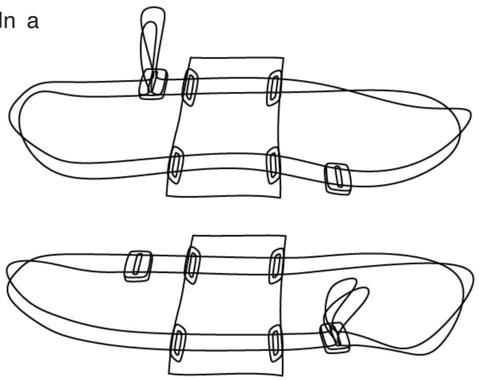


Figure 4-27 - placing two bighlocks on the sling, using either one can shorten the length from both sides

quick-release ladderlock (figure 4-28), tension on the strap along the length of the fitting blocks the exchange of the strap through pressing the one part of it on another against a strategically positioned bar.

This one sided design was mirrored into a symmetrical version which is the bightlock. There the strap enters and exits the fitting along the same path, and goes through a number of other bars in between. Pulling on the middle section of the strap, which is accessible on the surface of the bightlock, easily feeds the strap into that side and shortens the sling. This excess strap in the form of a bight, cannot be released by tension on the sling through the same logic as the quick-release ladderlock. Releasing this excess strap into the main sling is a matter of tilting the bightlock. This motion which can be done on either side and has been accounted for by the placement of ledges, releases the strap quickly and easily.

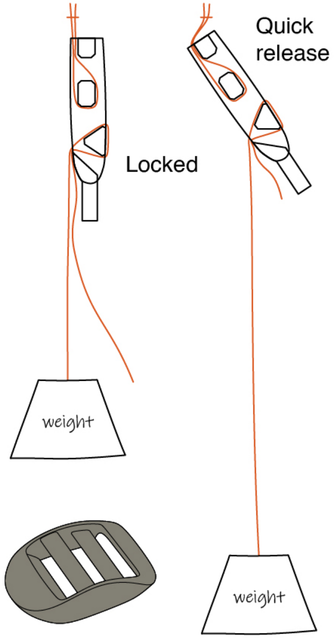


Figure 4-28 - quick-release ladderlock

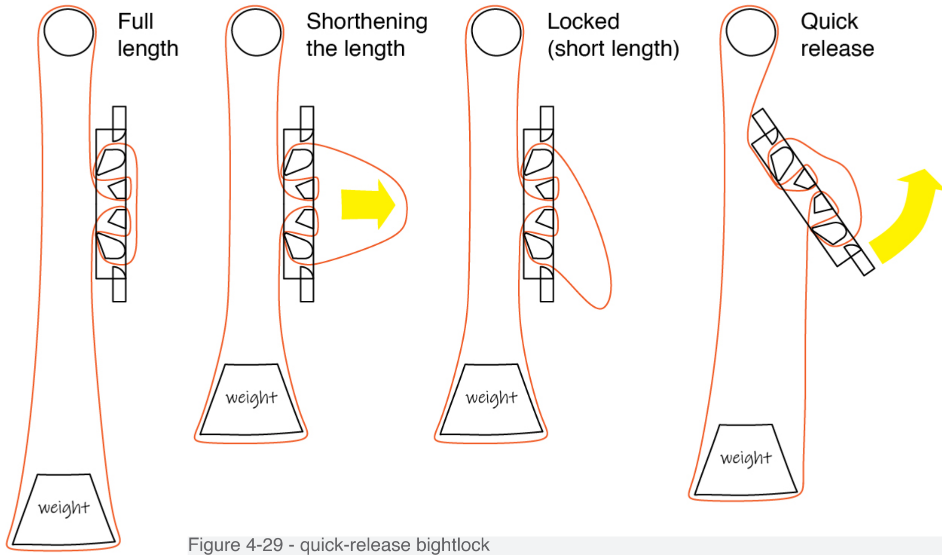


Figure 4-29 - quick-release bightlock

Other than fulfilling the symmetry requirements, the bightlock is an arguably easier interaction for tensioning. Pulling on the middle rather than end of the strap is advantageous as it affords a more comfortable grip. Moreover, as the strap is actually double, the distance of pulling is cut by half. This at the same time, eliminates the need to sheath a long running end that might otherwise collide with the spokes of the bicycle wheel.

Combinations

As the aim, besides reimagining perceptions of carrying, was to provide a good capacity, combinations of bags were also considered. Carrying multiple bags on a rack requires them to be attached to each other as no external entity is providing such attachment, and then for the whole of them to attach to the rack. Here, a knot known as 'girth hitch' was utilized. Girth hitch is actually a very simple and familiar knot that most people know and use, although not by its name. In relation to the bag, this knot means one handle going through the loop of the other and then being pulled. The former thus becomes the short and the latter the long handle of the bag. This creates closure for the bag and also presents an opportunity to attach it to another bag. The long handle of both bags going through the short of each, closes their tops, connects them to each other and leaves two long handles free to be used for attachment to the rack.

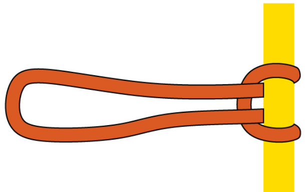
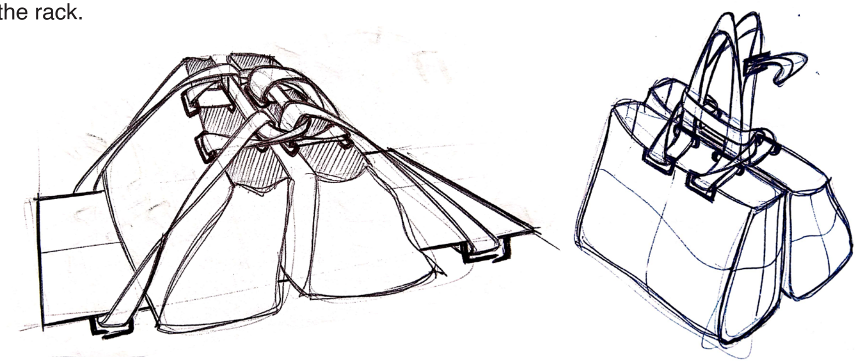


Figure 4-30 - a girth hitch



Reflection

This process of ideation was halted due to the recognition of a number of issues. Firstly, the length of strap required for attaching a bag to the four corners of a normal rack is more than two meters, quite a burden for a bag that is meant to be compactly folded. Furthermore, such a length entails quite a disparity between carrying on a bicycle and by hand, requiring a substantial amount of length adjustment to reach the handle size suitable for the hands.

Another issue is that of slipping into the assumption of passivity. Thus far, the support offered beneath the bag by the surface of the rack had been regarded as imperative. However the area of a normal rack cannot support any more than the capacity of a large basket installed on it. Given that if the bags are full enough to considerably stick out from the sides, the motions of the bicycle (such as tilting that happens when turning a corner) can destabilize the bags. One way to solve this is by adding a sturdy surface to the bottom of the bag, so that even only a portion of it being supported by the rack creates stability. However this would eliminate the flexibility and compactness of the bag. Expanding the rack's surface area is also not a feasible solution as it becomes a spatial burden when not in use. Creating a collapsible version of a large rack as the final resort is also not desireable as such total reliance on the surface of the rack falls into the same passive perceptions this design process set out to negate.

4.4.3 The Place of the Solution: The Bag

Halting the process of ideation, the limited scope of research which had revolved around solutions compatible with simple, foldable grocery bags was expanded to include bags that have active relationships with the bicycle even though not largely used in shopping practices. The majority of these solutions make use of what is called ‘pannier racks’. They are different from regular racks in offering a more supportive frame on the sides which blocks collision with the wheel for bags resting against it.

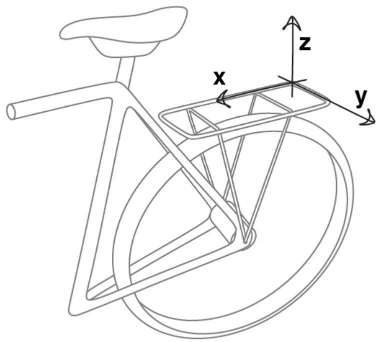
Figure 4-31 - different pannier racks (sources from left-first row:
1. flickr.com/photos/rjl20/136210433/
2. flickr.com/photos/vikapproved/2344564720
3. flickr.com/photos/vikapproved/2771688583
second row:
4. commons.wikimedia.org/wiki/File:Bike_carrier_on_Raglan_bus.jpg
5. www.flickr.com/photos/ah_blake/8922007664
6. commons.wikimedia.org/wiki/File:Surly_Long_Haul_Trucker.jpg)

As figure 4-31 shows, there is a startling variety within pannier racks, and finding the boundary between urban and professional versions of them is not an easy task. But generally, the urban versions are made of aluminium tubes rather than steel, far lighter though with less weight capacity. Fixed panniers, discussed in the previous section, also require such racks to be installed on a bicycle. The bags discussed here, which are referred to as ‘pannier bags’, differ from those in that they attach/detach to and from the rack quickly and easily, compared to the somewhat permanent installation of a fixed pannier. Therefore, what needed to be focused on was their mounting system.

Figure 4-32 - pannier bags (sources from left:
1. flickr.com/photos/7394371@N06/3974095559
2. jrkotrla.com/index.php?/category/47)

Mounting Systems

To discuss mounting systems in an easier way, a base is in order. Fixing an object in space requires three points of attachment, through which a single line cannot pass. Such an arrangement blocks both sliding and rotating motion along all three axes. The labelling of the axis illustrated on the right is used throughout the analysis that follows.



Probing a variety of mounting systems in pannier bags, two basic elements were recognized. (The conclusions presented in this section are gathered from the following sources: lovelybike, 2011; Arkel, 2019; wirecutter, 2020; Ortlieb, 2020; Axiom, 2021; Basil, 2021; Jandd, 2021; Two Wheel, 2021)

a. Load-Bearing Attachment

This attachment which is to the top of the rack happens through different types of hooks, usually equipped with a locking mechanism. Furthermore, to account for variety in the construction of different racks, there is a rail on which these hooks can slide to find a suitable point of attachment to the edge of the rack. The function of this element is to support the weight of the bag and block it from sliding down along the Z axis, and the locking feature of the hooks which creates friction with the tubes of the rack stops sliding along the X axis. In addition, having more than one hook along the X axis, also block rotation along the Z and Y axes (see examples at basil.com/en/city-shopper-grijs.html and ortlieb.com/en_us/back-roller-pro-classic+F5354)

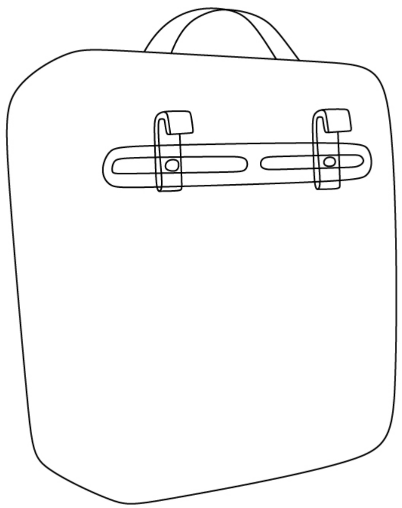


Figure 4-33 - load-bearing attachment

b. Sway-Blocking Attachment

This element corresponds to the side of the rack, and given that the two top points of attachment leave the possibility of rotation around the X axis open, its function is to block the bag from swaying when the bicycle tilts. This is done in two major ways:

- **Connection to the Stays**
  First, there are solutions that utilize the rack's stays (tubes connecting the rack to the centre of the wheel). This usually involves a hook that goes behind one of the stays and grips it. Given the variety among rack structures and subsequently placement and angle of the stays, there is also a need for a path along the X axis by which this hook can be adjusted to find the appropriate point (see examples at ortlieb.com/en_us/back-roller-pro-classic+F5354 and axiomgear.com/products/bags/monsoon-panniers/monsoon-oceanweave-45/). Another way to use the stays is by a horizontal strap that can close around two or more of them by the means of a buckle or Velcro (see examples at twowheelgear.com/collections/panniers/products/pannier-duffel-bag and basil.com/en/urban-dry-shopper-black.html).

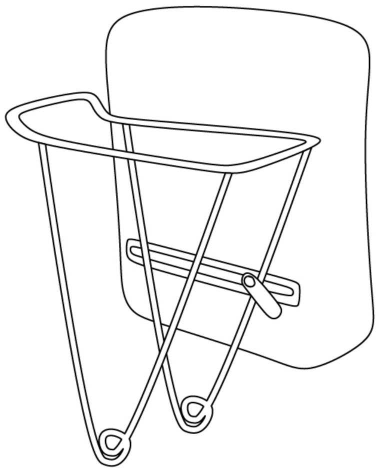


Figure 4-34 - sway-blocking attachment, connection to stays through hook-on-rail

- **Connection to the Centre Point**
  The other examples connect to the centre of the wheel which is a more consistent feature among the racks. What is needed here is adjustability along the Z axis since bags as well as racks have different heights, and therefore the distance between this element and the centre of the wheel varies. This is done by a hook installed on a cord with adjustable length; either an elastic one, e.g. a bungee cord (see examples at jandd.com/detail.asp?PRODUCT_ID=FRR-WR and arkel-od.com/orca-35-waterproof-front-rear-bike-panniers/), or a strap equipped with a ladderlock (see examples at jandd.com/detail.asp?PRODUCT_ID=Large-Bicycle-Panniers-Touring).

These mounting systems are quite easy and fast to use. However, among the most considerable of their downsides is the bulky addition of hooks and adjustment elements to the bag, which is usually followed by considerations to hide them. Yet more recent examples, such as Ortlieb QL3 system (see ortlieb.com/en_us/ql3-1-mounting-set), have been developing in the direction of solving this by displacing the majority of these elements onto the rack in the form of an adaptor, and thereby reducing the volume of attachment

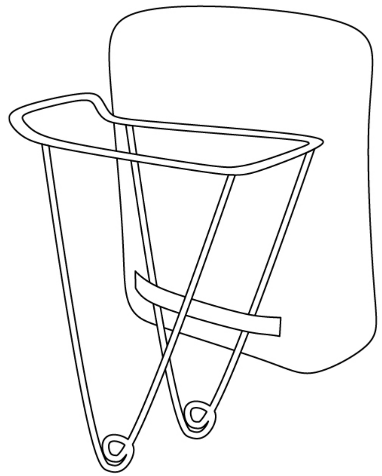


Figure 4-35 - sway-blocking attachment, connection to stays through a strap

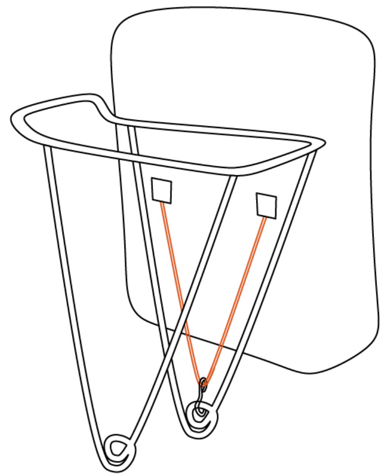


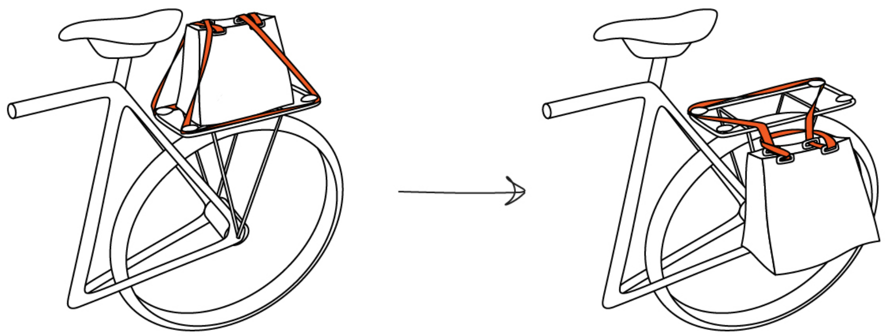
Figure 4-36 - sway-blocking attachment, connection to centre point elements on the bag. Nevertheless, these share the complexity and relatively high production cost of their predecessors.

Beyond the realm of advanced backpacks, limited examples of simple grocery bags can be found that attach to the side of the rack. The first example is bikezac 2.0 (see copenhagenbags.com/products/copy-of-bikezac-2-0-teal) which is an unfastened bag made of woven polypropylene. The bag uses only two hooks along the top edge of one side to attach to the rack, and for closure has a T shape fitting that connects to a narrow strap on the opposite side. The bag, while quite simple and still foldable, lacks the sway-blocking attachment.

Other bags include DIY panniers made of grocery bags of various materials. One example (see ladyfleur.bike/2014/03/21/bike-crafts-panniers-from-reusable-grocery-bags/tie-down-option-2/) is a fixed pannier composed of two bags whose handles are sewn together and then fixed on the rack. The next (see instructables.com/DIY-Bicycle-Pannier-Saddle-Bag/) includes a mounting system similar to the pannier bags reviewed above (two hooks at the top and a bungee cord attachment at on the side), which is installed on a wooden panel placed in the bag for sturdiness.

4.4.4 Second Concept: A Grocery Pannier

With these insights the positioning of the bag on the bicycle changed. Although still making use of the rack, the task of supporting the weight was redirected from the top surface of the rack to the handles of the bag. Fixing the bag on the side of the rack will at least require three points of attachment as mentioned. The aim was to create a relation that allows this positioning while keeping the bag simple and devoid of any bulky elements, and maintaining its ability to be folded.

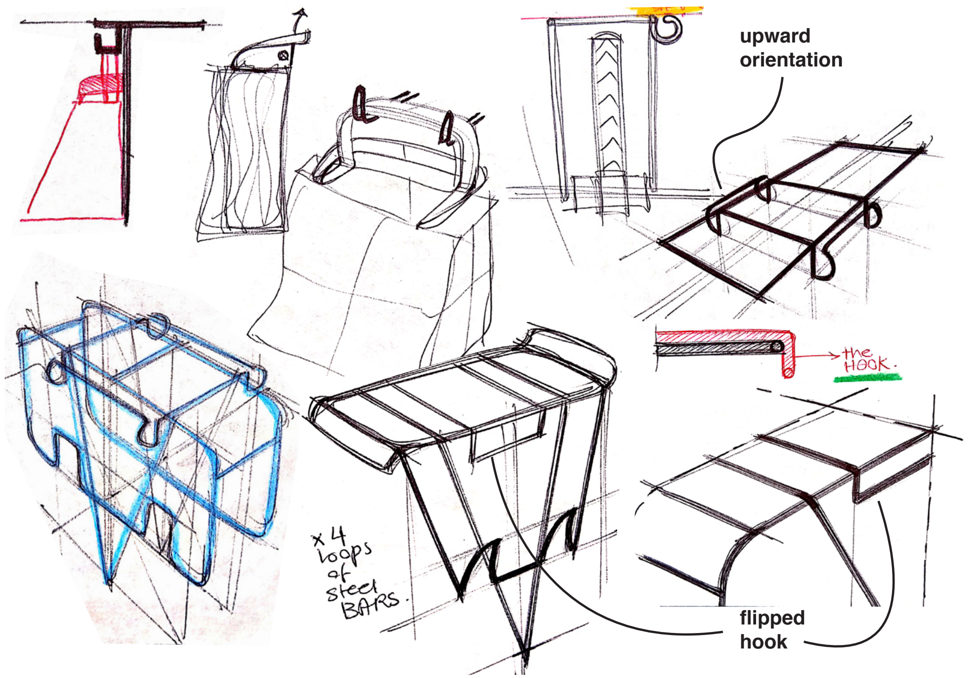


4.4.5 Development

Load-Bearing Attachment

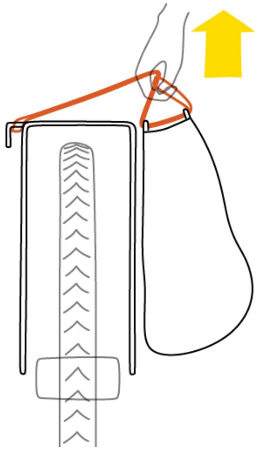
The girth hitch proved quite useful in this new configuration. Putting one handle through the other one, closes the bag while also producing a long handle on one side which can be attached to two points on the rack. The side position of the bag, compared to the previous one on the top, has brought it closer to the centre of gravity and thus less prone to fall off in motion. This new found stability meant that the attachment points on the rack no longer needed to be at the corners to provide sufficient stability. This significantly reduced the length of the strap needed; even less than that of some tote bags.

The side position for the bag opened a space to rethink the snaphooks as points of attachment given that elements without any moving parts can easily fulfil the same task. After exploring various options, using the aluminium tubes to create some type of hook was settled on. The envisioned hook at first was facing upwards. In order for such a hook to be accessible easily, it would either have to stick out, which meant hindering the use of other panniers, or up, which would deprive the users of the rack surface for carrying other items. While it was important to keep the spatial disturbance of this additional feature in the rack to a minimum, the most important problem with an upward hook orientation was that of affordance.



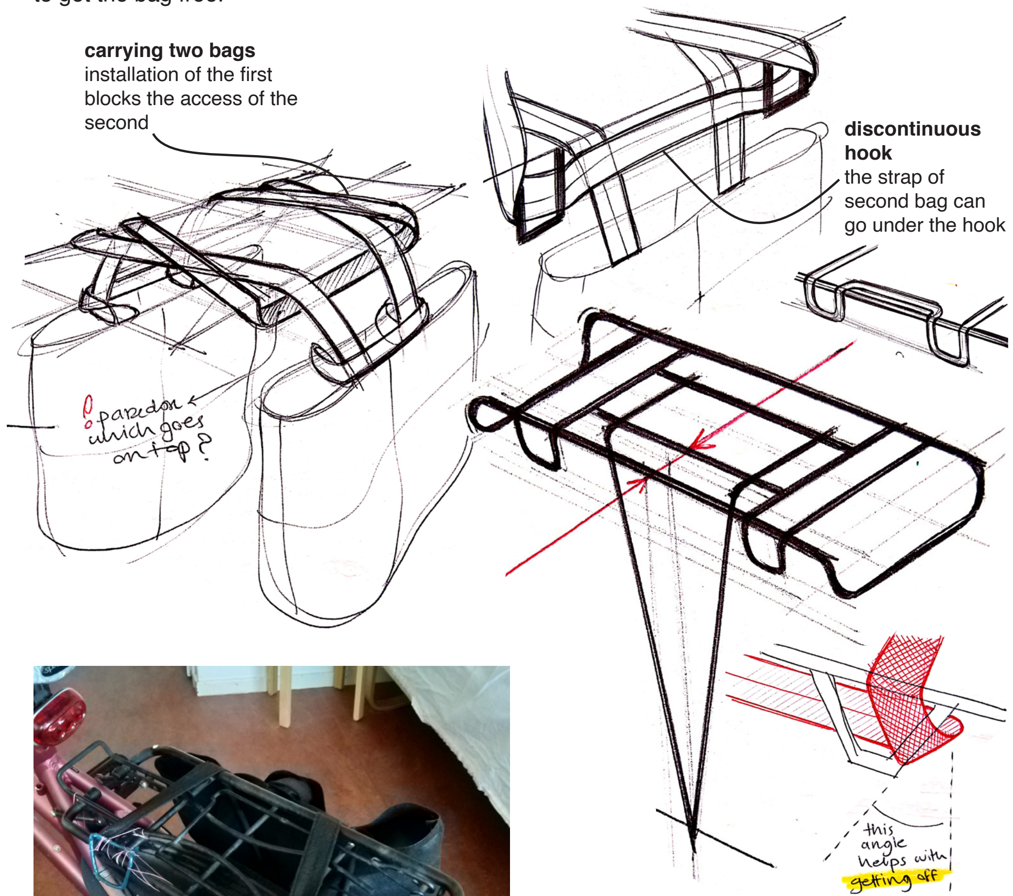
To explain, after performing the girth hitch, the long handle of the bag should cross over to the opposite side of the rack and there connect to the hook. This offers significantly more stability compared to a situation in which the bag simply hangs from the hook situated on its own side of the rack. A hook of normal orientation, invites the users to hang the bag on the same side. To resolve this issue, the hooks were flipped upside down so that they cannot be used by the bag of their own side but have to be utilized by the bag on the opposite side.

Basic prototyping revealed a rather trivial feature of this configuration. The bag once girth-hitched by the handles and hung from the hook would not require any tensioning. As this is an anti-gravity solution, the weight of the bag creates tension in the downward direction which secures it.



Thus, in this new position, the interdependent handles have created a kind of nonlinearity between the functions of closure, attachment and tension. Rather than solving each separately through specialized features in the bag, all are accounted for in a single part. This nonlinearity means that under no singular direction of force, the attachment would come undone. For instance in the motion to get the bag off the bicycle, pulling on the smaller handle will result in the bag being lifted, but the tension applied upward on that handle is met by the obstacle of the flipped hook on the other side. Thus, mere force on one side cannot get the bag free. This is an interesting feature which creates additional security in the attachment. Therefore, to get the bag off, one hand must grip the short handle and lift the bag slightly, while the other pushes down on the second handle, enough to go below the flipped hook and free from it.

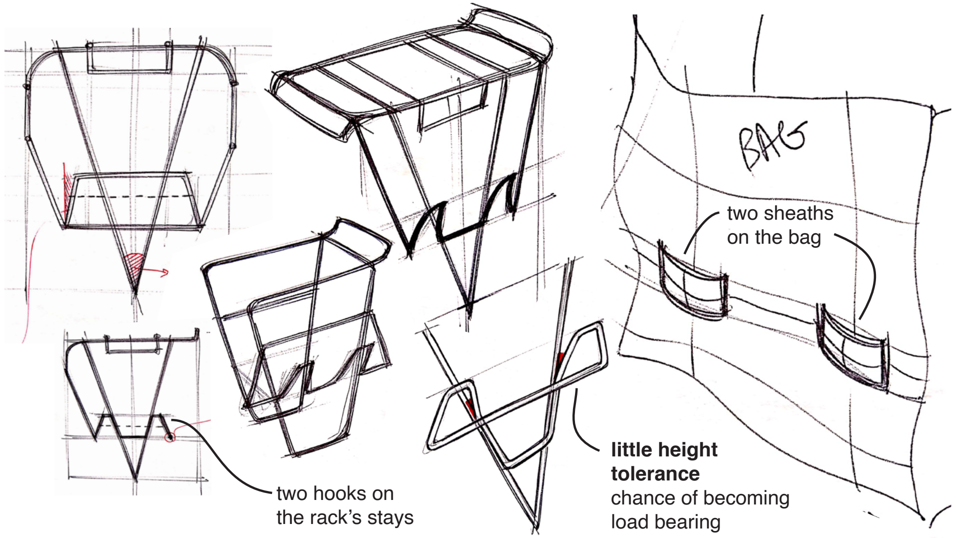
The next consideration of the load-bearing attachment was about having two bags, one on each side. This required the flipped hook to become discontinuous. As illustrated below, having one continuous hook on each side, means while a bag is installed, the strap of the next bag cannot access the underside of the hook. Therefore, the hooks became two on each side. Also an angle was added to their outer edge. This was done to create a more natural form for the strap when it bends around this point, but also to afford an easier motion when the handle is pressed down on to get the bag free. It is important to note that this angle does not jeopardize the security of the bag, as the default direction of tension is the opposite of the direction needed to get the bag free.



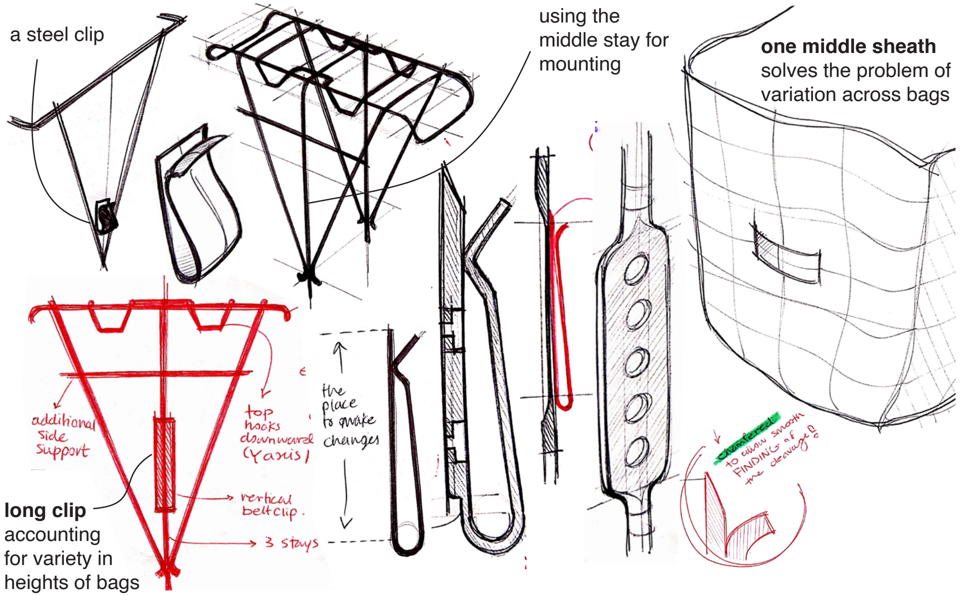
Sway-Blocking Attachment

The aim in designing this part was also to reduce complexity, mass and spatial cost of the attachment on the bag. The bulky elements on the pannier bags shown in the previous section result from accounting for the variety in the configuration and dimensions of pannier racks. Yet as the sway-blocking attachment does not bear any load, more simple routes can be explored in fulfilling this function. Furthermore, given that interaction with the load-bearing attachment requires both hands, it is imperative to keep the user input at a minimum for this part.

Early ideas revolved around two pieces of strap being sewn to the side of the bag which would serve as a kind of sheath for corresponding hooks on the rack. These hooks were envisioned to be of the same tubular structure as the rack. However, such an element has a very limited range of compatibility when it comes to bags of different widths and heights, making it difficult to support people of different bodily configurations and needs. Furthermore, if the hooks are not long enough to allow some tolerance, a bag whose handles' length place it at slightly lower-than-desired height, would shift some of its weight onto this attachment which is not for bearing loads.

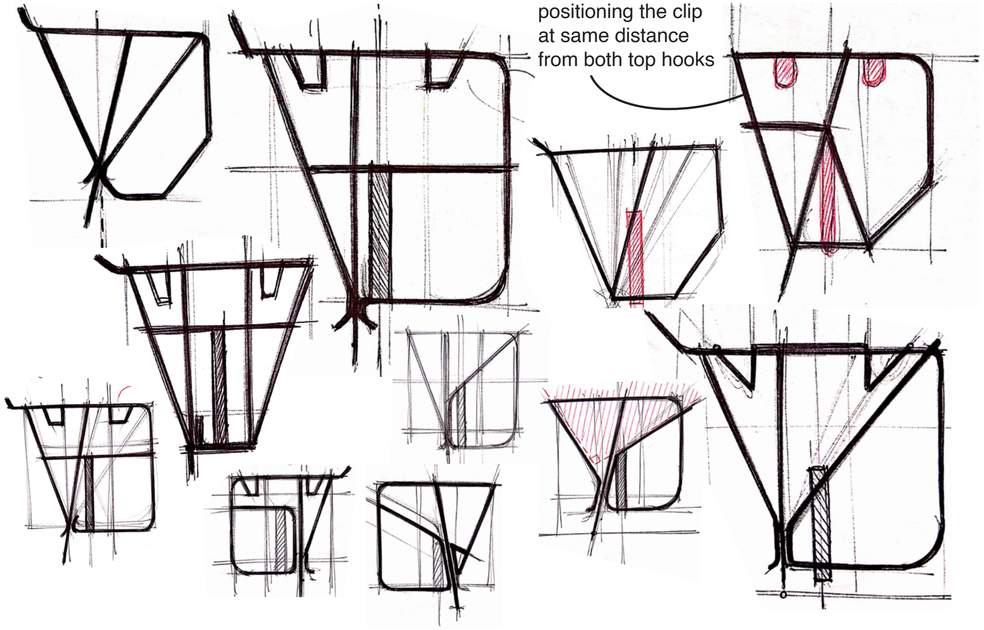


To resolve both problems a steel clip was considered instead. The clip, being singular and mounted on the middle stay of the rack, would only require a single sheath on the bag and thus far more generalizable across a variety of bags. Furthermore, the vertical length of the clip means that no matter how low the bag gets positioned, none of its weight would be borne by the clip.

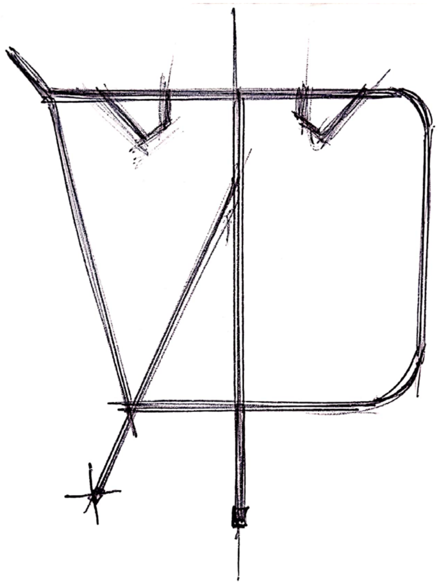


However, this idea added complexity to production and assembly while also increasing the cost of the product, which were determined to be kept to a minimum. More importantly, pannier racks unlike normal rear racks are not symmetrical. This is due to a problem known as 'heel clearance'. To avoid any collision between the feet of the cyclist and the bag positioned on the side of the wheel as they paddle, all pannier racks are tilted backwards so that they do not reside exactly above the rear wheel. This means there is no vertical tube in the centre to be used for mounting the clip.

Figure 4-37 - the asymmetrical configuration of a pannier rack (source: flickr.com/photos/wcouch/8675049697)



This presented a problem with finding a position for the clip which would place it at the same distance from the both hooks at the top, which is a necessary feature if the elements of the bag are to remain generalizable. Finally, after exploring more options, it was decided to flip this point of attachment as well. Instead of having an upward facing hook of some kind, having a tubular extension below the lower edge of the rack can easily block any sway motion. This flipped orientation eliminates any possibility of the hook becoming a load-bearing attachment, no matter at what height the bag resides. However, to be compatible with the top hooks, it should be quite long so it can tolerate the necessary move upwards in the sequence of unhooking the load-bearing attachment. Furthermore, this length also increases the compatibility of the rack with bags of various sizes, and as the extension is made of the same material of the rack's frame, it can easily be integrated in the structure at a position between the two top hooks.



Side Support

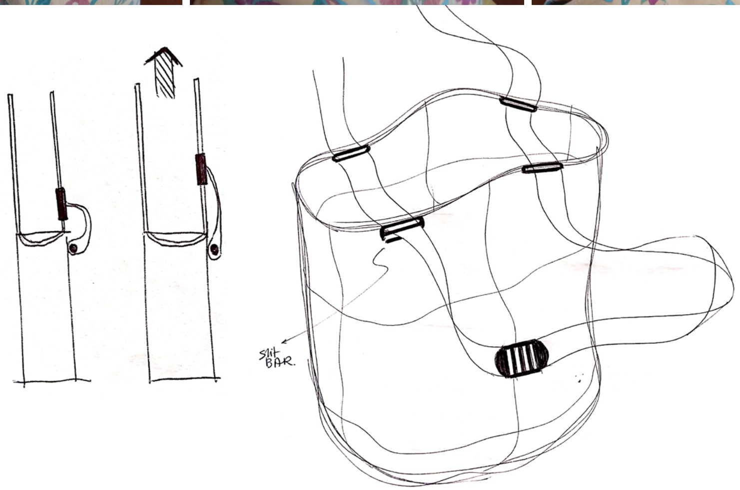
The next part included consideration about the insufficiency of pannier racks' frame to support the side of a grocery bag with no sturdy structure of its own. Existing pannier bags that reside in similar positions all enjoy a degree of sturdiness which is absent in a simple grocery bag filled with all and any kind of shapes. As shown in the previous sections, the DIY examples of panniers made of simple grocery bags solve this by adding a sturdy surface, e.g. cardboard or wooden panel, inside the bag. However, as the aim is to keep the bag a foldable and compact solution, such a support has to be displaced onto the rack. This can be done in the form of a grid made of thinner aluminium tubes against which the pouch of the bag will rest.

Length Adjustment

As mentioned earlier, the pro-gravity configuration of the bag has eliminated the need for tensioning. However, given the wide variety of pannier racks which in part rise from the variation in bicycle frames and sizes, an adjustment fitting remains a necessity to adjust the handles to a length suited for each bicycle.

However, unlike the top position of the bag, the pannier position means only one side of the bag can connect to the rack, i.e. the side equipped with the middle sheath. Therefore, only one handle of the bag needs to have adjustment capacities which is the opposite side. Installing a bightlock to fulfill this function offers the advantage of symmetry, as unlike the ladderlock it does not dictate from which side the excess strap exits the sling, which would necessitate more deliberation for interacting with the bag. With a bightlock, no matter where on the sling the fitting happens to be, it can shorten it from both sides.

However, this convenience for carrying with a bicycle comes at the expense of the walking mode. Using the bightlock to shorten the strap leaves the excess strap sticking out in the form of a bight which would be an obstacle to easy use of the bag. To solve this, one of the oval rings can have an additional bar which is slit in one point. After adjusting the strap to a desirable height, the bight can be slipped in the slit bar. Thereafter, upon tensioning, it will be placed at the appropriate height from the base to align with the rest of the handle.



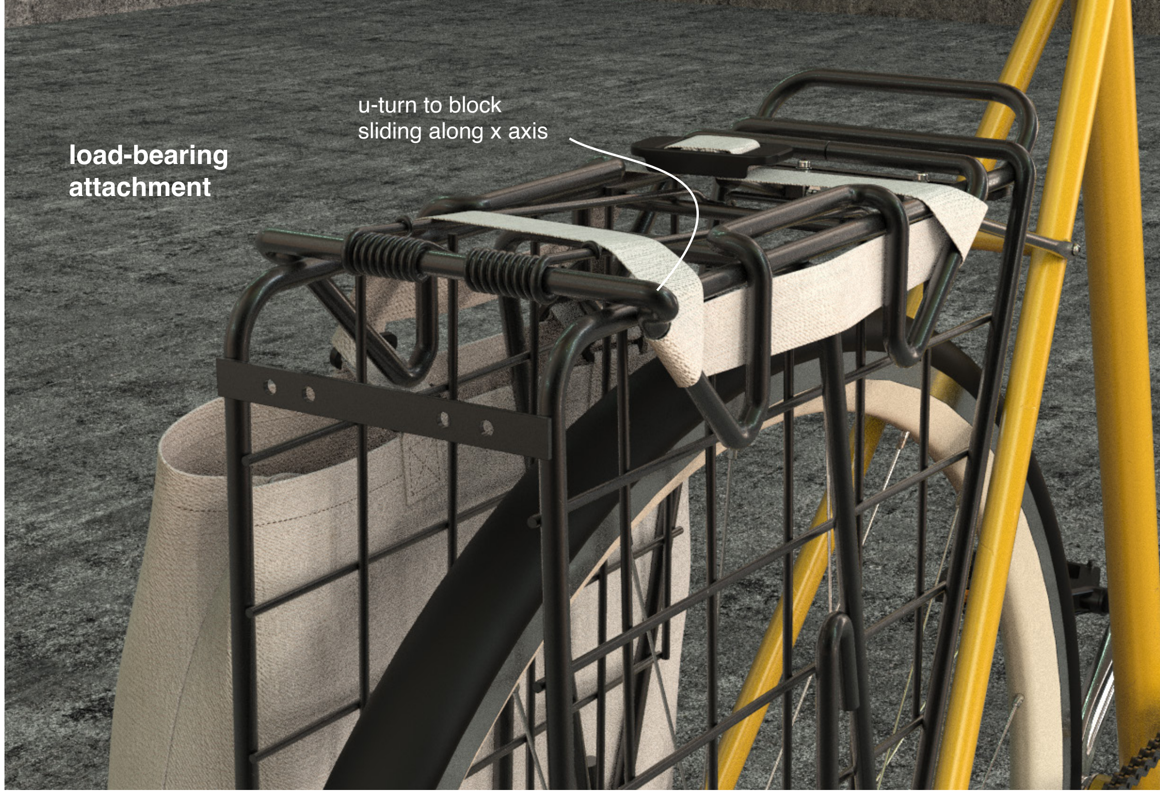
5 Final Proposal

A Two-part Solution

The final proposal is a two-part solution for adding carrying capacity to bicycles: a bag and a rack. It is important to note that these two items are designed based on the existing versions of the products and are meant to present features that can be generalized across a wide variety of shapes and sizes within their respective product family.

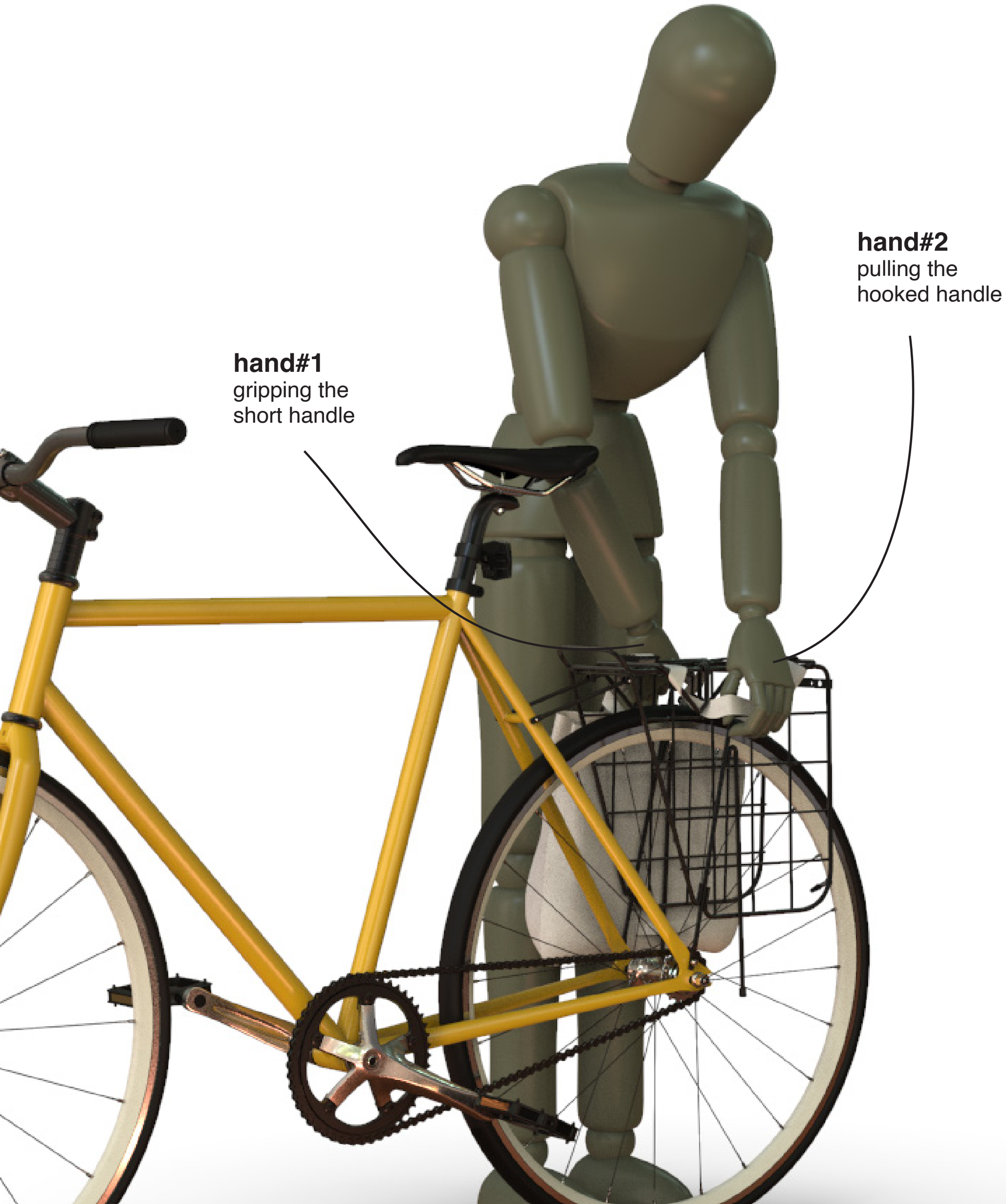
5.1 Attachment Configuration

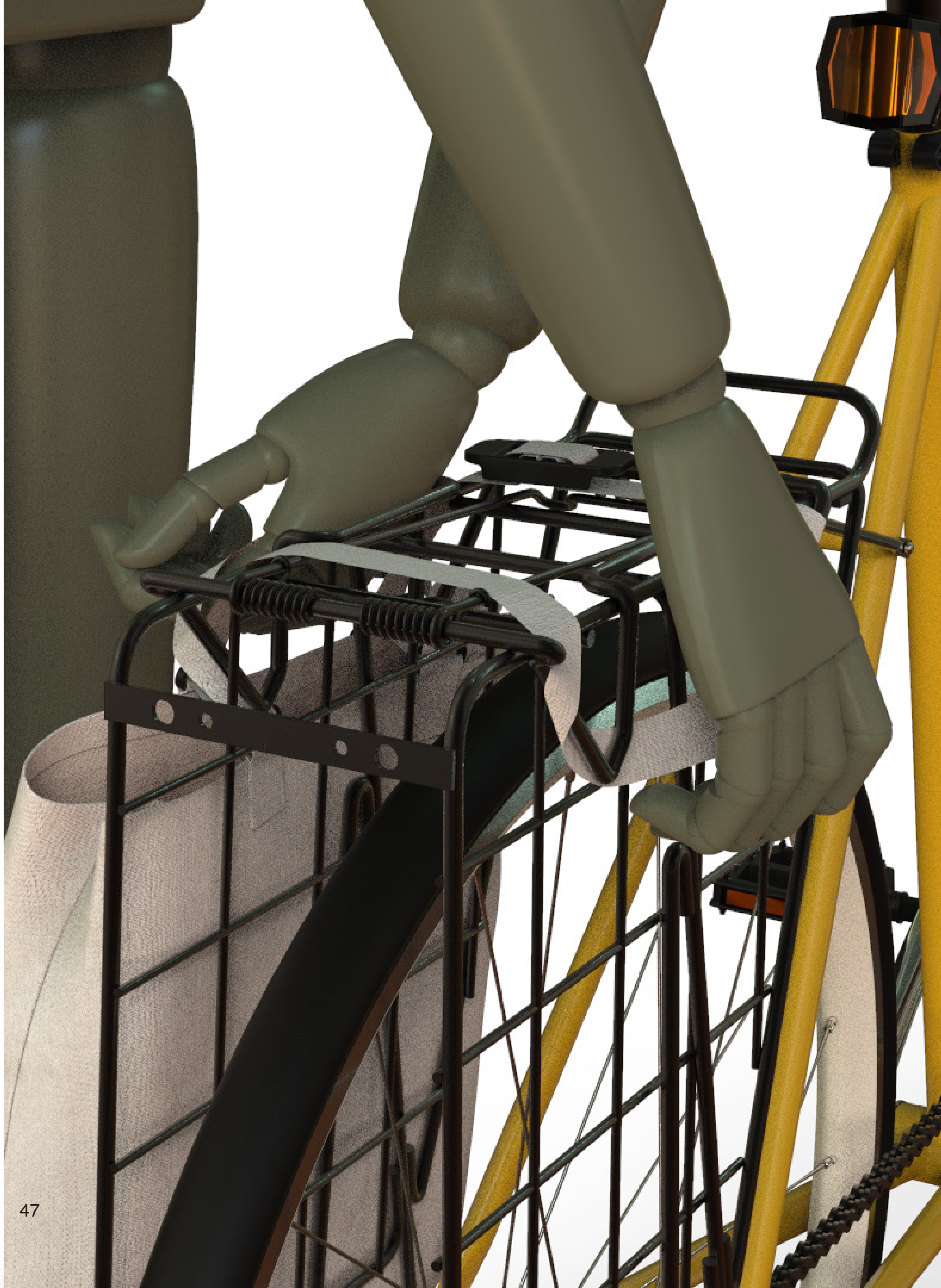
As the previous chapter showed, the attachment consists of two main parts. The first part is the load-bearing attachment at the top, which takes the form of two triangular hooks on each side. To block the slippage of the strap along the X axis toward the back, a small u-turn is necessary at the end of the hooks. This feature is not needed in the front as the upward turn of the main frame stops any slippage toward the front. The second part, which is the sway-blocking attachment, can be viewed at the bottom in the form of a vertical tube that extends below the main frame of the rack. Both parts are made of the same aluminium tube structure as the rest of the rack which reduces production steps and cost.



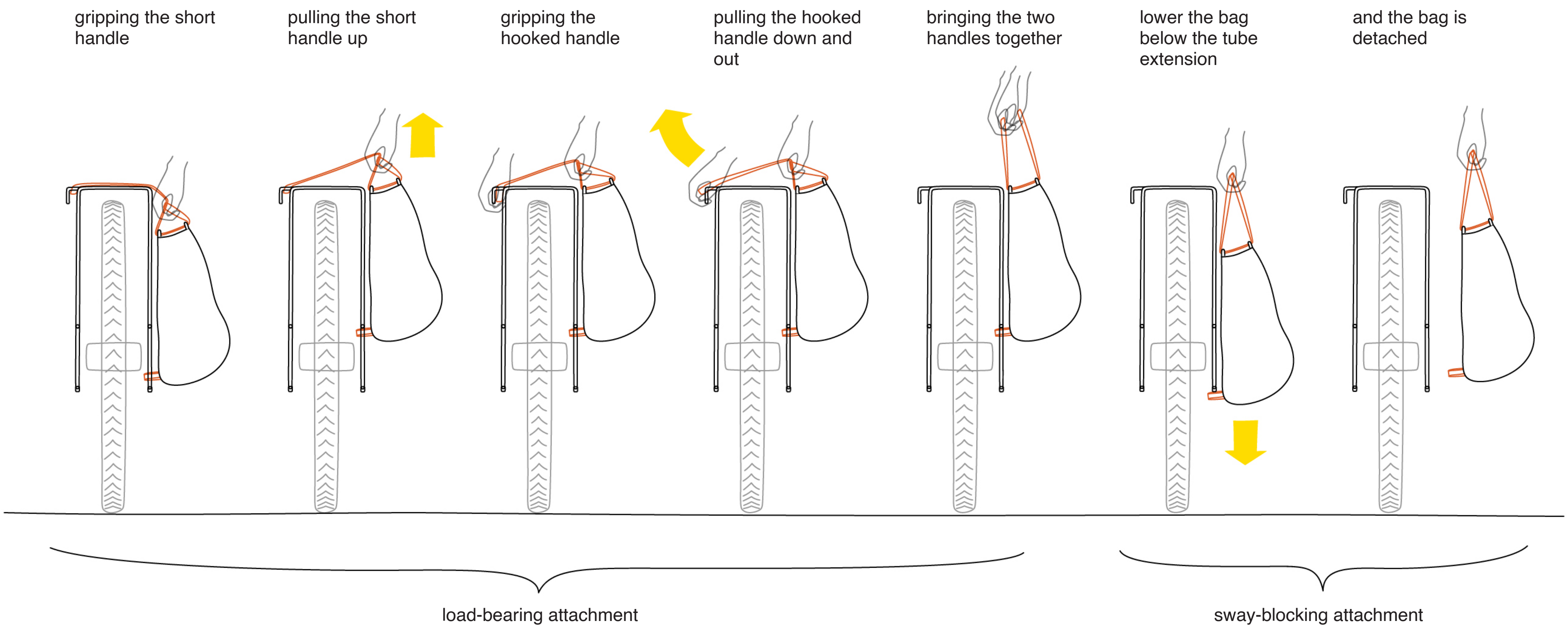
5.1.1 Use

Interacting with this configuration requires both hands. As the figure shows, to detach the bag from the load-bearing hooks, one hand must grip the short handle at the neck of the bag while the other hand pulls down on the long handle that is hooked to the opposite side.





The flow of this interaction has been shown in the diagram below, including the detachment from both the load-bearing and sway-blocking parts of the rack. Note that the steps required to attach the bag are the reverse of this sequence.



As the figure shows, it is necessary for the sway-blocking attachment to be a long piece, so that the distance between where the extension begins and where the sheath of the bag stands is enough to tolerate the movement upward needed to detach the load-bearing hook.

5.2 The Bag

The bag is essentially a simple unfastened grocery bag, with one major distinction; the handles. The one sling, two handle solution has replaced two separate handles with a continuous sling of strap that goes through four oval rings at the top of the bag to create two interdependent handles. The oval rings are sewn along the top edge of the bag by four textile straps. The other addition is a short textile strap sewn to the lower part of the back of the bag. This feature which interacts with the sway-blocking attachment of the rack has been kept simple, both in form and position, in order to make it generalizable across a variety of bag types and sizes.

Production and CMF

Simple unfastened grocery bags come in a variety of shapes and materials. They can be sewn from two textile faces or five. They can have a surface pouch or a net one, which can be made of cotton canvas, woven or nonwoven polymers such as polypropylene, polyester, biopolymer, etc. It is not the intention of this project to determine the material of which the bag is to be made as the variety in the materials cited enable different characteristics within the bag. These include water-resistance, tear-resistance, compactness, weight, texture, etc. which are important to varying degrees to users of different tastes and needs. Furthermore, determining the sustainability of the material used to make the bag is a highly context-dependent decision as the availability of local resources and production facilities in the region, as well as considerations for end-of-life and disposal of the bag, play a key role. Thus, as this project has been a general reflection on carrying and bicycles in different urban areas worldwide, any definite answer to the question of material would be unsuitable. However, the following list of material options can be considered.

Material options for the bag:

Renewable sources

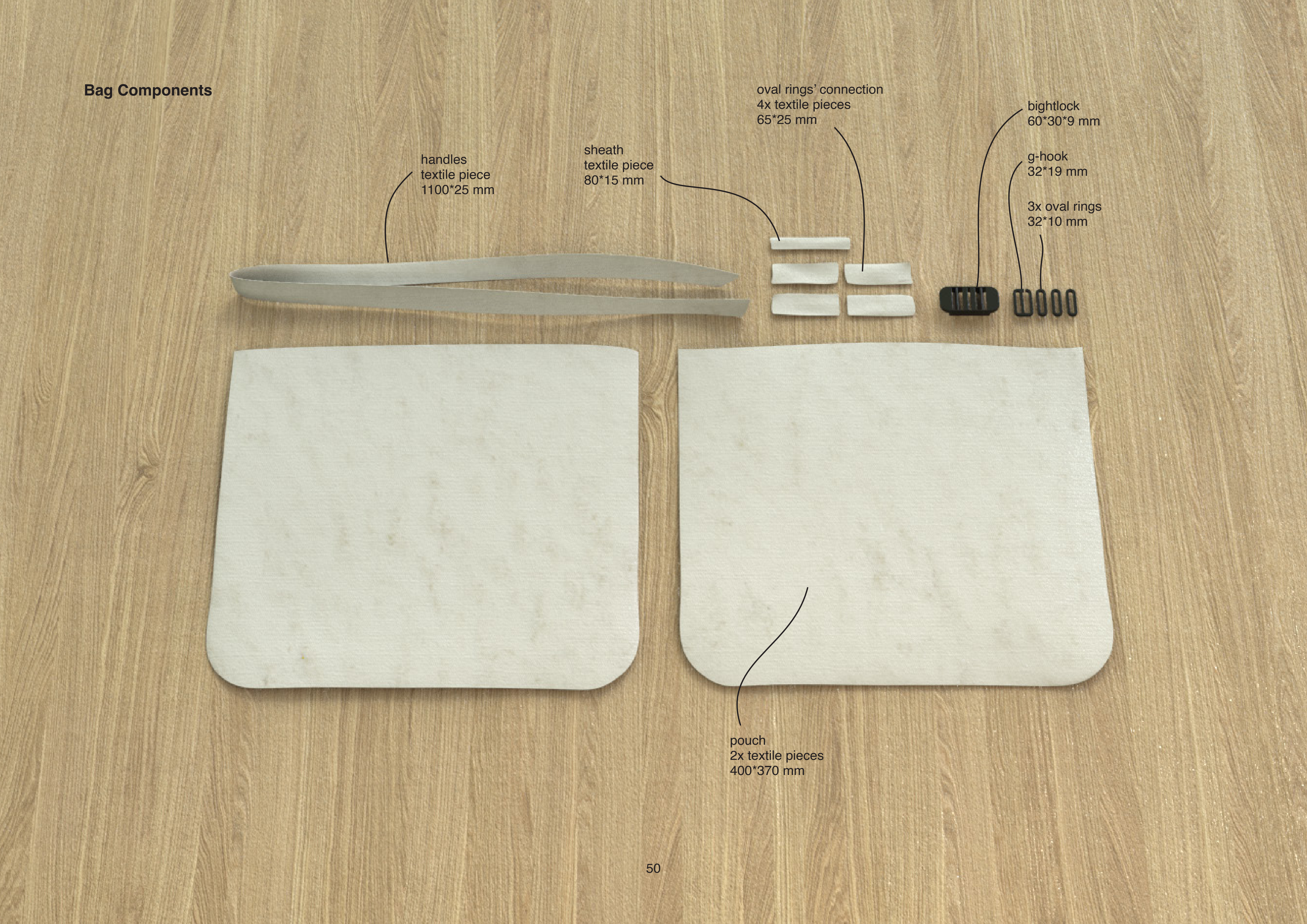
1. Plain cotton cloth: lightweight, compact and soft, susceptible to water, gets soiled easily, medium durability
2. Cotton canvas: medium weight, less compact but more sturdy, less susceptible to water and getting soiled (due to tighter weave patterns), high durability

Non-renewable sources (based on an analysis by Bisinella, et al., 2018, pp. 25-28)

1. Polyester (woven from long thin polyester fibres obtained from processing other polymer types): extremely compact, lightweight and soft, water-resistant, high durability
1. Non-woven polypropylene (PP): lightweight, compact and soft, water-resistant, medium durability
2. Woven polypropylene (PP): lightweight, less compact but more sturdy, susceptible to water, high durability
3. Biopolymer (usually polylactic acid): lightweight and compact, susceptible to water, biodegradable (most types only in full scale facilities), low durability and high cost

In line with the above decision, only a sample representation of the bag was created for this document. Using light ivory as the colour (RAL 1015), the rendering simulates a plain weave cotton fabric. However, as the production of the bag is simple and the product family increasingly heads toward being a fashion item, manufacturing the product in an array of colours and patterns can serve to attract a wider user group.

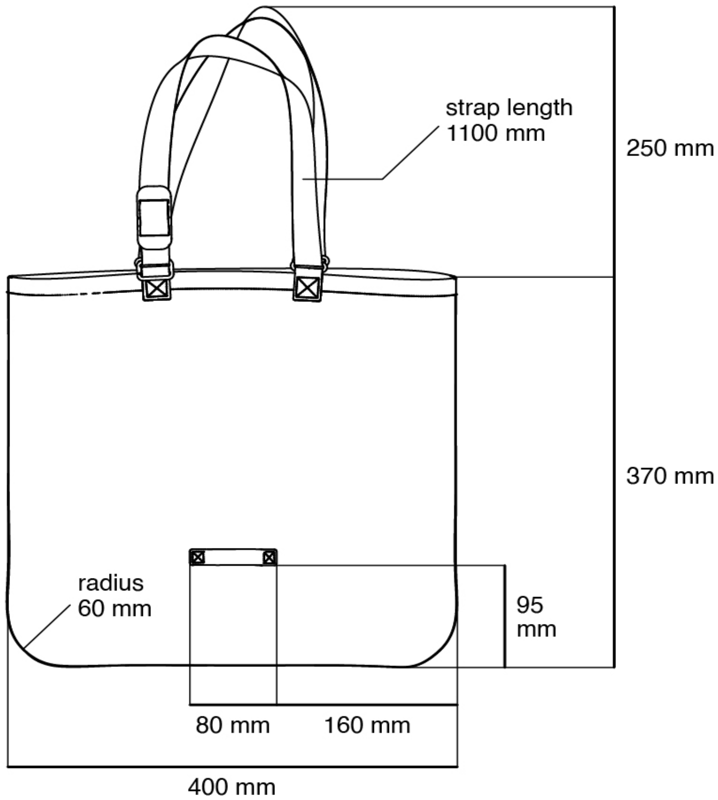
Bag Components



The two features of the bag, namely the independent handles and the back sheath, are meant to be features that can be applied to a wide variety of bags to make them more easily carryable by bicycles. This can be envisioned within industrial production of bags as well as the growing movement of DIY and personalization around the use of durable bags.

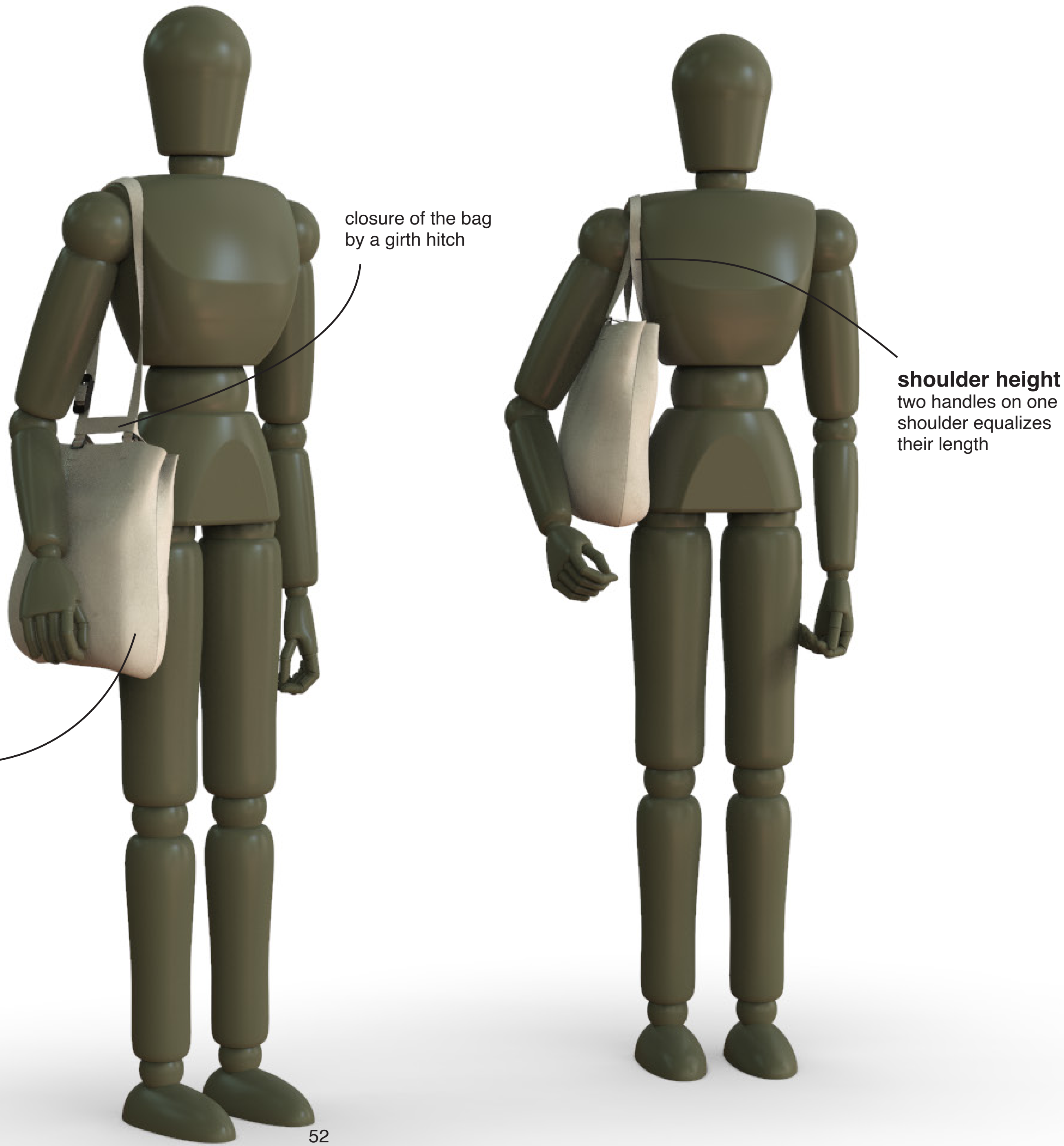
It should be noted that the interdependent handles are not an essential feature for attaching the bag to the designed rack. While it certainly makes it easier, as the figure on the right shows, normal tote bags which have separate handles can also be used on the rack. The interaction is slightly more difficult as one handle has to be knotted to get shortened and receive the other handle through itself to make the girth hitch that closes the bag. As prototyping has revealed, the handle size of normal tote bags (around 500 mm each) places the bag at an appropriate height for carrying next to the back wheel. That said, a normal durable grocery bag still lacks the sway-blocking sheath which means it will sway and beat against the side of the rack as the bike tilts. However, this does not present a major obstacle in the use of the product, as some pannier bags also lack the lower attachment.

Technical Drawing



5.2.1 Use in the Walking Mode

The interdependent handles offer novel opportunities for use on the body. As the right figure shows, once placed upon the shoulder, the height of the interdependent handles becomes equalized by the weight of the bag, thereby resembling the use of a normal grocery bag in that position. However, the length of the strap can also be transferred to one side to produce a longer handle. This long handle, if passed through the short one, can close the top face of the bag, which coupled with the lower standing height of the bag resembles a messenger type of bag. This configuration can become useful for longer walking trips as it is a less engaged position for the user and given the security offered by the closure of the bag, there is no chance of any item falling out.

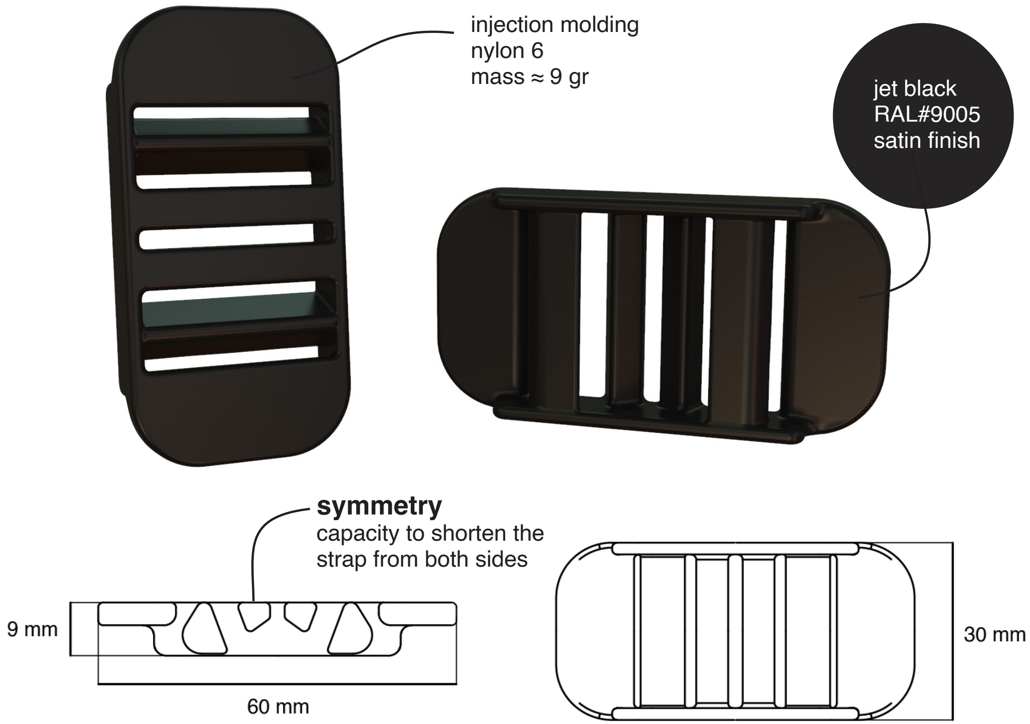


5.2.2 Bightlock

The interdependent handle has an adjustment fitting called a bightlock. This feature, which is a mirrored version of a quick-release ladderlock, was designed to afford symmetry in use. While the strap size used in the bag will place it at an appropriate height next to the bicycle wheel, this adjustment fitting is necessary to offer the possibility to adjust the length which is inevitable given the variety in configuration of bike frames, bags and their users. The significance of the bightlock lies in its capacity to shorten the strap from either sides and later release it into the main sling with the same options. This feature thus reduces the need for reflection when attaching the bag to the rack.

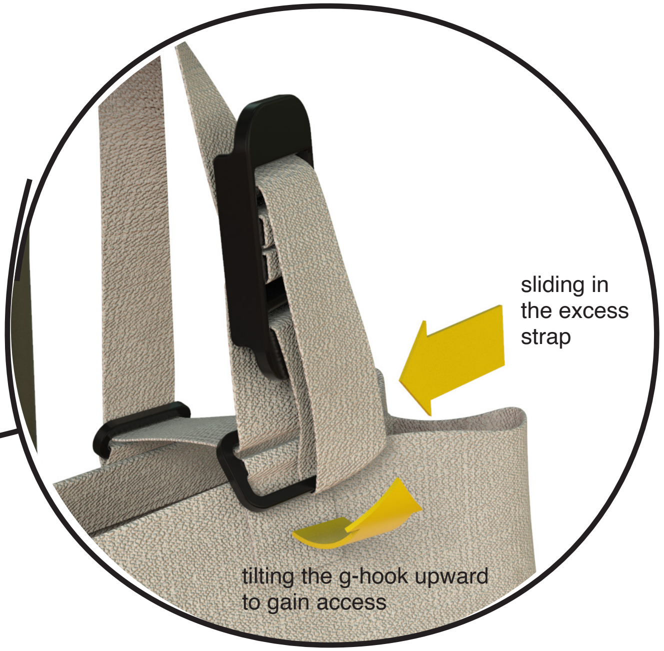
Production and CMF

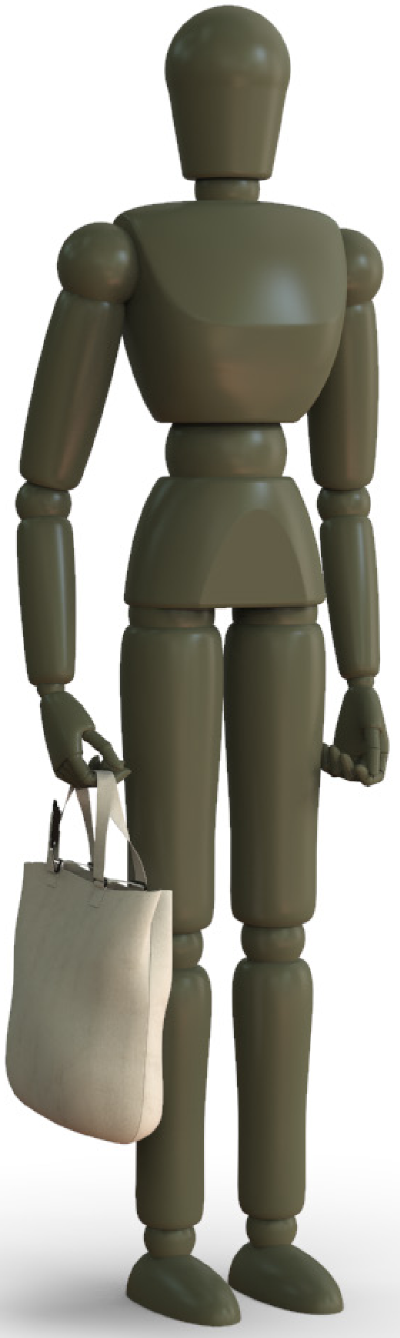
The bightlock, together with the oval rings, can be produced through injection moulding. To improve the grip of the components as well as providing them with a finished appearance in the same step, the surface of the moulds can be media blasted, which will give the final pieces a matte or satin finish. As with the majority of strap fittings in urban products, using nylon 6 as the material provides sufficient strength and durability while keeping the cost and weight low. In line with the decision to maintain variety in the material of the bag, jet black (RAL 9005) was selected as the colour for these components. This will enable some degree of compatibility with different colours and textures of various textiles, while keeping the overall cost of production low. This decision was also consistent with the colour selection of the rack.



The symmetry in use offered by the bightlock, however, comes at a price for the walking mode. In scenarios where the user holds the bag in their hands, it would be more convenient to have a shorter handle than when it is carried by the shoulder. Yet shortening the handle by a bightlock, means the excess strap will be sticking outward in the form of a bight, raising a need for sheathing it. That is why one of the oval rings along the top edge of the bag is actually a G-hook, i.e. an oval ring with an additional slit bar.

To make use of the slit bar, after shortening the strap, the G-hook which is only sewn to the bag from its middle bar, should be tilted upward so that the bight can gain access. After sliding the bight in, the tension applied to the sling by the weight of the bag will align the bight with the rest of the handle.



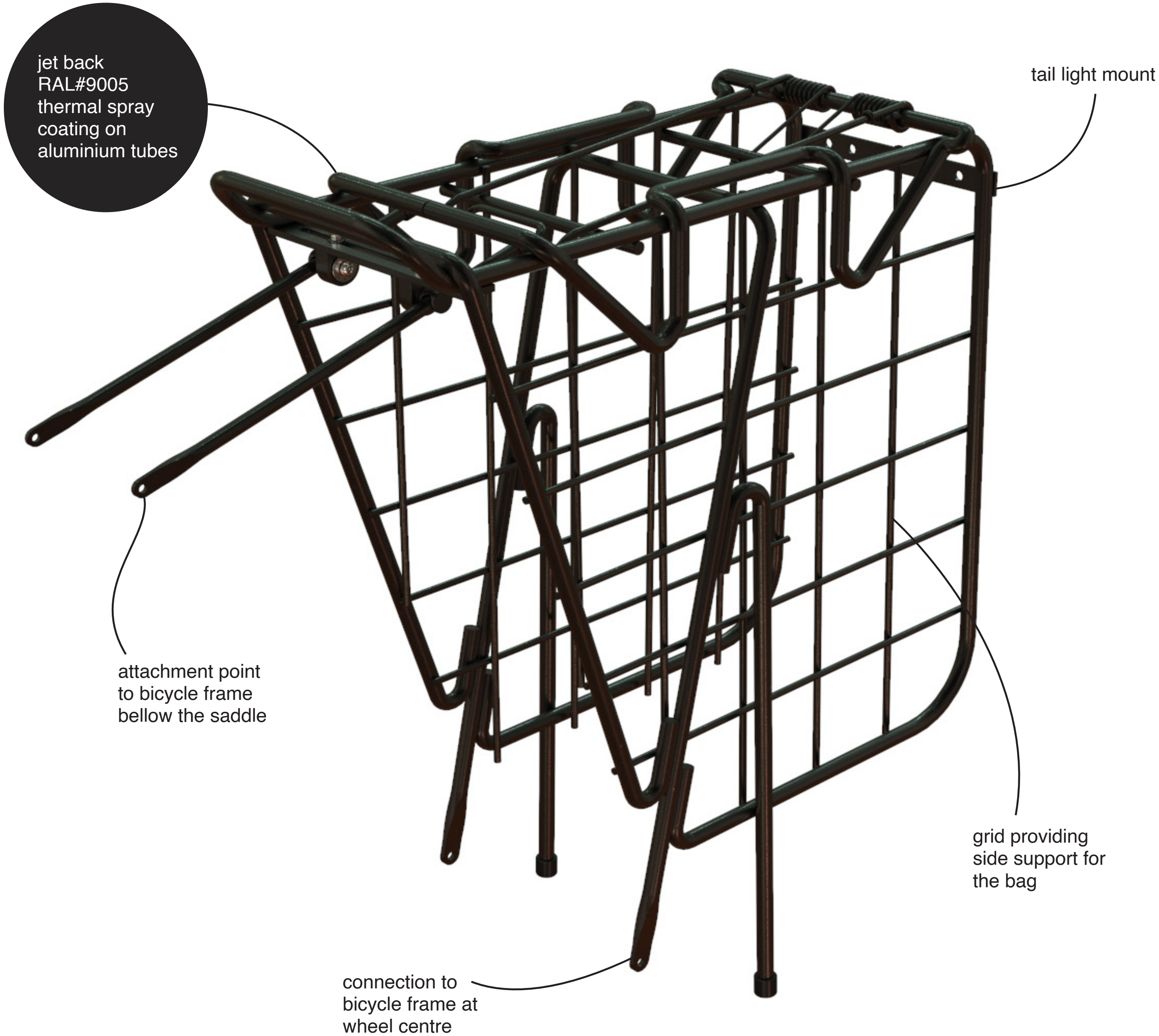


5.3 The Rack

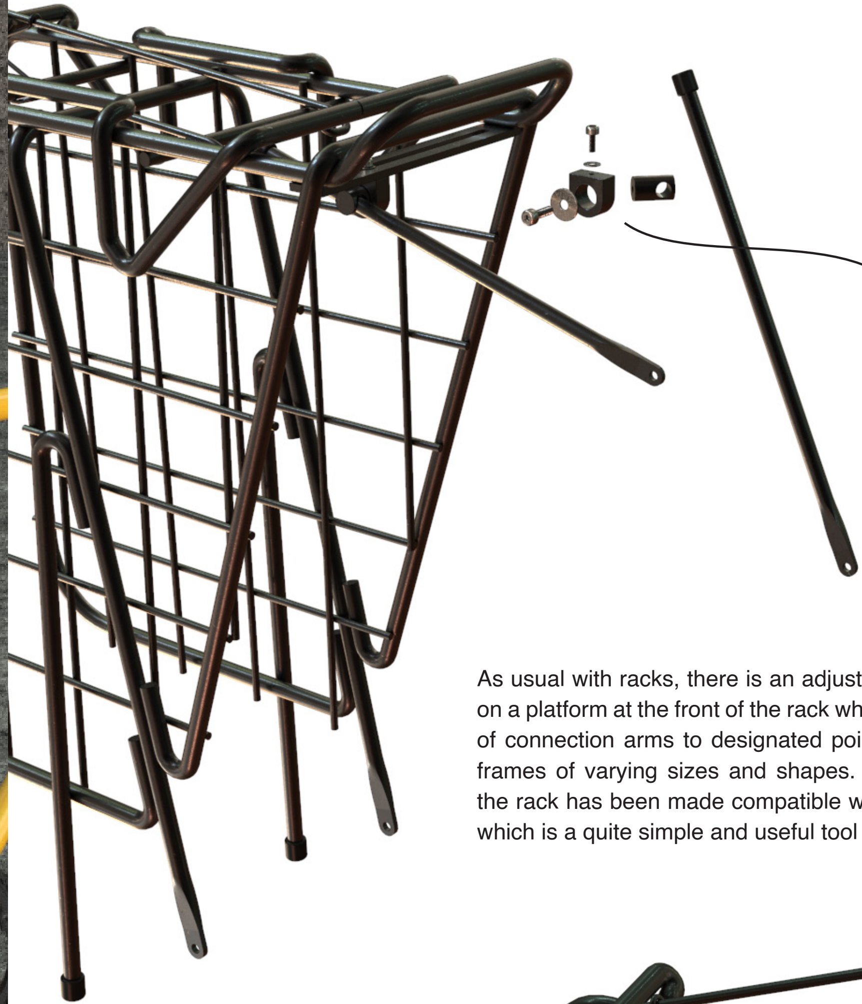
The rack was also designed based on existing versions of pannier racks. It has the basic features of its product family namely a frame of several aluminium tubes bent to the desired form and later joined together by the means of welding. It has four points of attachment to the bicycle frame; two to the centre point of the wheel and two to below the saddle. Also on the back, there is a tail light mount with four standard holes (suitable for M5 bolts, spaced 50 or 80 mm apart) to enable the installation of a light by the users. Added to this configuration are three main elements which make it possible to carry the grocery bag: the triangular hooks at the top, the vertical extension at the bottom and a grid for side support, all of which are made of the same material as the rack only with tubes of varying sizes.

Production and CMF

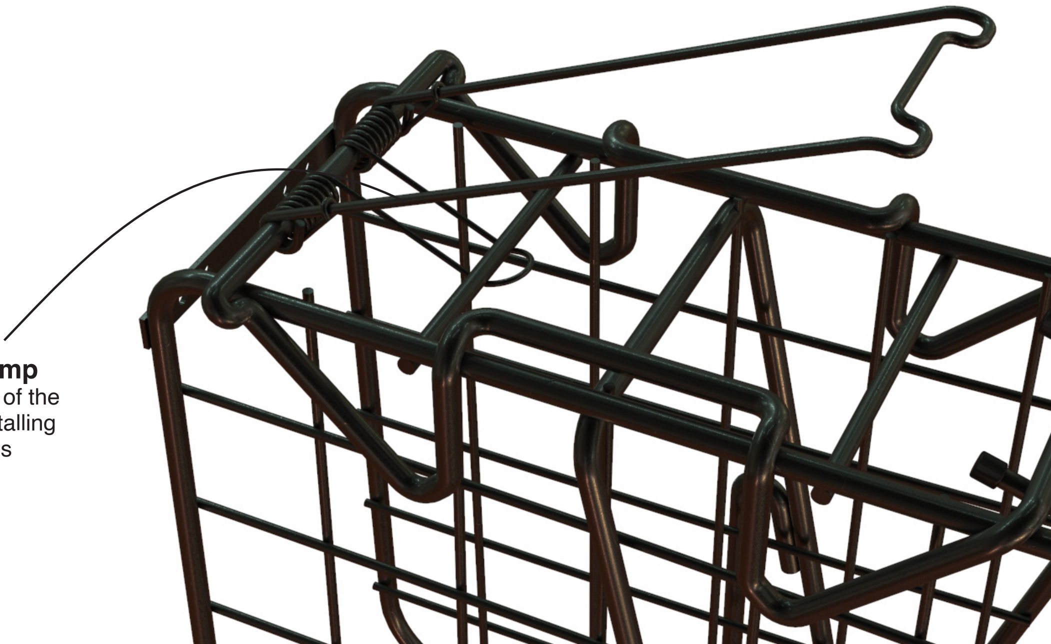
Across the wide variety of urban pannier racks, there seems to be a consensus on the use of aluminium 6061 as the material of choice. While the novel use of the rack in this project requires testing with a prototype to be certain, taking aluminium 6061 as a base, the product is estimated to mass at a total of 565 grams, which is only slightly higher that most urban pannier racks. In addition, to improve the corrosion and scratch resistance of the final product at a relatively low cost, thermal spray coating has been considered. Selecting jet back (RAL 9005) as the colour of this high quality finish, the coating can also make the rack aesthetically compatible with a variety of looks in urban bicycles.



Rack on the Bicycle

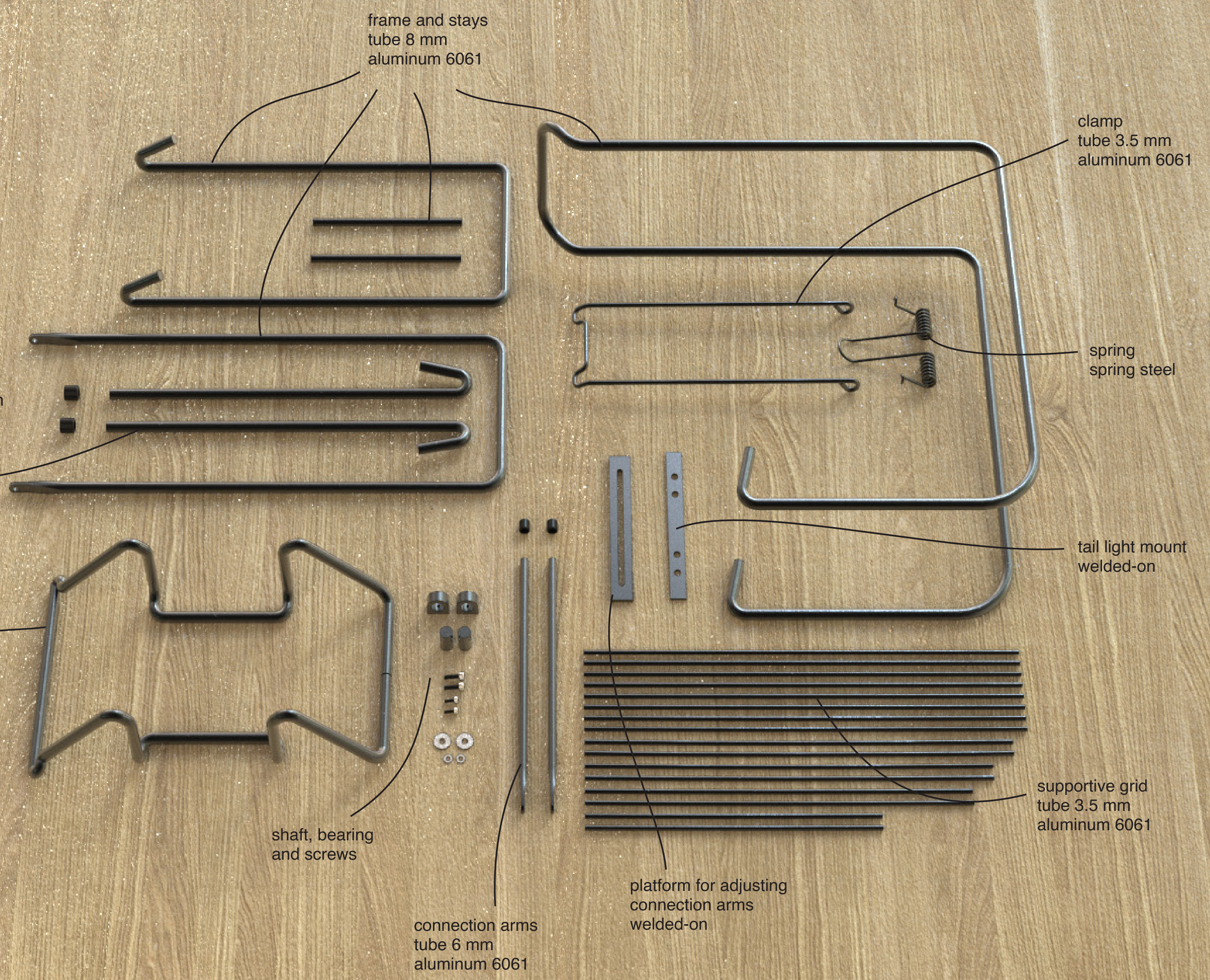


As usual with racks, there is an adjustment mechanism installed on a platform at the front of the rack which enables the adaptation of connection arms to designated points of attachment on bike frames of varying sizes and shapes. In addition, the design of the rack has been made compatible with having a spring clamp, which is a quite simple and useful tool in the urban environment.

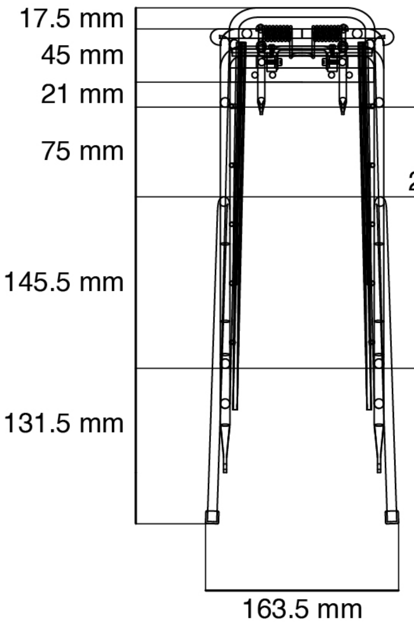


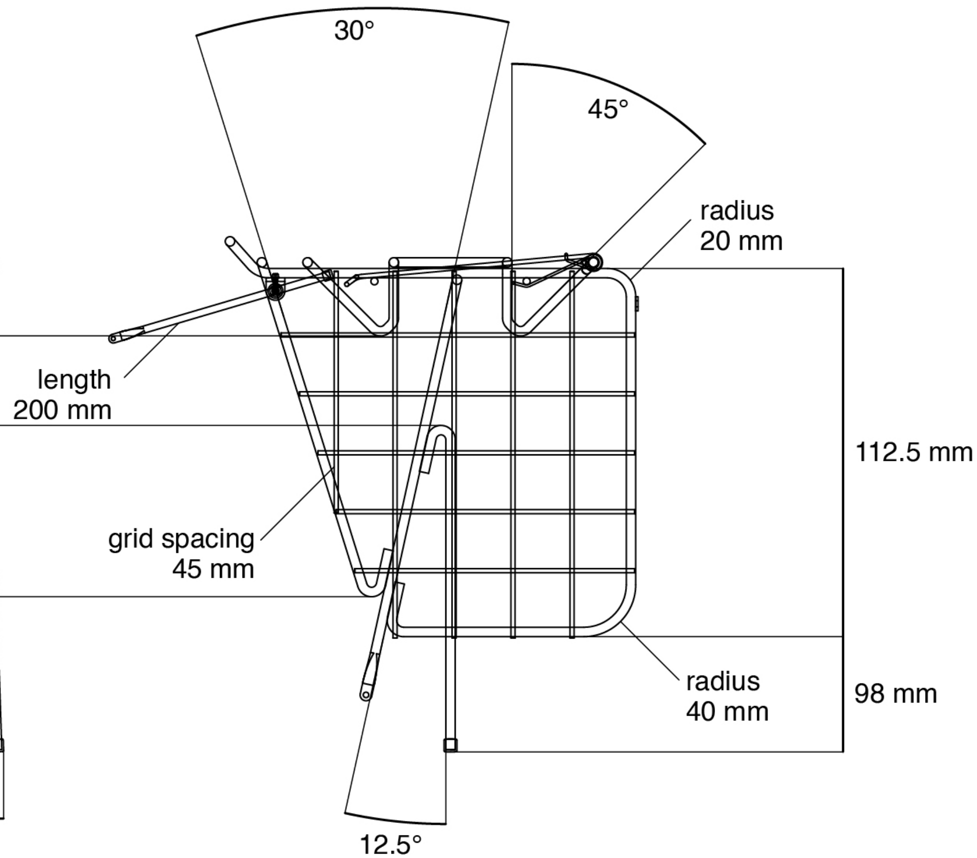
Rack Components

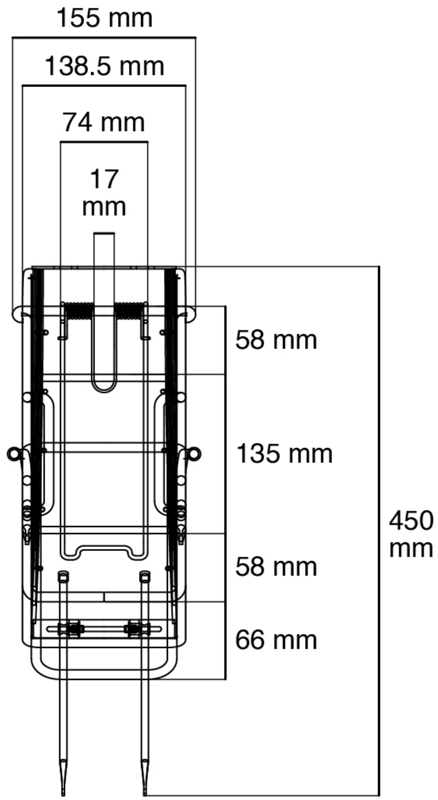
overall mass
≈ 565 gr

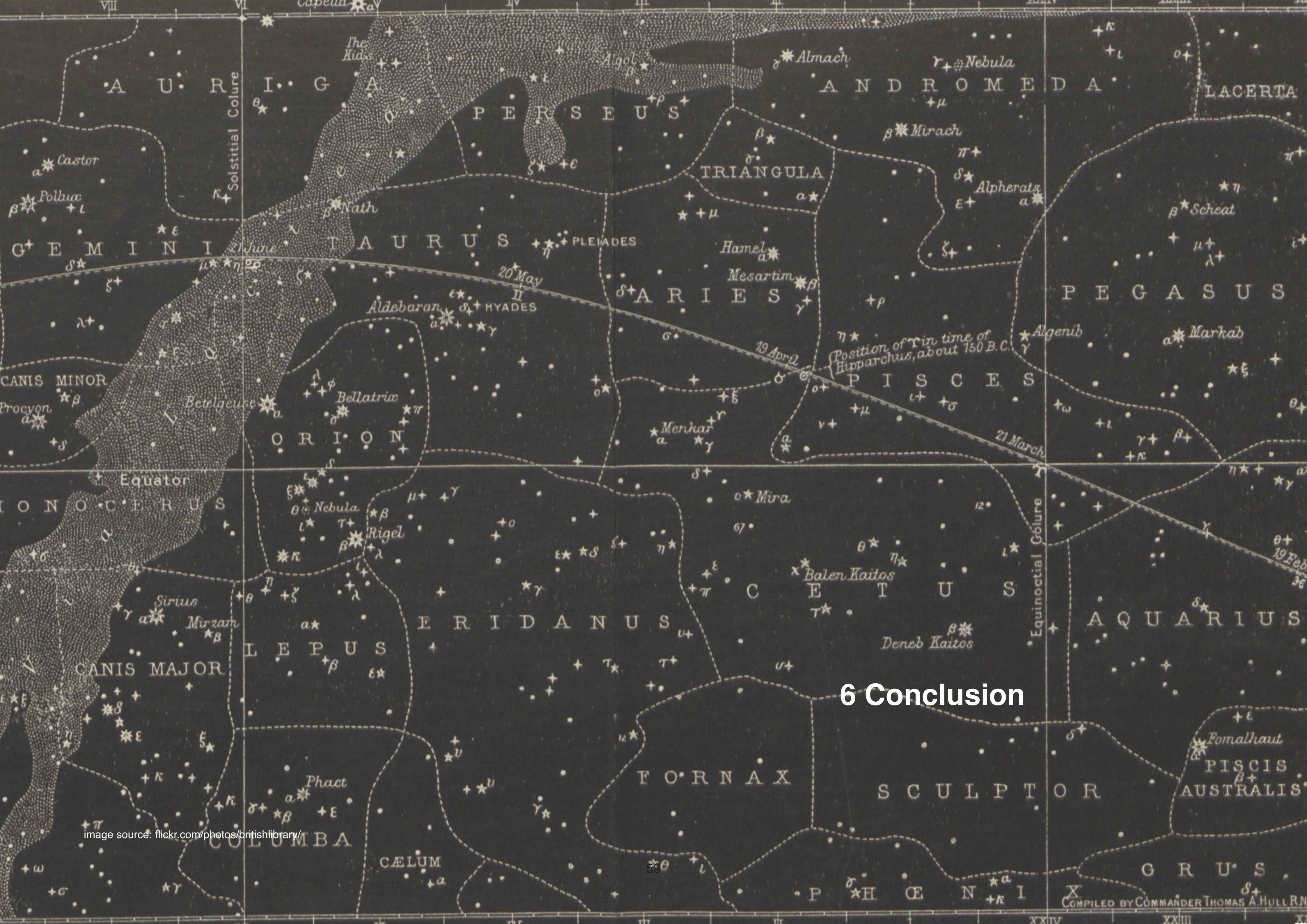


Technical Drawings









6 Conclusion

image source: flickr.com/photos/britishlibrary/

6.1 Active Elements

It is very difficult, if not impossible, to find a backpack lacking the top handle. This is an extremely simple and low-cost element which has come to be a principle in designing backpacks that range wildly on spectrums of shapes, interactions and functions. One of the ways to demolish the passive carrying perception propelled by cars is to develop sets of elements by which objects, bags and vehicles can have active relationships to each other – to encourage a kind of design that does not stop at the boundary of the space it occupies. At the same time, this should not give in to further specialization in products following which comes complexity and cost. Such elements should be of modest material mass and details which makes them an affordable and light burden on the objects' production, assembly and use while also increasing their appropriation through ease of use. Furthermore, it is imperative to keep their intervention in the function of the product to a minimum to allow the wide variety of existing products interacting with them in different scenarios to be maintained.

Such undertaking doubtlessly entails much more development and iteration cycles across a far more diverse range of products, and unfortunately, due to the covid-19 pandemic, the project concluded without a chance to build and test a working prototype which would have provided valuable insights to this end. Hopefully in kinder times, these steps can be catered and the process resumed. Nevertheless, a rudimentary sketch of such elements can be derived from the project.

The Bag

- **Dynamic Handles**
  The handles of any bag are the weight supporting elements of it. Designing them in a dynamic way, for instance allowing length adjustment, exchange of strap between multiple handles and excess strap for uses beyond that of relating to the human body, opens the door for appropriation of the bag in various ways and innovation for carrying loads in different transportation modes.

- **Complementary Points of Attachment**
  In addition to the handles, which are often confined to one side of the bag (the top of a handbag, the back of a backpack, etc.), attachment points of simple construct on other faces of the bag can provide the third point usually needed for it to be spatially fixed on different vehicles and scenarios of use.

The Rack

- **Contour-aligned Hooks**
  Placing hooks on the rack of a bicycle can provide a range of possibilities for bags as well as objects to be attached to it by the means of handles and straps. Such an element can bypass a lot of complexity in the design of pannier bags or adopters suited for them. However, to be of little disturbance to the already extensive uses made of bicycles, it should not penetrate the space around the rack in a way to cause difficulty.

- **Supportive Grid**
  The flipped hook solution together with the supportive grid on its sides creates a kind of 'potential pannier'; a base of three faces around the bicycle wheel which can easily be occupied by bags if they have some type of handle and adjusting capacity to position them at an appropriate height. The supportive grid removes the need for a sturdy structure in the bags carried by bicycle while having very little weight and almost no spatial cost to the cyclists. If integrated in pannier racks, this element can simplify the design of future pannier bags and expand them to further user groups and unexplored practices.

The picture painted by these elements, while quite rough, is a window into decoupling the wide variety of carrying products within the urban transport landscape from the passive carrying perception propelled by cars.

6.2 Nonlinear Design for Sustainability

What this research hopes to have achieved is drawing attention to the things we take for granted as designers. The assumptions lying at the basis of our practices that no matter how boldly we strive for sustainability, end up producing the same hopeless results. Reviewing the trio of classical social theory, reductionist approach and domination as an outlook, while by no means a comprehensive analysis, was an attempt to paint an alternative picture that is nonlinear and relational within which the subsequent design process could progress.

It should be noted that at the outset of the project, the process was envisioned to be a collaborative design exploration with users, likely to culminate in a system outcome. While failure to do this is obviously against the mutual and nonlinear relationship argued for in the first section of the approach, the impact of covid-19 pandemic in guiding the project in another direction cannot be denied. Limited access to university facilities together with general social distancing guidelines made this a rather closed project. This is particularly regretful given the extensive use of bicycles as a mode of transport in Lund and the doubtlessly rich reservoir of insights which could have been gathered by interacting with users.

That said, the adaptation of the approach outlined in the second chapter ended up being disproportionate. With regards to domination, any meaningful attempt to negate the linear outlook would have required direct interaction with not only user groups of the product but also those impacted by its use in various ways. However, on a more abstract level, replacing encompassment by vehicles as the means of transporting bags with a two-way relationship between the bicycle and the bag can be viewed as a rejection of the one-way vocabulary of domination. Furthermore, bestowing other modes of transport with improved carrying capacity without upholding car-propelled perceptions of inclusive spaces, is a challenge to the cars' domination of city spaces and in effect the intrinsic inequality of car-oriented spatial and institutional structures between motorists and the *others*.

From a complexity theory perspective, it has to be noted that much work is needed before such an approach can be successfully integrated in the design of physical products, and there is no illusion about the shortcomings of the project in this regard. However, the nonlinearity between the different functions within the bag, e.g. the load-bearing attachment, the sway-blocking attachment and the closure of the bag, which is experienced in the sequence of hooking and unhooking the bag from the bike, can be viewed as a step away from the reductionist way of doing things in which elements are designed to be independent and finalized in their own right. Moreover, creating excess capacity and possibilities of attachment between various products in the transport ecosystem is a step toward a constitutive approach to the hierarchy of carrying.

From a social theory perspective, which ended up being the most focused throughout the project, it can be argued that while each of us exercise our agency in selecting, purchasing, using and indeed designing products, there are norms and stereotypes in society around the notions of transportation and carrying that have been shaped over the last decades with the assumption of cars as the default mode of transport. Different groups of people can be 'carless' for a variety or combination of reasons; ideology, lack of financial or spatial capacity for owning a car, living in areas without adequate road development, being under-aged for driving, etc. These groups may walk, skate, scoot, cycle, ride buses, trams, trains or monorails to get to places they want to go. Yet with them they carry products that are designed within a picture of the urban setting in which cars are indispensable and indisputable. Thus, by being complicit to this image of transportation, designers are increasingly delegating the control of how we move ourselves, others, objects, and indeed how we organize the urban environment and ourselves as a society, to cars and the unsustainability surrounding them.

As we strive for a sustainable urban transport ecosystem, it is important to acknowledge the extensive and severe influence the car has had over the development of many aspects of life during the last century, which is made more ubiquitous each day as the wide range of products, systems and services we design reproduce and reinforce its hegemony. Raising awareness being the first step toward change, designers must dismantle these assumptions through the objects they furnish the society with. If the material and immaterial elements of social life, which we play a key role in shaping, cease to rely on unsustainable perceptions, their hegemony cannot continue. And design can be on the forefront of imagining new ways of understanding and doing that can sustain a harmonious relationship between us and nature and indeed ourselves.

The time we spend deliberating how to change, what to change and (unfortunately still) whether to change, is time spent limiting our alternative paths of action. The current course of events indicates the inevitability of change to human organization which will be of all aspects of life and substantial indeed. Hopefully, before sheer force of inevitability we can muster the courage, altruism and passion to change.

Afternote

I hope the reader can forgive the rather odd and even at times confusing organization of this document. And that if this was not a sound industrial design project with a definite brief and detailed analysis for production and marketing, it was an amusing thought experiment. It is not my intention to claim to have escaped the outlined assumptions, and indeed looking back on the process, many slips into the presumed way of thinking can be cited. Such an undertaking is rather difficult as they are deeply entrenched. I only hope to have started to tread the path of departure.

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Figure References

Figure 2 2 - Lorenz Attractor (source: Encyclopædia Britannica ImageQuest, quest.eb.com/search/139_1915122/1/139_1915122/cite

Figure 2 4 - an example of Cellular Automata (source: commons.wikimedia.org/wiki/File:R090_rand_0.png)

Figure 2 5 - Koch snowflake fractal (source: Encyclopædia Britannica ImageQuest, quest.eb.com/search/132_1469555/1/132_1469555/cite)

Figure 3 1 - traffic Jam (source: pexels.com/photo/road-traffic-street-car-4212617/)

Figure 3 2 - comparing density in urban planning; low density(left - source: pexels.com/photo/aerial-photography-of-gray-houses-1486785/) and high density (right - source: commons.wikimedia.org/wiki/File:Residential_buildings_along_a_road_in_San_Francisco.jpg)

Figure 3 4 - cocooning aspect of the car (source: pexels.com/photo/panel-with-buttons-on-contemporary-car-door-4150584/)

Figure 3 5 - escorting aspect of the car (source: pexels.com/photo/happy-asian-kids-traveling-in-car-4473498/)

Figure 3 6 - carrying aspect of the car (source: flickr.com/photos/29233640@N07/3342093669)

Figure 4-3 - the two components of a bearer (sources from left:
1. Yellow plastic carrier bag. Encyclopædia Britannica ImageQuest. quest.eb.com/search/118_804370/1/118_804370/cite
2. commons.wikimedia.org/wiki/File:Ghost_Backpack.jpg
3. Red suitcase, artwork. Encyclopædia Britannica ImageQuest. quest.eb.com/search/132_1559584/1/132_1559584/cite)

Figure 4-7 - relational capacity on a hiking backpack (left, source: Hikers carrying backpacks at Crater Lake, mountain landscape, Chilkoot Trail, British Columbia, Canada, North America. Encyclopædia Britannica ImageQuest. quest.eb.com/search/322_3863427/1/322_3863427/cite) and a military backpack (right, source: commons.wikimedia.org/wiki/File:Molle_Rucksack_NG0805_1179.jpg)

Figure 4-8 - straps used on variety of levels and different uses (sources from left:
1. commons.wikimedia.org/wiki/File:XXth-conference-of-Gazprom%27s-young-scientists_02.jpg
2. Gym bag. Encyclopædia Britannica ImageQuest. quest.eb.com/search/118_821235/1/118_821235/cite
3. commons.wikimedia.org/wiki/File:Ergo_Ratsche_mit_langem_Hebel..jpg)

Figure 4-9 - winding as the method of creating tension across scale, from ships to backpacks (sources from left:
1. Cargo ship mooring line. Encyclopædia Britannica ImageQuest. quest.eb.com/search/132_1496723/1/132_1496723/cite
2. Boat in the Soo Locks, Michigan, USA. Encyclopædia Britannica ImageQuest. quest.eb.com/search/132_3127946/1/132_3127946/cite
3. commons.wikimedia.org/wiki/File:Adjustable_boarding_stirrup_PA200107.jpg)

Figure 4-12 - different bearers with active and passive relationship to parts of the body (sources from left-first row:
1. pexels.com/photo/man-wearing-black-backpack-704805/
2. pexels.com/photo/woman-in-white-tank-top-and-black-pants-carrying-black-sling-bag-3577288/
3. pexels.com/photo/woman-carrying-gray-tote-bag-standing-beside-red-bookcase-2078019/
4. pexels.com/photo/man-in-pink-crew-neck-t-shirt-wearing-black-cap-4665730/
second row:
5. pexels.com/photo/anonymous-elegant-ethnic-businesswoman-with-laptop-bag-walking-on-zebra-crossing-6000119/
6. commons.wikimedia.org/wiki/File:Leather_Fanny_Pack.JPG
7. pexels.com/photo/young-sportswoman-listening-to-music-in-park-3776837/
8. pexels.com/photo/happy-woman-with-carton-box-in-bedroom-4247730/
9. pexels.com/photo/happy-woman-with-flowers-in-paper-package-5410146/)

Figure 4 13 - passive relationship between bearers and the trunk of cars (sources: flickr.com/photos/moodlegal/45626834111/)

Figure 4-14 - different carrying solutions for bicycle that encompass bearers (sources from left-first row:
1. commons.wikimedia.org/wiki/File:Bicycle_2.jpg
2. commons.wikimedia.org/wiki/File:Danish_bicycle_cargo.jpg
3. https://commons.wikimedia.org/wiki/File:Bay_State_Bike_Week_2011_(5556311070).jpg
second row:
4. https://www.flickr.com/photos/barriesutcliffe/3862006200/
5. https://commons.wikimedia.org/wiki/File:Bike_rack.jpg)

Figure 4 15 - extensive use of active bags in bikepacking (source: ridefar.info/2021/04/the-varied-definitions-of-bikepacking/)

Figure 4-16 - urban examples of bags' active relationship with the bicycle (sources from left-first row:
1. pixabay.com/photos/bike-pedersen-velo-4930903/
2. https://www.flickr.com/photos/lenore-m/2864380344
3. https://www.flickr.com/photos/ubrayj02/4250024103
second row:
4. https://www.flickr.com/photos/sudoshift/5932822180
5. https://www.flickr.com/photos/7394371@N06/3974023151/
6. https://commons.wikimedia.org/wiki/File:Meritullinkatu_25_-_Helsinki_1986_-_ser860330_-_hkm.HKMS000005-km0000nv5l.jpg)

Figure 4-17 - durable grocery bags (sources from left:
1. pexels.com/photo/fashion-person-woman-texture-6786665/
2. Reusable shopping bag. [Photography]. Encyclopædia Britannica ImageQuest. quest.eb.com/search/132_1216165/1/132_1216165/cite
3. pexels.com/photo/person-holding-orange-fruits-in-white-net-3737624/)

Figure 4-18 - different positions for baskets on bicycles (sources from left:
1. commons.wikimedia.org/wiki/File:Pashley_wicker_basket.jpg
2. commons.wikimedia.org/wiki/File:Bicicletas_en_Jap%C3%B3n_(14757269742).jpg)

Figure 4-19 - limited carrying capacity when shopping by bicycle (sources from left:
1. commons.wikimedia.org/wiki/File:Woman_on_a_bicycle.jpg
2. China Tackles Pollution Caused By Plastic Bags. [Photographer]. Encyclopædia Britannica ImageQuest. quest.eb.com/search/115_2702736/1/115_2702736/cite)

Figure 4 20 - cargo-bikes and trailers (sources from left:
1. commons.wikimedia.org/wiki/File:Butchers%26Bicycles,_Mk1,_2015,_white_06.jpeg
2. commons.wikimedia.org/wiki/File:Bicycle_cargo_trailer.jpg)

Figure 4-21 - a fixed pannier (source: commons.wikimedia.org/wiki/File:Pretty_Kewl_Bicycle,_White_Frame.jpg)

Figure 4-22 - a collapsible basket (source: flickr.com/photos/99247795@N00/5621255686)

Figure 4-23 - a simple rear rack (source: flickr.com/photos/geiranders/4763374112)

Figure 4-24 - partial closure of grocery bags (sources from left:
1. pexels.com/photo/person-holding-a-net-bag-3737612/
2. Reusable shopping bag. Encyclopædia Britannica ImageQuest. quest.eb.com/search/132_1306414/1/132_1306414/cite)

Figure 4-31 - different pannier racks (sources from left-first row:
1. flickr.com/photos/rjl20/136210433/
2. flickr.com/photos/vikapproved/2344564720
3. flickr.com/photos/vikapproved/2771688583
second row:
4. commons.wikimedia.org/wiki/File:Bike_carrier_on_Raglan_bus.jpg
5. www.flickr.com/photos/ah_blake/8922007664
6. commons.wikimedia.org/wiki/File:Surly_Long_Haul_Trucker.jpg)

Figure 4-32 - pannier bags (sources from left:
1. flickr.com/photos/7394371@N06/3974095559
2. jrkotrla.com/index.php?/category/47)

Figure 4-37 - the asymmetrical configuration of a pannier rack (source: flickr.com/photos/wcouch/8675049697)