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MASTER THESIS

Friendly robot delivery

Designing an autonomous delivery droid for collaborative consumption

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Master of Science Thesis, Industrial Design Engineering

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Master of Science
Friendly robot delivery - Designing an autonomous delivery droid for collaborative consumption

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Abstract

HUGO is an autonomous, last mile delivery robot concept currently under development by Gothenburg based tech agency Berge. The aim of this thesis was to design a top module for HUGO, making the robot fit into the context of collaborative consumption.

A literature study about collaborative consumption, last mile delivery, and robot interaction was conducted to deepen the understanding of these subjects and to find requirements that the context of collaborative consumption pose on HUGO. Also, potential HUGO users were repeatedly involved throughout the project to establish user needs and requirements posed on the robot in order to make it visually appealing and user friendly. To gather user insights, a questionnaire was sent out, interviews were held and focus groups were implemented. User needs and criteria were identified regarding the design and function of the robot as well as the delivery service connected to it.

A brief attempt at integrating a delivery robot into current Swedish collaborative consumption services was made by creating user journeys showing step by step how the service could work.

Some concerns emerged regarding the integration of autonomous delivery robots in the public space, however, the user study indicated that users are generally positive to autonomous delivery drones, proving HUGO's potential as delivery method. The user study further indicated that for an autonomous delivery robot to be accepted in the public space, it is essential that its purpose and primary function are obvious.

The project resulted in HUGO C - a product proposal for a delivery robot suitable for collaborative consumption. This concept is unique in that it is modular and can transport between one and four parcels at a time as well as adapt its compartment sizes to the user needs.

Keywords: autonomous, delivery, droid, collaborative, consumption, social, robot, interaction, last mile, delivery.

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Elin Janebäck & Matilda Kristiansson, Gothenburg, June 2019

Contents

1. Introduction

Our society is experiencing numerous changes caused by rapid product and service development. Most sectors are exploring new grounds regarding artificial intelligence, digitisation, mobility and market redistribution, all of which inciting new needs followed by new products and services. The logistic market is indeed an example of such a sector, undergoing both growth and progress. Due to e-commerce rapidly gaining market grounds, logistic stakeholders are required to keep up with increasing online shopping habits and demands for closer, faster and easier delivery services (Vakulenko et al., 2019). One solution has been a larger number of pick up points spread across city centres as well as rural areas, another has been stationary pick up boxes allowing round-the-clock access (Andersson, 2016). However, the very last distance of the logistic chain, the last mile, is still a problem to be solved. In most cases, this part of deliveries is depending on customer effort. Although home delivery is on the rise, this option too comes with logistic difficulties such as unattended or delayed delivery attempts and high costs (Morganti et al., 2014).

Whereas some companies have realised the possibilities of an improved end phase of deliveries, the development of solutions on Swedish soil has been absent. Above all, big stakeholders like Amazon have initiated several projects concerning last mile delivery, mostly focusing on aerial tactics up until now. These airborne concepts have turned out to be somewhat problematic and perhaps too futuristic for the current delivery market. Hence, the development of last mile delivery vehicles has moved into a bit more grounded settings - the roads and pavements (Sawadsitang et al., 2018). Compact robot droids, presented by big e-commerce stakeholders amongst others, are being presented as the next step of delivery innovation, enabling flexible deliveries to the customers' doors (Joerss et a., 2016). Moreover, these electric delivery robots are meant to reduce the amount of green house emissions caused by fossil fuelled vehicles collecting parcels from pick up points.

Now Berge, a design oriented consultant company based in Gothenburg, has caught the wave and initiated their project HUGO, an acronym for Here U GO. Purposed to transform last mile delivery within the city of Gothenburg, HUGO will create value for people and city infrastructure when removing the logistic efforts of individuals whilst replacing a share of car travels. Presently, HUGO's development concerns mechatronic features and navigation skills, and the functional prototype consists of six wheels mounted onto a rectangular platform. In order for HUGO to serve its purpose it needs to be equipped with a top module suited for transporting goods, also serving as main component for user interaction. In other words, the top module will constitute both the aesthetic appearance, the primary logistic functions, and the interactive elements of the design. Combining these product dimensions, not compromising any part in the final design, will be crucial for product usability and user experience.

1.1 HUGO today

HUGO is currently being developed by an in house team at Berge, with competences ranging between design, business, mechatronics and software. Realising last mile delivery is "costly, time consuming and unsustainable" (Hugodelivery.com, n.d), the HUGO group identified a segment in need of change, and created the concept HUGO. The project vision is to "be in the forefront of [the e-commerce] transition, pioneering the landscape of last mile deliveries in the near future" (Hugodelivery.com, n.d). The HUGO team has, as mentioned, focused their work so far around the software development to enable testing in proper environments. Moreover, the group has explored the fields of modularity, customer journey flows and visual language amongst other things (Hugodelivery.com, n.d).

At the start of the thesis project only the platform and the individually motorised wheels where built and assembled. All technical components where either incorporated in the platform, or in a neck mounted at the front of the platform. However, along our thesis project, the HUGO team has begun their own product development of the top module, envisioning HUGO in a business to customer (B2C) system.

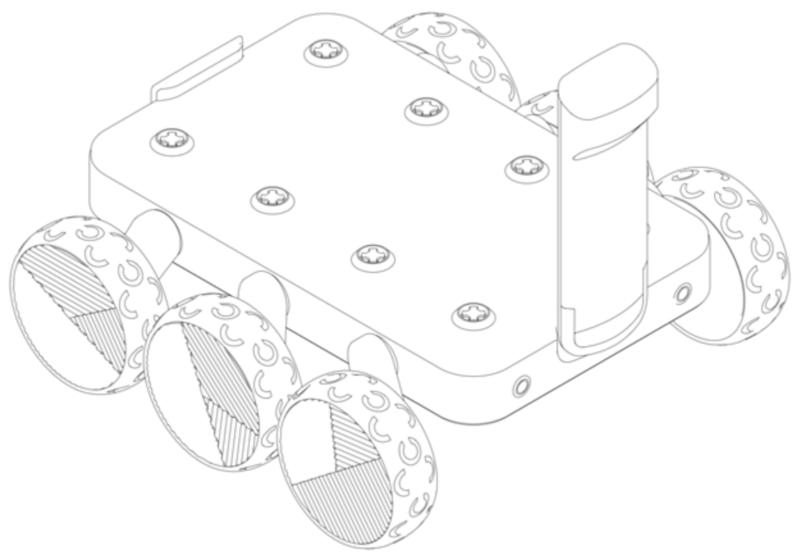


Figure 1.1: Isometric drawing of HUGO when the thesis project was initiated.

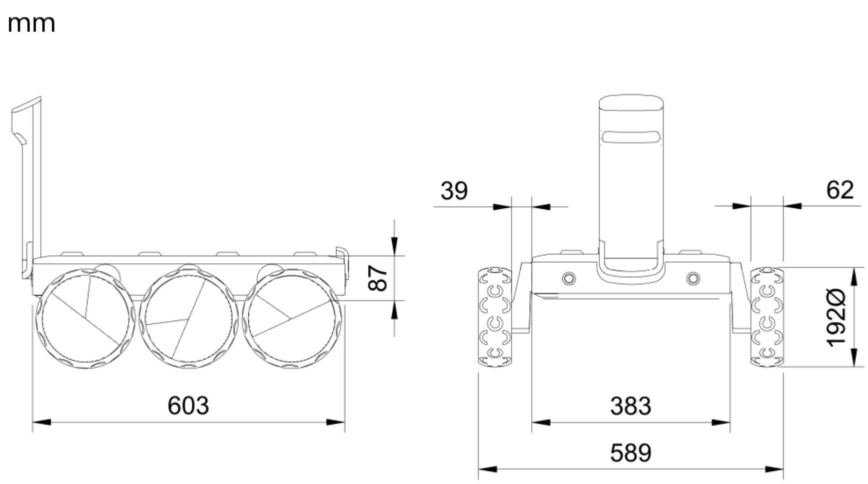


Figure 1.2: Right and front view drawings of HUGO when the thesis project was initiated.

1.2 Aim

The aim of this project is to, by means of practical and user centred research, design and visualise a product proposal of a delivery droid suitable for collaborative consumption. Main research areas will be the acceptance and imagined experience of users, and the utilitarian attributes needful for operation in Gothenburg. At large, the project aims to narrate the criteria present in a last mile delivery context, whilst exploring how they could be met by an autonomous robot.

1.3 HUGO C

From the project commencing, Berge has kept the directives few and the thesis scope open. Hence, the approach to HUGO C, as in Collaborative, has been oriented more towards their concept vision, than to the aesthetic work of the official HUGO team. Yet, some features and ideas of their renderings will be accounted for in this project as well. Firstly, the volume of the current platform discloses the minimum dimensions for the main battery and other electric components, and is therefore crucial to recompose in any HUGO version. Secondly, using individually motorised wheels will allow for the robot body to accommodate added cargo space since the motors are positioned in each wheel instead of somewhere else on the robot. As for the number of wheels, six constitutes enough power to support the robot forward whilst carrying a load of 12 kg, and will therefor also be inherited onto the thesis project concept. Thirdly, interest for a modular solution arose when discussing the subject with Berge, and resulted in own set criteria regarding a somewhat modular solution.

Above all, we felt the urge to target the product development towards a prevailing economic model, the collaborative one. Mainly due to personal interests for more sustainable solutions, but also because we want to develop a longstanding delivery alternative, suitable for future consumption. Fact is, the collaborative model can no longer be considered a trend, but a significant and profitable business model challenging entrepreneurial frameworks (Zhang, 2018). Innumerable enterprises have entered this new market domain with innovative service-product systems encouraging collaborative peer-to-peer operations. Thus, more items attend inter-human handovers, some of which employ shipment. For the local shipments, delivery robots might as well be an delivery alternative, simplifying the process of sending or receiving physical goods, and encouraging the activity.

2. Theory

The theory relevant for the understanding of the project is presented below, covering theory about collaborative economy, last mile delivery, social robots and current delivery robots. Investigating these topics established a solid theoretical basis on which user involvement and creative exploration was founded.

2.1 Collaborative consumption

Due to the collaborative emphasis of this project, the concept of collaborative consumption had to be further clarified in regards to what it includes, its main drivers, and what customer values it induces.

A collaborative consumption is according to Belk (2013) "people coordinating the acquisition and distribution of a resource for a fee or other compensation". There is a variety of terms describing economic systems where users enter collaborate activities involving sharing, renting, buying or selling goods. Two of these are the umbrella term sharing economy, often used when addressing collaborative settings, and second hand economy. Together, sharing and second hand economies cover most aspects of a collaborative system concerning customer to customer (C2C) operations. There is no exact definition of the term sharing economy, however for the sake of this paper, Matofska's definition in Somers et al. (2018) is used: "a socioeconomic ecosystem built around the sharing of human, physical and intellectual resources, which includes a shared creation, production, distribution, trade and consumption of goods and services by different people and organisations." An important distinction of a sharing economy is the idleness and inactive use of goods. If a new demand is created, it is referred to as on-demand economy (Frenken & Schor, 2017).

The second hand part of a collaborative model covers permanent purchase or by other means transfer of goods in between consumers (Frenken & Schor, 2017). The second hand market reiterates product life cycles and enables additional consumption after previous consumer consider her- or himself done with an item.

Böckmann (2013) has identified three categories of trends driving the collaborative market. These are societal, technological and economic. In addition, Somers et al. (2018) mention a social driver focusing on trust in the system and its participants, implying it is cardinal elements for the willingness to share. Societal drivers include an enlarged population density inducing the amount of opportunities to practise sharing. The change in population has also led to a growing awareness of environmental problems, causing corporations to take action and attune their offers. Community cooperation towards sustainable development is yet another example of the many societal drivers enabling an expanding sharing environment. Technological drivers are for instance secure and trustworthy payment methods, democratic mobile device access and the recognition of social networking, all making up for favourable and digital sharing circumstances. In fact, Zhang et al. (2018) acknowledges the fast expanding social media to be the reason for the sharing economy's rapid growth, and for market adaptation across multiple sectors. Lastly, the main economic drivers are considered capitalising on idle inventory, an increased financial flexibility through new profitable systems, and shifted preferences regarding access to inventory over ownership.

According to Hamari and Ukkonen (2013) in Böckmann (2013), customers in the sharing economy desire economic benefits and sustainable alternatives over ownership of goods. Böckmann (2013) concludes that this demonstrates a need for flexibility in time and location when accessing goods. Convenience is also important, it should be easy, effective and satisfactory to use a sharing service. All steps of the sharing experience should be considered, from searching for information, making a decision, paying eventual fees, to finally having the product delivered.

Collaborative activities are continuously growing in popularity and spreading in business (Naturskyddsföreningen (2015), Toni et al., 2018). Collaborative activities are also finding their way into new areas as novel forms of collaborative consumption emerge, Toni et al. (2018). In 2011, TIME Magazine announced collaborative models as one of the top ten concepts that will change the world, (Naturskyddsföreningen, 2015). A quick review of available online sharing marketplaces showed that in Sweden, there is a considerable number of online sharing services. Further, according to the online secondhand market Blocket (n.d.), 70% of all Swedes have bought something on Blocket. The total value of the advertised products on the website was equal to 14% of Sweden's GDP (gross domestic product) in 2016. Participant of collaborative services purchase, sell and share many kinds of items. Below are the most commonly sold items on Blocket and Tradera as well as an overview of what is commonly advertised on Hygglo. A big part of the items from these product categories ought to fit into HUGO's compartments in order for it to serve many people and their needs.

Most sold items on Tradera, 2016 (Tradera, 2016):

- Women's clothing
- Kids' clothing
- Vinyl
- Men's clothing
- Ceramics & china
- Toys
- Garden equipment
- Swedish stamps
- Women's shoes
- DVD films

Most sold items on Blocket, December 2018 (Jonsson, 2018). Mobile phones and tablet are also the two fastest selling items overall (Furubacke, 2017):

- Video games
- Tablets
- Mobile phones
- TV Projector
- Appliances
- Tickets (travels)
- Toys
- Computers

- Winter sport
- Musical instruments

A review of commonly advertised product categories on Hygglo showed these to be: tools, technology, home, clothes, and outdoor equipment.

2.2 Last mile delivery

To grasp in what setting HUGO will exist, what general problems there are, and how they have been solved up until now, the concept of last mile delivery was investigated. The term last mile delivery refers to the final leg of logistic transport, not necessarily implying an exact distance but a last phase of a logistic occurrence. The extent of the last mile differs in regards to location and geographical conditions. Cardenas et al. (2017) compares the last mile of a delivery chain to resemble a tree and its branches. As the system advances from its roots, it serves more people and suffers from more inefficiencies due to pressured networks, Gevaers (2013). Until now, most last mile deliveries has occurred between businesses, or in between businesses and customers (B2C), but is now changing along with new financial systems solely consisting of C2C transfers.

2.2.1 Problems

The logistic sector is experiencing a great deal of challenges. Most of them can be traced back to urbanisation and city design, but also major transitions in many transport systems (Cardenas et al., 2017). Route networks is one topic of concern both within cities and to and from them, mainly in regards to space, distance and geographic access. The rise of home deliveries further problematise the logistic puzzle when requiring high degrees of service and fine tuned organisations (Morganti et al, 2014). These new needs are implemented in vehicles designed for older logistic systems, not fully suitable for logistic advancement.

Another problem not yet solved is on-time deliveries. According to Cardenas et al. (2017), urbanisation and strict consumer requirements on availability and time accuracy has led to higher frequency in shipments, conforming poorly with delivery efficiency and sustainable visions. Contemplating human error in delivery chains, all first time deliveries are far from successful inducing additional logistic phases and added costs. In addition, the market is experiencing a higher rate of returns, straining the last mile segment even more (Morganti et al., 2014).

2.2.2 Emerging solutions

Because of high expenses connected to last mile deliveries, multiple companies have attempted to reduce cost in any way possible. Some logistic giants operating in Sweden, DHL and Bring for example, has invested in self service technologies offering flexible parcel collection to e-commerce customers. In this way, companies confide in customers for last mile transports, making the end user both receiver and creator of a service, extending time accessibility but restricting distance conveniences, Andersson (2016).

In McKinseyCompany's fall report on travel, transport and logistic, Joerss et al. (2016)

mention four dominating home delivery models. Apart from today's model, revolving around human delivery agents, they highlight drones, autonomous ground vehicles (AGVs), bike couriers and droids as prominent last mile models in terms of cost and customer preferences. Drones, also entitled unmanned aeral vehicles (UAVs), has perhaps been the most ostentatious contribution to last mile development. According to Stolaroff et al. in Brunner et al. (2018), delivery by drones can be profitable whilst potentially both decrease energy use and lower the emission of greenhouse gases. Their existence in realistic urban systems does however require some challenges being addressed. D'Andrea (2014) emphasises product design, localisation, navigation and coordination to be key problem areas, as well as societal concerns like privacy, security and local regulations. Moreover, Sawadsitang et al. (2018) stress the mere fictive assessments of drone reliability in most scientific work carried out. In the event of unpredictability or interruption, drones are neither tested nor dependable.

Autonomous ground vehicles, AGVs, act much like portable warehouses, encasing parcels whilst transporting them. These vehicles vary in size and loading capacity, but conform with non human, mobile pick up points. Due to their volume, AGVs operate on streets in unity with car traffic unlike autonomous droids, smaller autonomous ground vehicles, designed for pavement travels (Joerss et al., 2014). All kinds of AGVs are sprung from two major trends in delivery models, noted by Xia & Yang (2018); the warehouse moving closer to the final customer, and deliveries expanding into multi deliveries. Yet, for AGV systems to be successful, their business models need cultivation whilst the technology needs maturity. Furthermore, the entire autonomous ecosystem must be further perfected to obtain acceptance and trust amongst citizens. For deployment of AGVs in particular, infrastructure and landscape scenery have to be re-imagined and fit for autonomous presence (Xia Yang, 2018).

In conclusion, the prerequisites for new delivery contributions favour devices operating on ground, since the threshold for aerial solutions can be considered too major for prosperity in the near future. Also, due to narrow city centres and overcrowded streets, any traffic newcomer is preferably prescribed to pavement areas. Moreover, concepts introduced in a last mile context must be able to adjust to and reschedule potentially failed delivery attempts and returns just like today's delivery options. They should also inherit flexibility in terms of both time and place to fully satisfy customer needs. Moreover, acquired technical improvements are necessary for proper manoeuvring and valued presence in urban areas, in due time inciting market acceptance.

2.3 Robots

The term robot is one under continuous progression. In ISO 8373, the International Organization for Standardization (2012) defines a robot as an "actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks". This definition is proper for describing industrial robots, but fails to address the interactive situations a robot may face in cases where its environment is shared with humans. In other words, it does not address service robots much like delivery robots, nor the nature of social robots, a type of robot increasing in society (Duffy, 2003). In this project, delivery robots and social robots were considered important as a frame of knowledge and understanding since HUGO will require traits from both categories to operate successfully in social delivery settings.

2.3.1 Delivery robots

To better understand the product genre, to bypass any design disfavours and to notice successful product strategies, current delivery robots where mapped out. In this project delivery robots are considered small, autonomous ground vehicles, titled mini AGVs or delivery droids. These vehicles are not too strictly designated, apart from the fact that they have smaller volumes than standard AGVs, and travel with a relatively slow speed, around 5-10 km/h (Joerss et al., 2014). Government regulations are yet to be presented, and few current rules apply to delivery robots (Xia Yang, 2018), leaving them in a limbo state. The seven delivery robots examined (see figure 2.1) where chosen due to their degree of realisation, having been completely elaborated and prototyped, and tested or launched in public settings.

Figure 2.1: Images of delivery robots currently operating or being tested in public areas; 1. JD robot, 2. Starship, 3. Dispatch Carry, 4. Kiwibot, 5. Marble, 6. Robby 2, 7. Scout.

The JD robot is a larger delivery droid operating in China. As the name suggests, it is owned by JD.com, China's second largest e-commerce company (Matsuda, 2018). The robot covers a radius of five kilometres from its base and consists of 22 compartments accessed via doors on the side of the robot body. The robot uses face recognition or passwords for customer certification, and is programmed to reschedule deliveries if the customer fails to complete first time deliveries (Matsuda, 2018). The Starship robot is not connected to a parcel company, but is instead an independent initiative signed to various restaurants and stores in parts of California. The droid comprises one compartment, and reaches a radius of six kilometres from its starting point. It is unlocked in a appurtenant application in which the customer also buys whatever item he or she wishes to get delivered (Starship, n.d). Carry, the the company Dispatch's contribution to the delivery field, constitutes of four side compartments and doors sliding upwards. It is designed to deliver groceries, mail and parcels and interacts with primary customers through a screen (Kulkarni, 2016). Since the beginning of this project, Dispatch has reportedly been acquired by Amazon (Harris, 2019). Kiwibot is the smallest droid reviewed. It is advertised as a food delivery robot primarily operating on American university campuses. The service is supported by an application in which, similarly to the Starship application, customers order goods and delivery at the same time (KiwiCampus, 2019). The Kiwibot is the only robot equipped with eye symbols on its front screen, and uses this human like feature and its cuteness as a unique selling point.

The Marble robot runs on the streets of San Francisco and delivers groceries, meals and packages. The robot consists of one compartment accessed from the side with a gull-winged door, and is equipped with a keypad for identification and unlocking. The Marble team emphasises accessibility and inclusion as focal points in their product and service design (Marble, 2018). Robby 2 is also operating in San Francisco, namely the Bay area. Robby 2 delivers groceries, meals and packages much like Marble, also including one compartment. Robby 2 can travel considerably longer than all other robots studied, up to 32 kilometres on one charge, meaning its coverage is a 16 kilometre radius. Scout is a droid by the e-commerce giant Amazon aimed to deliver Amazon parcels primarily. Also, Amazon has partnered up with for example Domino's pizza for meal deliveries. Little is known about Scout and Amazon is acting secretive. Its testing region is however known to be Washington (Holt, 2019).

Some functional and aesthetic similarities can be established, see figure 2.2. One major rectangular shape often constitutes the overall form, although most robots has been given a softer expression through the use of radii and rounded elements. All of them are equipped with lids or doors opening in different directions outwards from the body. All robots are equipped with regular wheels to advance and reverse, although the amount, width and groove differs slightly. As part of the autonomous family, all robots carry technology enabling them to navigate and travel in unforeseen environments. Although the creators of these robots are not too keen to fully explain all technical components, they mention combinations of cameras, sensors and lidar to compose the autonomous core. On most concepts, this technology is placed in the front or on top of the product body. Some are also provided with technical elements on the back of the body to simplify reversive actions. The investigated robots' business models resemble one another. All robots are complemented by an application supporting users with offers, information and updates about their orders.

Size wise, many aspects diverge. Firstly, the outer dimensions and proportions vary from the bigger kinds like JD and Marble to the rather tiny Kiwi. The number of compartments vary in between the robots, from 22 in JD to one in Starship, Kiwi, Marble and Robby 2. The loading volume in each compartment and robot differs as well. Whilst most of these robots are purposed to deliver parcels, some of them have partnered with food services offering food and meal deliveries, putting additional requirements onto the robots' interior.

In terms of expressive attributes, the designs of current delivery droids differ. Although all concepts except JD and Marble uses screens as facial parables, only Kiwibot projects human like traits thereon. Overall, their demeanour is an introvert and passive one, not initiating any interaction. The setting in which delivery robots reside is a social one, hence they are all social robots to some extent. Most social characteristics are, albeit passive, incorporated in their behaviour amongst human as well as in their interactive touch points, whereas little in the product design itself is attuned to human contact. Instead, most studied robots have been assigned vehicle like traits in their aesthetics, for instance treaded wheels, mudflaps, light sources in the front and back, and the overall product body proportions. Perhaps, the resemblance to other transportive devices is one way to communicate what entity it replaces, and to communicate its purpose.

Summarising knowledge gained from these previous solutions, some specific design dimensions can be discerned and further looked upon. Mainly, most robots differentiate themselves through distinct and unique selling points and exteriors. Opposed, their delivery offering is often kept broad, including parcels as well as meals and groceries, to avoid loosing delivery opportunities and important groups of customer. One can also conclude slightly different service flows, and as a result also various interactive components. On one hand, some of the robots rely on applications for communication and verification. On the contrary, other robots utilise space on the product body for touch screens or keypad. Depending on the service sequence, the final project proposal will need to be endued with appropriate touch points, whether these are digital or physical.

	SIZE LxWxH	CAPACITY	COMPART-MENTS	RANGE	ITEM
JD.COM	1,8×1,8×0,8	300 kilo	22 comp.	5km radius	Post/ parcels
STARSHIP	1×0,5×0,7	-	1 comp.	3km radius	Items/ meals
CARRY	1×0,5×1	45 kilo	1/2 comp.	-	-
KIWIBOT	0,5×0,4×0,5	4-5 meals	1 comp.	-	Meals/ snacks
MARBLE	1×0,5×1,1	-	1 comp.	5km radius	Meals
ROBBY 2	1×0,5×1	Large suitcase	1 comp.	16km radius	-
SCOUT	1×0,5×1	-	1 comp.	-	Parcels
HUGO	0.6×0,4-0,6 ×0,5-0,8	12 kilo	4 comp. minimum	-	Parcels/ items

Figure 2.2: Diagram of the benchmarking of autonomous delivery robots. The dashes mean that information was not found.

2.3.2 Social robots

Unlike ISO, Bartneck & Forlizzi (2004) have specifically defined social robots, addressing them as "autonomous or semi-autonomous robots that interact and communicate with humans by following the behavioural norms expected by the people with whom the robot is intended to interact". This definition clarifies the relation between man and machine whilst also mentioning how a social robot should act according to the social norms of human beings. Duffy (2003) revolves his work around this in particular, addressing it as levels of anthropomorphism in social robots' physical appearance and behavioural skills. Anthropomorphism holds many advantages within the product development field, and relies on humans' tendency to ascribe human like traits to inanimate entities in order to rationalise their actions.

Duffy (2003) states the possibilities of applying anthropomorphism onto design strategies, especially when dealing with social robots. The role of anthropomorphism is one of great importance when designing products and systems for coexistence in both social and physical spaces. Moreover, due to it being an innate mechanism amongst humans, it may facilitate human-machine interaction. The application of anthropomorphism onto design systems does however require awareness. Duffy (2003) refers to it as a needful balance between machine capacity and the expectations it causes. Incorporating too human like attributes will lead to presumptions of high intelligence and well developed behavioural skills, furthermore causing the robot to appear insufficient when unable to meet expectancies. The phenomenon is illustrated by Mori 1982 in Duffy (2003) focusing his thesis around facial expressions, addressing the elusive circumstances as "the uncanny valley", a state in which robots are considered too realistic. In short, Mori pays attention to the vast drop of acceptance that occurs for a certain degree of anthropomorphism in the robots' facial structure.

Apart from visual properties, near by factors may also influence machine perception. Bartneck & Forlizzi (2004) states the importance of surroundings and expectations of social behaviour depending on what activity a social robot is supposed to mimic and in what environment it resides. Apart from communicative features conforming to this rule of thumb, functionality as well as form should also correspond to the robot's intention to avoid unmet capacity expectations, and to furthermore evoke an intended user experience.

To conclude, anthropomorphic traits are favourable to implement on machines, like delivery robots, as long they are not too exaggerated. The quantity should rather be kept too low than too high to avoid thorough rejection. Contemplating Bartneck & Forlizzi (2004) and their belief in a clearly expressed purpose, the expression of delivery robots should therefore reflect their transferal service. Referring to the robots studied, they manage to communicate their purpose well. Yet, for a higher level of cognitive exchange, and a more intense human-machine interplay, HUGO will need to be more expressive than current delivery robots.

3. Method

To research the project aim, a user centred approach was applied throughout the project by repeatedly involving potential users. The essence of this user centred approach was to establish user needs and requirements so as to create an appealing, user-friendly product and service, but also to determine factors allowing for widespread acceptance of this type of product in public spaces. An overview of the project's implementation can be found in figure 3.1. As seen in the figure, the project consisted of the three phases *establishing prerequisites*, *concept development* and *final design*. In this paper, the methodology and the findings are structured according to these phases.

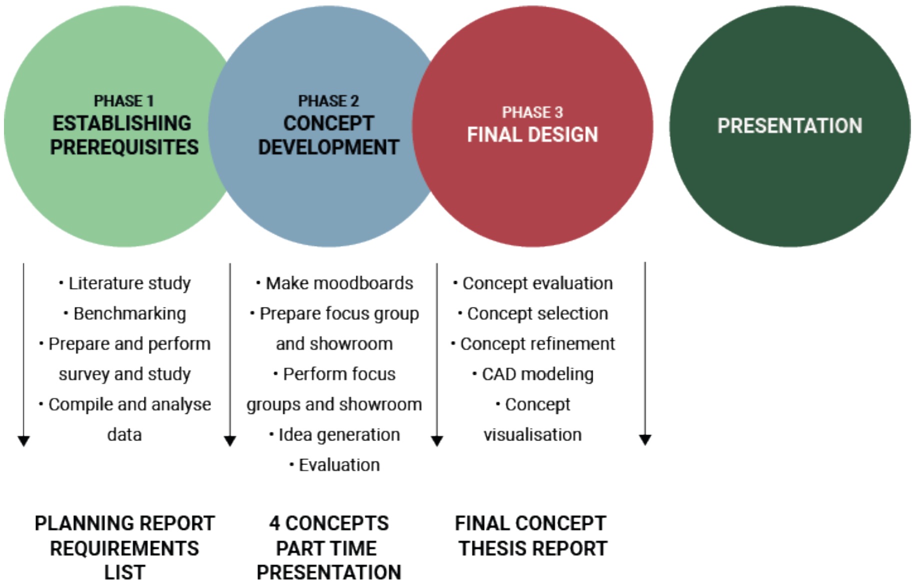


Figure 3.1: Illustration of the project process.

Below, all implemented methodologies are recounted and motivated. The order reflects the project time line, with the exception of idea generation activities used in an iterative manner.

3.1 Establishing prerequisites

Phase one comprised gathering of user insights, benchmarking, and a literature study to understand subjects relevant to the project. This information was compiled into a preliminary version of a criteria list, which was used as a basis for initial concept development and was updated along the way as new criteria emerged.

3.1.1 Literature study

A literature study was performed regarding sharing economy, collaborative consumption, delivery droids, and social robots. The search engine on Chalmers Library's website was used to find papers on the subjects. If the abstract of a paper was interesting, the whole paper was read to judge whether it was relevant. The relevant papers were then used to gain knowledge about the subjects and to understand the context in which HUGO C will operate. The literature study provided an understanding of current last mile problems, and proved why autonomous delivery droids are relevant. Concretely, the study resulted in functional criteria for droids that are to operate in a collaborative economy context and aesthetic criteria for social acceptance in that context. Additionally, guidelines for the design of the robot in terms of interactive touch points were defined.

3.1.2 Benchmarking

An analysis of existing delivery robots was performed to investigate service design, droid design, functionality and business models. The goal with the benchmarking was to find strengths and weaknesses in other delivery robots as well as to find patterns of common features amongst them. This was done by reading about different robots online and, when possible, inspecting the services through their applications. The benchmarking resulted in insights regarding aspects that work well in current delivery droids, as well as insights about how HUGO could fit into the product family. Also, the mapping of existing delivery droids demonstrated a market gap to fill considering the lack of modularity in today's solutions.

3.1.3 Collecting user insights

Interviews were held and a questionnaire was sent out to gather qualitative and quantitative user data respectively. Subsequently, the user data was analysed, which mainly resulted in criteria for the service provided by the robot, but also in some design criteria.

Questionnaire

A questionnaire was constructed to gather quantitative data regarding experiences with online second hand shopping and experiences of interacting with robots. The survey consisted of either short text or multiple choice questions. The questionnaire was intended to collect data on the extent of use of different online services for buying, selling or renting used goods, which in turn led to defining the context for the HUGO service. Further, it indicated pleasure and pain points in the usage of existing services, resulting in insights about how a delivery robot can facilitate current pain points in this process. The survey also resulted in criteria regarding what requirements a home delivery service (such as HUGO) should fulfil in order for people to choose it. In addition, data was collected about concerns regarding home delivery and about previous experiences of robot interaction. The survey was shared online on social media and resulted in 45 replies. Among the respondents, 25 persons were male, 19 were female and one preferred not to say. 44.4% of the respondents were aged between 18 and 25, 26.7% were 26-30, 13.3% were 31-39, 4.4% 40-49 and 11.1% 50-59. Regarding occupations, the ratio of working to studying was 53.3% to 46.7%.

Interviews

Semi-structured interviews, Wilson (2014), were held, recorded and transcribed. In total, ten interviewees participated. The interviewees were chosen with regard to gender and age to get a broad representation of users. Half of them were female and half of them male. Half were students between the age of 20 and 25, and half were aged 55-61 and working. They had varying levels of technical experience and different occupations.

The interviews intended to generate a more profound understanding of the wishes and needs of the users and to grasp needs which were not directly expressed through or covered by the survey questions. There was a predefined interview template, but the interviewer was allowed to ask questions other than those on the template in order to gain a deeper understanding of the interviewee's answers.

The interviews consisted of three parts covering experiences with online collaborative consumption, home deliveries and robot interactions. First, the interviewees were asked to fill out a user experience curve, (UX-curve) Kujalaa et al. (2011), regarding any online collaborative consumption experience of their own choice. The idea behind the UX-curves was to identify potential pain points in the process of buying, selling or renting something from another individual online. Second, they were asked questions regarding online collaborative consumption, home deliveries and robot experiences. This was also used to identify potential pain points in using these services, as well as identifying important factors for home deliveries and preferences in robot interaction. Last, photos of various delivery robots were shown to the participants who were in turn asked to react to each of the robots. The participants were asked to colour a PrEmo version 2 scale, Caizedo (2009), according to the feelings the robots evoked and to simultaneously think aloud so that the interviewer had the possibility to ask clarifying questions about their experience as well as take notes. The PrEmo scale was used to identify users' attitudes and opinions about the different existing delivery robots. From this, criteria was obtained regarding factors that contribute to user acceptance of delivery robots. These criteria covered desirable features of the droid, both when driving and standing still. The reason as to why the PrEmo version 2 was used was that it was considered clear and fast to use. Besides, the visual tool intended to engage the interviewees more by varying the tasks.

The interviews resulted in an evaluation of the aesthetics of current delivery robots including what positive or negative emotions their different features tended to evoke. This led to aesthetic criteria being defined to make autonomous delivery robots downtown a positive experience for pedestrians as well as users. The interviews also gave insights into factors important for users when shopping used goods online and ordering home delivery. Moreover, the interviews led to criteria emerging regarding the service connected to the robot.

3.1.4 Analysing user data

The user insights from phase one were analysed in different ways depending on the type of data. A KJ analysis, Scupin (1997), was used to structure and analyse the written replies of the questionnaire and the transcriptions of the interviews, since it suited this type of data. Quotes from the interviews and the questionnaire were grouped into categories which emerged when going through the material. As a result of the KJ analysis, user needs, wishes and requirements were identified and compiled in the list of criteria. The KJ analysis also provided an overview of the category sizes, illustrating how important different types of requirements were depending on the size of the categories and the number of common statements they contained. The results of KJ analysis contributed to the list of criteria, primarily in terms of service demands but also with design requirements.

The parts of the questionnaire which consisted of multiple choice questions intended to collect statistics were illustrated and analysed through diagrams. The PrEmo evaluation was analysed by summing up the robots' scores and compiling the notes, resulting in aesthetic criteria. Although the UX-curves were intended to render additional pain points in current user experiences when taking part of collaborative consumption, they did not provide any useful results and were therefore not treated further.

3.1.5 Service analysis

After the insights from the user involvement had been compiled, the service around HUGO was briefly looked upon to trace necessary service touch points in a collaborative context. Moreover, HUGO's potential role in home deliveries from the websites Blocket, Tradera and Hygglo was roughly investigated to gain insight into how HUGO could fit into the process of buying, selling and renting used goods online. However, the service design was not a focus point in this paper and was left to more elaborate development in the future.

The ”User experience exploration pack - a tool for charting circular consumption journeys”, Selvefors et al. (2019), was used to map out different alternatives for how the HUGO service roughly could work. The service journeys were mapped out in general using this tool, without specifically considering HUGO's connection to services like Blocket and similar. Additionally, the tool visualised where in the service a user (primary or secondary) could interact with HUGO. Because of this, it was also used to find potential additional requirements on the design of the module and the service based on human machine interactions.

After the HUGO service was charted, user journeys for Blocket, Tradera and Hygglo were mapped out in order to understand how HUGO could be used as a delivery option with these websites. The current user journeys when buying, selling or renting something on Blocket, Tradera and Hygglo were mapped out first, followed by modified versions of these user journeys involving HUGO. Blocket and Tradera were chosen because of them being commonly used. Also, including Hygglo was a way to incorporate aspects of renting into the service design.

The ”User experience exploration pack” resulted in two different options for service journeys for HUGO, but did not result in additional requirements on the product design. The user journey mapping in turn resulted in user journeys for ordering a product with HUGO from Blocket, Tradera and Hygglo respectively.

3.2 Concept development

Phase two comprised concept development and resulted in four preliminary concepts. The concepts were evaluated according to the list of criteria leaving four concepts to be further developed. To physically explore these four ideas, mock-ups were made out of polystyrene and the concepts were also rendered in a CAD programme. Focus groups were subsequently held to evaluate the concepts, and insights from the evaluation were brought into the development of the final concept.

3.2.1 List of criteria

The list of criteria, a less strict version of a requirement list, was used to evaluate the concepts halfway through the process, and to verify how well the final design fulfilled the criteria that were identified. A list of criteria was used because the requirements and needs mainly consisted of design criteria. Phase one resulted in a preliminary version of the list of criteria, and more criteria was added throughout phase two. The list of criteria was based on interview data, questionnaire data, predetermined measurements and technical information from Berge as well as input from the focus groups.

3.2.2 Determining HUGO's expressions

To determine HUGO's expressions, words describing the essence of HUGO were defined based on insights from the interview material, literature study and also on our own ideas. The words were then organised into four word clouds, from which four concepts were later developed. From the words clouds mood boards (Technopedia (n.d.)) were created to visually convey the ideas and feelings representing each concept. The mood boards and word clouds were combined into four inspiration boards and used when developing the four initial concepts. The inspiration boards differed to explore a range of expressions, designs and functions in delivery robots. This lead to four concepts with a variety of characteristics, allowing contrasting expressions and features to be evaluated.

3.2.3 Exploring function and form

After having created inspiration boards for HUGO's expressions, brainstorming in combination with exploratory sketching were used to explore and communicate form as well as ideas showing how different design solutions were thought to look and function. This resulted in visual representations of what expressions different shapes and angles created, as well as a number of solution principles for specific aspects of the robot. The shape of the droid body was experimented with to understand how the different angles, radii et cetera communicated direction. These specific solutions were then combined into different ideas eventually developed into concepts 1, 2, 3, and 4.

Form was further explored and eventually visualised both digitally in 3D using a CAD software and by creating physical mock-ups. The mock-ups were constructed in one third of their actual size, since it was too time consuming to make them all in real size. A scale model in the form of a human was made to communicate the real size of the mock-ups. The mock-ups were constructed out of polystyrene, coated with filler and painted white, as their respective colours had yet to be decided and to minimise the influence of colour on the perceived design language.

The mock-ups were mediating tools for discussion when evaluating the design and parts of the functionality of the concepts during focus groups. The mock-ups visualised issues and benefits of the respective concepts. The mock-ups were further used to illustrate the proportions of the concepts. CAD renders were also used to evaluate the concepts along the way and during focus groups, visually communicating ideas in a way that would provide more rewarding feedback than sketches. Through renders and mock-ups, problems with the concepts were discovered which were not noticed in sketches.

3.2.4 Evaluating the concepts

Focus groups

Initially, a pilot focus group was held with two participants to test the clarity and appropriateness of the questions and the set-up. After this, three more focus groups were held to discuss the design, functionality and interaction of the four concepts. Additionally, materials for the insides of the boxes were tested with the participants. The goal of the focus groups was to find out whether the design languages of the concepts were interpreted as intended, what parts of the designs that worked or not, and what could be developed further. The functionality, aesthetics and interaction of the concepts were discussed openly based on three prepared discussion questions. They were openly discussed so as to spur new ideas and to make everyone comfortable to freely express thoughts and opinions. The evaluation of the design language was done through a semantic differential scale, Al-Hindawe (1996). Since this is a tool to evaluate what feelings a product evokes, it was considered useful to finding out whether the emotions experienced by the participants corresponded with the emotions the design was intended to elicit. The adjectives in the semantic differential scale were selected based on the word clouds.

One focus group was held with two Berge employees at Berge and the two other ones with students at Chalmers University of Technology. In total, eight people participated in the focus groups. The participants were gender balanced and aged approximately between 25 and 35.

The mock-ups, the sketches and the renders were used in the focus groups to get input and feedback about the concepts. The sketches, renders and inspiration boards of each concept were printed and stapled together as pamphlets. In these pamphlets, the participants could also find a summarising description of how each concept worked. Brief, oral presentations were held about each concept and the participants got to browse the pamphlets as well as look at and touch the mock-ups to get a complete picture of the design of the concepts.

The next part of the focus groups included an evaluation of potential interiors for the boxes where six materials were tested. The materials used were a dark grey fine sand paper, a blue plastic with optic texture, transparent bubble wrap, light brown cardboard, aluminium foil and a light yellow foam rubber with a hole pattern. First, the participants were presented with six boxes, each with the insides coated with one of the six materials. Here, they were only allowed to look at the materials while answering questions about how they thought they would experience the materials and what they would be willing to transport inside which box, given the examples camera, fancy clothing and tool. Next, the participants were instructed to do the same procedure again, this time allowed to touch the materials. Different properties were by the participants connected to different materials and personal preferences emerged about which material was favoured for transporting what products.

The outcomes of the focus groups were criteria for the properties of the interior materials as well as insights about advantages and disadvantages of the concepts and design criteria for these.

Showroom
A showroom was designed to gather quantitative data regarding the four concepts. After the focus group at Berge, the material (mock-ups, pamphlets et cetera) for the focus group were left at Berge together with question forms containing the same questions that were discussed orally during the focus group. The intention was to have a showroom where other employees at Berge could come whenever it suited them to look at the concepts and answer the same questions discussed in the focus group, but in text. Sine not everyone had the time or possibility to participate in a focus group, the showroom was a way to receive additional input on the concepts from the Berge employees and to get a larger basis for further concept development. This led to input from five more people, who participated in the showroom.

Ergonomics test
After completing all focus groups, an ergonomics test was added to the methodology agenda due to concerns being raised about physical strain aspects. The test was intended to investigate stress caused by loading and unloading the robot, and to further facilitate design choices involving functional and proportional criteria. Two regular sized moving boxes was used as mediating objects, corresponding to various alternative heights depending on how the boxes where arranged. They also enabled testing of opening directions, space margins and reach capacities for the different versions of box constructions. Apart from cardboard boxes, two objects with different weights, approximately 1 kg and 8 kg respectively, where used as representatives of parcels. The objects where first lifted in an ergonomic positive way, followed by less considerate lifts. The test led to comprehension of measurements and proportions of the robot, and preferences regarding beneficial compartment openings.

3.3 Final design
Phase three consisted of designing the final proposal of a modular autonomous delivery droid. The final design was mainly based on the feedback from the focus groups, resulting in a reinvented concept with functions and design language favoured by participants. These features were further researched to see what was possible to achieve and implement in HUGO C. Based on findings from the two previous phases, the form and expression of HUGO C were thoroughly designed to comply with established criteria. Concerns rose about how HUGO C would communicate with users and pedestrians and were also dealt with in the final design. To explore different renderings and expressions, sketching and 3D modelling tools were used.

The modularity was defined by the criteria that HUGO should be able to carry a maximum number of at least four items. The approach taken to determining the functionality of the modular cargo space was to continuously iterate solution ideas and consulting a mechanical engineer. Hand drawings and mediating objects were used to communicate and test out ideas. The design of details, such as lights and eyes, were approached through exploratory sketching, bearing in mind that were to conform with the shape of HUGO C's body and platform. Additionally, materials were selected for the final design based on their properties in outdoor environments, manufacturing and colourability.

4. Establishing prerequisites

In this chapter, the results of the user involvement in phase one as well as the service journeys and the list of criteria are presented. The outcome of the user involvement is divided into insights regarding collaborative consumption experiences, robot experiences and PrEmo evaluation.

4.1 Collaborative consumption experiences

The questionnaire provided quantitative data about experiences of collaborative consumption services, as well as attitudes towards autonomous robots, while the interviews resulted in qualitative data regarding the same topics. Amongst the questionnaire respondents, more than 90 percent had one or multiple experiences with collaborative services. 60 percent said that they use collaborative services on a regular basis, see figure 4.1. As regards to the nature of the overall experience, almost all, over 95 percent, was assessed positive, see figure 4.2. As for the interviewees, all had experience of home deliveries and online second hand shopping, although no one had experience with renting used goods online.
When reflecting upon what collaborative services the questionnaire respondents have used, the most frequent ones were Blocket (90,7%), Tradera (58,1%) buy and sell groups and pages on social media (44,2%) and giveaway groups and pages on social media (39,5%). Smaller ventures got few or no votes.

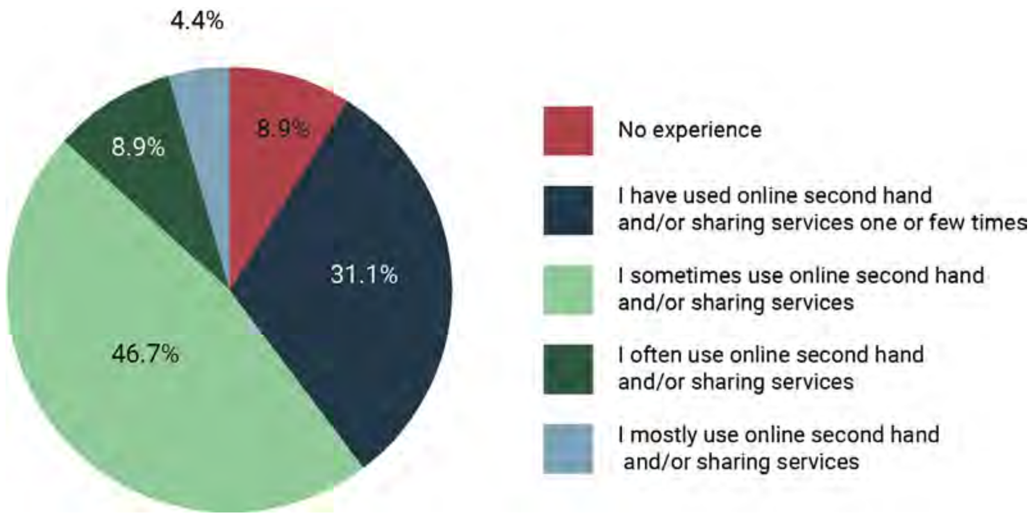


Figure 4.1: Diagram of questionnaire respondents' experience of collaborative services.

Concerning what motives there are for entering into collaborative activities, the most reasons where monetary (86%). The respondents were also driven by environmental motives (60,5%), whereas easiness, good conscience or unique offering were less common reasons, see figure 4.3. During the interviews, the following reasons for buying used products online were mentioned: cheaper price, possibility to find unique products or certain kinds or brands of products, and will to engage in more environmentally friendly consumption.

Although, when portraying positive features of the services tried, some where not fully aligned with these motives. For example, many respondents mentioned the simplicity and convenience in collaborative services to be of great importance, input conforming to

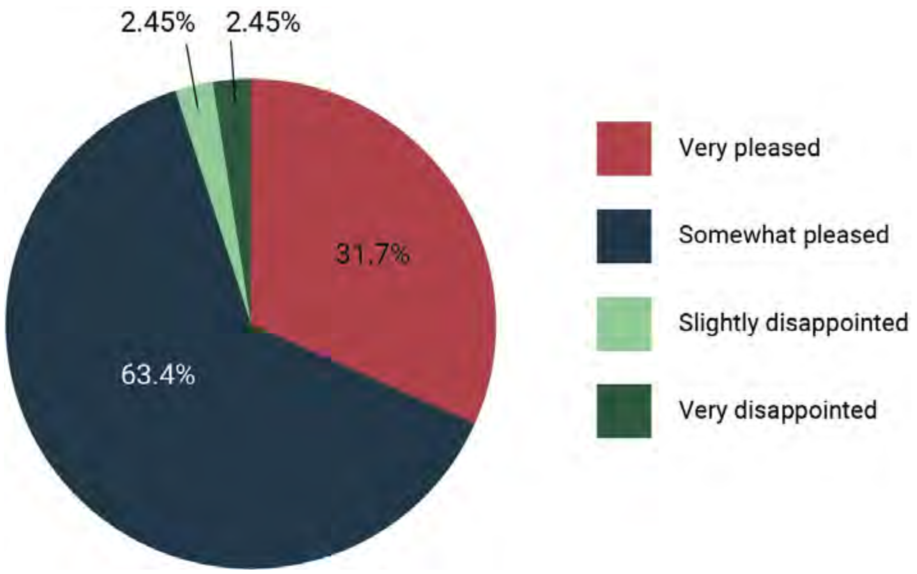


Figure 4.2: Diagram of questionnaire respondents' type of experience of collaborative services.

Böckmann (2013)'s findings emphasising the very same. The availability and affordance of quality items was also considered unique selling points, unlike the motive percentage indicates. Cheap pricing was mentioned many times, as was environmental friendliness in consensus with the two major motives. The speed of collaborative transfers was also referred to as a positive aspect, as well as the rating functions of most services. This rhymes with the value creating factors of collaborative services found in the literature study.

The benefits deviating the most from respondents' motives had to do with the social dimensions of collaborative communities. Whereas some respondents enjoyed the contact with other people, others addressed the perceived distance and little amount of interaction to be great bonuses when entering collaborative services.

On the other end, respondents where also familiar with poor traits. The most frequently reported one concerned the uncertainties of a collaborative marketplace. Respondents emphasised lack of control over the process of accessing something. Many described an uncertainty regarding the condition and consistency with pictures and text, and payment methods where addressed somewhat shady and risky. Below are two quotes from the questionnaire exemplifying negative emotions connected to buying from or selling to strangers. Moreover, images where called blurry and hard to discern. The fear of ”nut jobs” was mentioned as a major downside, especially on occasions including a live handover. In accordance with Somers et al. (2018), the interviewees' addressed the importance of trust. Had they no way of knowing that the service was reliable, they were not willing to use it. Regarding home deliveries, all interviewees thought that current time slots for delivery were too long and happened at an inconvenient time of day (usually at office hours). When not receiving home delivery, most commonly, the interviewees mentioned that they go to pick up points (which are usually kiosks or grocery stores) to collect their parcel.

"*People need to come to your house to pick things up and as a female living alone it does not always feel safe to invite strangers over.*" - Questionnaire respondent

"*People are people, not business. They can be slow and when it comes to meeting people I more and more realise how disrespectful a lot of people are towards other people's time.*" - Questionnaire respondent

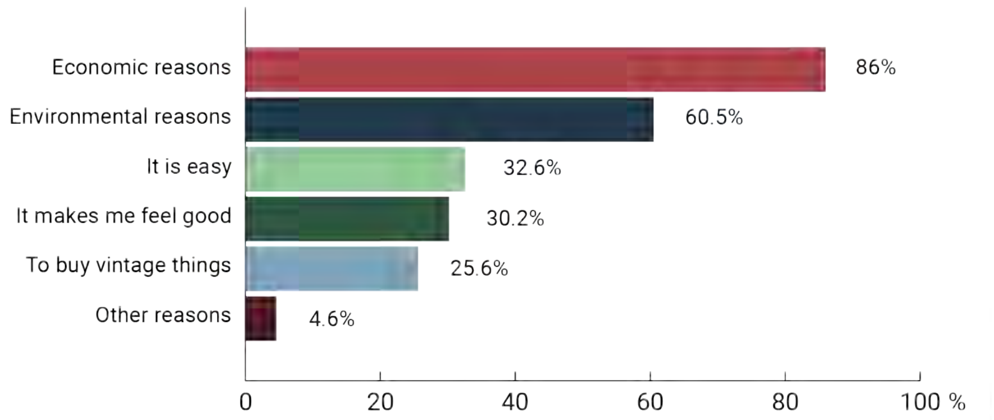


Figure 4.3: Reasons for using collaborative services according to the questionnaire respondents. Multiple options were possible.

Important factors when selecting home delivery were according to the interviewees: intact product, correct product, price, fast delivery, and environmentally friendly delivery. However, lower environmental impact was seen as a plus and not a crucial reason for using a delivery robot for most of the interviewees. When the questionnaire respondents where asked to rank six factors of delivery, depending on what they found most important, the collected result shows that an intact product is the most important factor, followed by delivery on time, environmentally friendly ways of delivery, possibility to affect time of delivery, fast delivery and lastly personal interaction ranked as the least important factor.

4.2 Robot experiences

Having seen images of a range of autonomous and/or mobile robots, the respondents' initial thoughts where spread across a wide spectre. Overall, the comments where either very positive and hopeful, or rather sceptical. Covering the aesthetic language of robots on the images, opinions also varied. Many respondents used the adjectives cute and cool to describe the robots' appearances. However, others called the robots cold and closed off, not communicating their purposes but instead having hidden agendas.

As illustrated in figure 4.4, more than half of the respondents (59,1 %) have encountered and interacted with some sort of autonomous and/or mobile robot. Out of these people, more than 86 percent consider the overall experience pleasant, see figure 4.5.

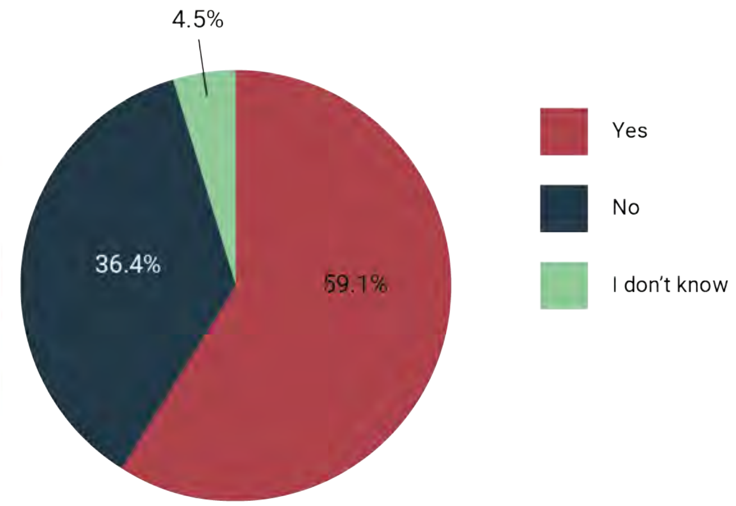


Figure 4.4: Diagram of questionnaire respondents' experience of autonomous and/or mobile robots.

Describing good aspects of autonomous and/or mobile robots, their ability to relieve humans from heavy or boring duties in an effective manner was frequently mentioned. Their promising future was also brought up, as was their silent nature and somewhat good company. Opposite, the respondents mentioned non intuitive interfaces and bad responsive patterns to be the biggest downsides with robots like the imaged ones. Also, not having room for any customisation or flexibility in use was considered a negative aspect.

None of the interviewees had any prior experience with delivery robots, although the majority were generally positive towards the service that delivery robots can provide. Since the interviewees found it easier to express themselves about the delivery service in general than about robot interaction, the interviews mostly resulted in wishes and requirements regarding the delivery service. Despite this, a number of attitudes towards the aesthetics of delivery robots emerged. Generally, there was some scepticism towards delivery robots operating in the middle of the city, but people also saw benefits as well as other areas of use.

All of the interviewees expressed a wish for the delivery service to be intuitive, safe, and flexible in terms of possibility to affect delivery time and place, see quotes below. It was emphasised that the service of the delivery robot should be faster than existing delivery solutions and that the time slots for home delivery should be significantly smaller. Also, that the cost of using the service should be less than or equal to current solutions.

"*That [the robot] just appears and that it is very fast*" - Woman, 23

"*That I don't need to care about [the robot], it should do the job without me worrying about it*" - Man, 61

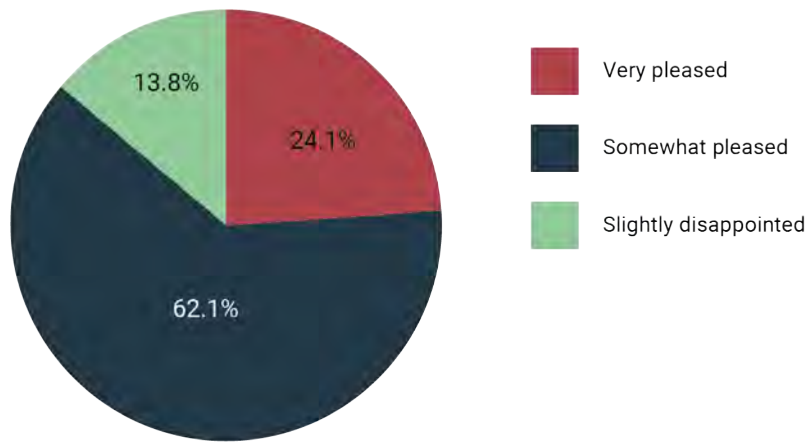


Figure 4.5: Diagram of questionnaire respondents' type of experience of autonomous and/or mobile robots.

The majority of the interviewees were positive to with a delivery robot being able to avoid standing in line to collect parcels at pick up points. Further, many stated that picking up parcels at pick up points made them feel like a burden to the personnel at these places. Some interviewees also mentioned that they were concerned about taking up time from shopping customers when collecting parcels at pick up points. Overall, interviewees found it positive to altogether avoid needing to put time and energy into collecting parcels.

Regarding robot interaction, determinant factors for using a delivery robot according to the interviews was that it should be easy, intuitive and simple to interact with. Further, when the interviewees were asked how they would like to interact with an autonomous delivery robot, the majority stated that they did not want to touch the robot's externals since it may be dirty or wet, but rather interact with it via their mobile phone with an app or a text.

Those who were interested in technology were intrigued to try using a delivery robot simply because of the novelty, in fact, most of the interviewees stated that their main reason for trying a delivery robot for the first time is curiosity:

"*I think it would be so fun, especially when they are new, you can look at it coming up the street and leaving your house, and stand in the window and look for it*" - Woman, 23

Safety was naturally an important aspect for the interviewees when asked what would make them choose a delivery droid as shipping option. To increase the trust in the robot, the majority expressed a wish of being able to track the delivery. In addition, many were concerned that the delivery may be matched with the wrong receiver and mentioned that a way to identify oneself before receiving the delivery would increase the feeling of safety.

Another aspect of safety was that the robot can constitute an obstacle for pedestrians on the pavements, especially for blind people, old people, children and people in wheelchairs. Further, people were worried that they will lose control by needing to adapt their path and pace to the robot instead of the other way around when walking on pavements.

Regarding what kind of goods the interviewees would send with a delivery robot, most were willing to send most kinds of products, with the exception of irreplaceable things with emotional value. When asked about what would make them trust a deliver robot they mentioned real time tracking, notifications and a good track record as crucial, which can be compared to Somers et al. (2018)'s findings regarding transparency and feedback systems being important for creating trust in a sharing system. One interviewee stated that before she was certain that the robot was trustworthy in terms of delivering intact products, she would only send goods with low value.

4.3 PrEmo evaluation

The visual evaluation of existing delivery robots according to PrEmo is illustrated in figure 4.6 below. As seen in the figure, the following robots were evaluated: JD.com, Starship, Dispatch Carry, Kiwibot, Marble, Robby 2 and Scout.

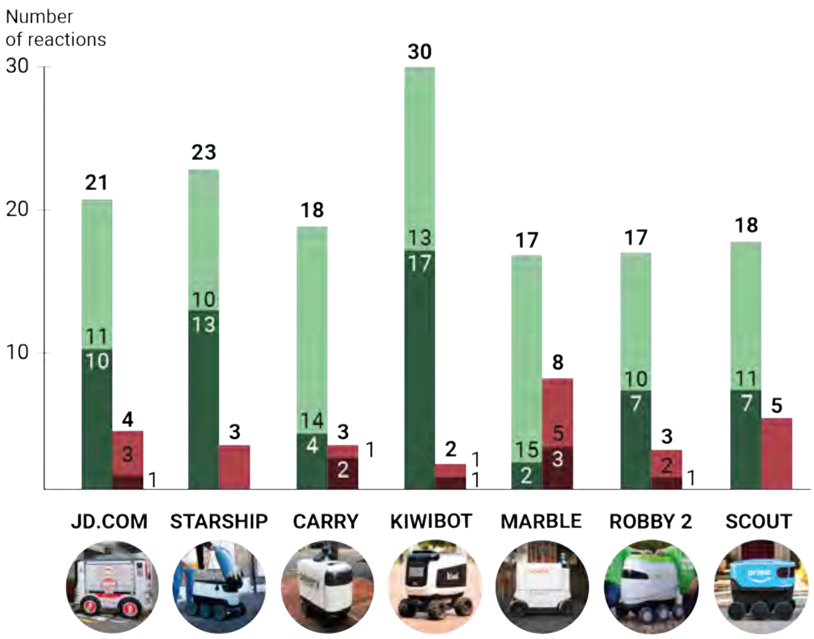


Figure 4.6: Summary of the PrEmo evaluation. Green coloured reactions represent positive reactions, whereas red coloured reactions represent negative reactions. Light coloured reactions where mild to moderate, whilst dark reactions where strong.

In total, the JD robot received eleven weak positive reactions, ten strong positive reactions, three weak negative reactions and one strong negative reaction. Positive thoughts that the interviewees mentioned about this robot were: kind of funny, safe, content and robust. Some also stated that the design of this robot made its purpose obvious. Negative aspects included: clumsy, big, and unaesthetic.

The Starship robot got ten weak and 13 strong positive reactions, as well as three weak negative reactions. In total it got 13 weak and 13 strong reactions. It was described in positive words by the interviewees as cute, nice, serious, steady, flexible, fun, reliable, it blends in,"I feel intrigued", and "looked like I imagined". The negative remarks it got were: unsafe, easy to steal, non-intuitive, too modern, looks easy to hack.

Dispatch Carry got a majority of weak emotional responses out of which 15 were positive and one negative. Out of the strong reactions it received, four were positive and two negative. The interviewees used the following words when describing their positive emotions towards Dispatch Carry: looks OK, looks high-tech, "I like that it is black and white". Aspects that elicited negative emotions included: sceptical towards the safety of it, looks less functional, unstable, neutral, indifferent, feels like someone is watching from the window on the front.

The Kiwi robot evoked the most emotions: 13 weak positive ones, one weak negative, one strong negative and 17 strong positive ones. The following positive words were used to describe Kiwi: cute, cute name, cute eyes, "I like the black and white", makes me happy, goal-oriented, good at getting around, stable, kind, "I like that it has a face", terrain driving, curious, energising. Kiwi's small size was mentioned as both positive and negative. Further, the following negative aspects were mentioned: indifferent, sceptical towards the safety of it.

Marble got 20 weak emotional reactions, 15 positive and five negative. Also, it received in total five strong responses, three negative and two positive. The negative emotions that Marble evoked were described by the interviewees as: boring, clumsy, less functional and less effective, looks like it cleans the streets, looks like a school project, weird, not pretty, ugly, angular, impersonal. The positive emotions it evoked were described as: "I like the edges", does not look so complicated, "I like that I can see what it does", "I would order food with this", clear purpose. One person stated: "It looks like a food robot, which is good, if delivering food is what it does."

The Robby 2 robot evoked 17 positive emotions, ten weak and seven strong, and three negative emotions, two weak and one strong. It was described positively by interviewees as: it looks OK, environmentally friendly, nice, cute, makes me happy, high visibility, and functional. The negative words used to describe it were: easy to steal, impersonal, clumsy, unsafe, not high-tech, silly, looks sad.

Scout gave rise to 16 weak emotions, eleven positive and five negative. All seven strong emotions it evoked were positive and were described in the following words: looks OK, secure design, interesting, good-looking, professional, the blue colour makes me understand that it is a post vehicle, cool, cute, easy to use, makes me happy. The following negative things was said about Scout: looks like a police, "I do not like Amazon", fulfils its purpose but not more, boring, looks like a garbage bin, I feel watched, not nice, threatening, angular, violent, "I wonder what it is".

Overall, the robots did not receive so many negative emotional reactions on the PrEmo scale, however, Marble and Scout stood out as they got the most negative reactions. Marble also had the most equal ratio of positive to negative emotions. Also the most strong, negative ones. However, people orally expressed the strongest negative emotions for Scout. Marble also received many negative comments, although less strong in com-parison. Kiwi mainly evoked positive emotions, to a big part because of it having eyes and facial expressions.

Generally, the interviewees preferred the robot to have a clear purpose as well as round shapes, since this tended to evoked feelings of safety and friendliness. Further, eyes were well received since they gave the robot a personality and led to the interviewees being more accepting towards it. This can be compared to Duffy (2003), who states that anthropomorphism is important for robots in social contexts. However, it was clear that there needs to be a balance between cuteness and perceived safety, since the robots which were cute appeared less safe to the interviewees. Other outcomes of the PrEmo evaluation was that proportional robots were viewed as better looking, steadier and more reliable. Further, a narrow, horizontal window on the front covering the technology (cameras, sensors etc.) gave associations to being watched which elicited feelings of uncertainty.

4.4 The HUGO C service

The service around HUGO C is not a focus point in this work but is left for further development in the future. Therefore, the design of the service has only been investigated superficially to show that there is a context for HUGO C. That is, the service is not fully developed, and below are loose suggestions of how it can work. Payment is not treated.
The user experience exploration pack resulted in two different potential service chains for how HUGO C can work. One where HUGO C travels from point A to point B with a product and one where HUGO C travels between the same points but can drop off the product at a storage to make room for another product to be delivered in between. The second alternative requires that a person unloads and reloads HUGO C at the storage, and that each product is packaged and marked. It is difficult to know how effective the different options are without knowing the demand for using HUGO C. But since option one requires less logistics, premises, packaging and fewer employees and because HUGO C should be a quick service, alternative one, without intermediary, was suitable and therefore chosen. This alternative does not pose additional requirements on the design of the boxes.

When looking into how Blocket, Tradera and Hygglo work, it was clear that HUGO C can be included in these chains without much adaptation of neither the services themselves nor HUGO C. The user journeys with and without HUGO C for the respective websites are illustrated in the figures below (figure 4.7, 4.8, 4.9, 4.10, 4.11 and 4.12).

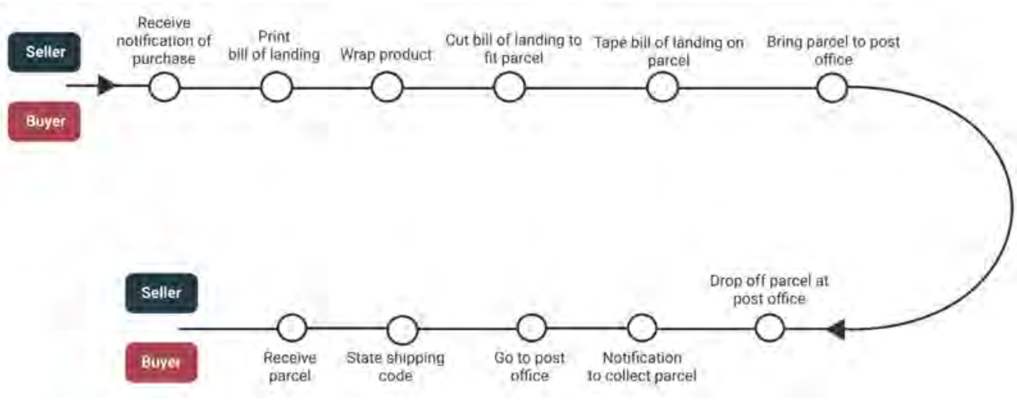


Figure 4.7: User journey for Tradera without HUGO C.

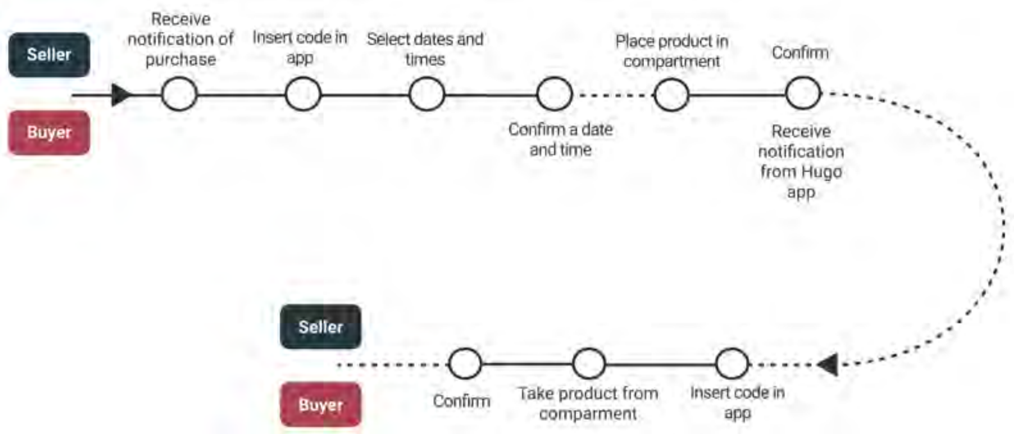


Figure 4.8: User journey for Tradera with HUGO C. The dashed lines represent HUGO C moving.

For Tradera, the seller starts by creating the ad where (s)he ticks off on a list which delivery methods that (s)he wants to offer the buyer, in figure 4.7 (s)he uses the default option Schenker. Next, the ad is reviewed and published. When the buyer then purchases the product, the seller is notified that it is time to mail the product (unless the agreed delivery option is pick up in place). To do this (s)he needs to print a bill of landing, wrap the product and mail the product. With HUGO C, the seller selects HUGO C as a possible means of delivery upon creating the ad, and then orders delivery via the HUGO C app or website when it is time to mail the product. Tradera sends an e-mail to the seller when the product has been sold, originally this e-mail contains contact information to mail the product to the buyer. With HUGO C, this e-mail instead contains a HUGO C code that the sender inserts in the HUGO C app or website. The code makes sure that HUGO C finds the address of the buyer and connects the buyer to the right product. In this way the integrity of the buyer and the seller remains. After the seller has inserted the code in the app, (s)he selects a number of dates and time intervals during which (s)he can mail the product. This information is sent to the buyer who gets to choose a suitable date and time among those that the seller has selected or decline the suggested dates and times. Subsequently, the seller is notified that the buyer has selected a day and time and that HUGO C will arrive that chosen day and time for the seller to mail the product.

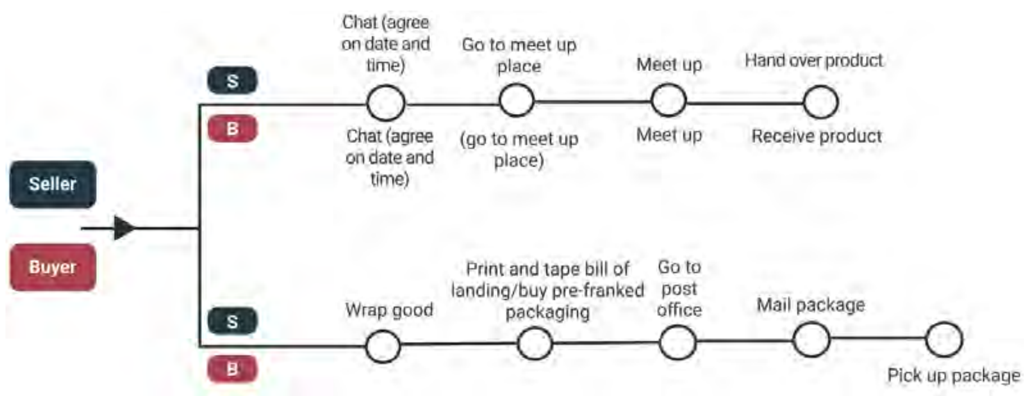


Figure 4.9: User journey for Blocket without HUGO C. The upper journey shows the sequence of steps when seller and buyer meet up, whereas the lower one illustrates the process of shipping an item.

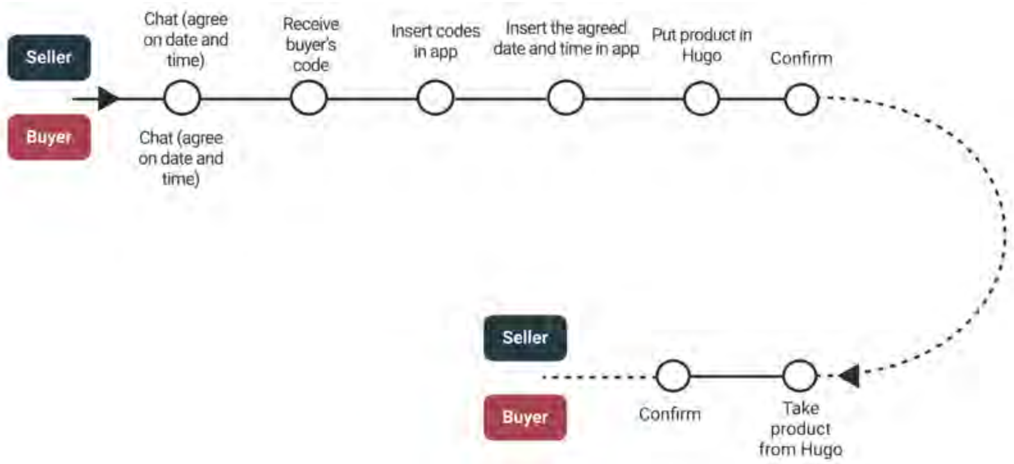


Figure 4.10: User journey for Blocket with HUGO C. The dashed lines represent HUGO C moving.

The sequence of events for shopping on Blocket starts with the seller creating an ad, which is reviewed and then published. Before there is a deal between the seller and the buyer, the seller and the buyer chat to agree on the purchase and potential shipping method. If they decide to meet up in person to carry out the purchase, they need to agree on a day and time. If they do not meet up, the seller mails the product to the buyer, for example as in figure 4.9. With HUGO C, the seller and the buyer agree via chat when (day and time) to use HUGO C, and the delivery is created via personal codes on the HUGO C app or website without revealing addresses.

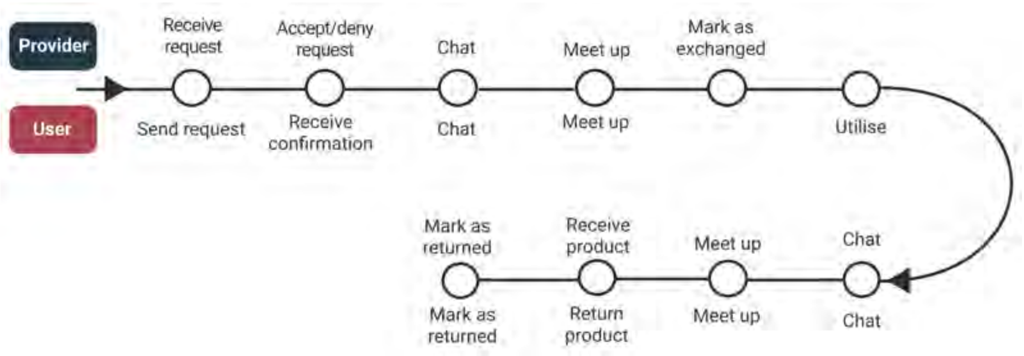


Figure 4.11: User journey for Hygglo without HUGO C.

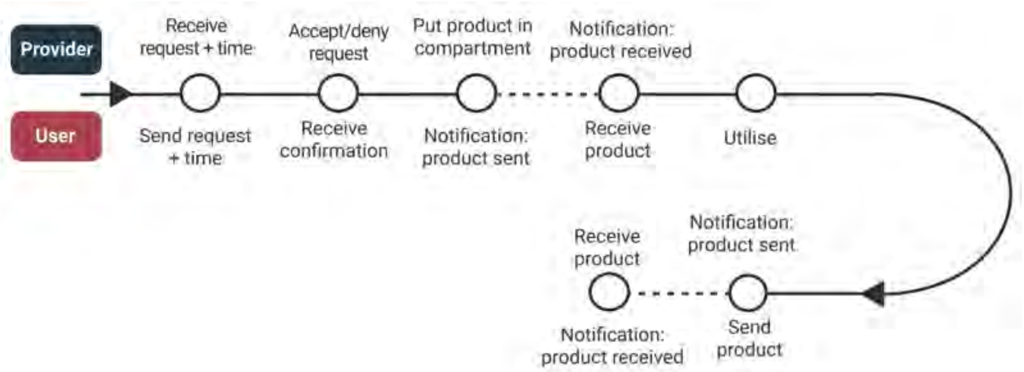


Figure 4.12: User journey for Hygglo with HUGO C. Dashed lines represent HUGO C driving.

With Hygglo, the provider creates an ad, publishes it and then receives a request from the user wanting to rent the product in the ad. This request contains one or more dates during which the user asks to rent the product. If the provider and the user agree on the date, there is deal and subsequently, they chat to agree on a time and place to meet and exchange the product. After the lease is over, the provider and user chat again to decide on a time and place to meet up to return the product. Finally, when the product is returned, the provider and user leave remarks on each other on Hygglo.

With HUGO C, the request that the user sends now includes a desired time to receive and return the product, respectively. Upon receiving the request, the provider either approves it or declines it. If approved, the HUGO C app lets the sender choose a time from a time interval when the robot will be at the sender's home. The times that the provider can choose from are based on the requested time of the user. The provider can then select any time within the interval when HUGO C is going to arrive at the provider's home to be loaded with the product for rent.

When it is time for the user to return the product, HUGO C will arrive at the user's home at the time of the end of the requested lease period. The user then puts the product in HUGO C and the robot transports it back to the provider. The provider will be informed when approving the request that the product will be sent back with HUGO C at the very end of the lease period, and that this means that the robot will arrive back at the provider's home approximately x minutes after it has left the user, depending on how far apart from each other they live.

4.5 List of criteria

The list of criteria is a collective representation of requirements and needs expressed by involved users and findings from the literature review as well as input from Berge. The list was continuously iterated and updated throughout the extent of the project, and acted as a basis during creative sessions and concept development. The list is divided into three groups of criteria; aesthetic product criteria, functional product criteria and service criteria. While the service criteria is important to keep in mind when formulating the service design connected to HUGO C, it is not further treated since the service is not a focal point of this project.

AESTHETIC PRODUCT CRITERIA

- Appear safe
- Have a product personality
- Look friendly
- Express its purpose
- Have its own product language
- Consist of clean and harmonious design and form
- Encourage collaborative activities
- Be visible behind objects
- Minimise dirtiness
- Be designed for light as well as dark conditions
- not cause feelings of uneasiness or fear
- protect personal privacy

Figure 4.13: Aesthetic product criteria

FUNCTIONAL PRODUCT CRITERIA

- Consist of interior keeping goods still, protecting them against vibrations and shakes
- Contain at least four boxes
- Be modular
- Include display for communication with users and passersby
- Have front and rear lights
- Have lights on the bottom to facilitate for cameras and sensors in darkness
- Have camera, sensors etc. on the upper part of the front
- Have sensors on the lower part of the front
- Be weather resistant
- Have few critical points in terms of tear
- Be easy to clean, both interior and exterior
- Prevent theft
- Maximise cargo space inside in relation to exterior shape
- Be lockable
- Consider ergonomic aspects
- Offer intuitive (un)loading of goods
- Have an Intuitive interface
- Consist of few interactive control elements
- Minimise environmental impact

Figure 4.14: Functional product criteria.

SERVICE CRITERIA

- Offer narrow time slots for delivery
- Enable possibility to affect delivery time
- Allow change of location for delivery pick up
- Enable delivery rejection
- Offer competitive pricing
- Notify user of estimated time of arrival
- Enable easy and fast account creation
- Allow GPS tracking of deliveries
- Include insurance/warranty
- Enable customer rating
- Assure service and company reliance
- Offer safe payments
- Require user identification

Figure 4.15: Service criteria

4.6 Conclusions

Most of the involved users had prior experience with collaborative consumption and the most common reasons for taking part in collaborative consumption were economic, environmental and finding unique products. Blocket and Tradera were the websites which were most commonly used. It was emphasised that collaborative consumption services should be easy to use, fast and convenient. Among the involved users, a general viewpoint was that avoiding social interaction in collaborative exchanges was seen as a plus due to safety and personal concerns as well as minimising invested time.

Further, the delivery service should be fast, cheap and flexible with narrow time slots for delivery. Preferably, the cost of using it should not exceed current delivery costs. For the home delivery to be perceived as safe, people wished for a function to track the delivery in real time, receive real time notifications, and to to have the possibility to identify themselves upon receiving a delivery.

Certain negative experiences prevailed in collaborative consumption, many had to do with it being difficult to know whether a product actually compares to what the seller promises and risky payment methods. It was clear that collaborative experiences are based on trust and it was also stated by some users that had they no way of knowing that the service was reliable, they would hesitate to use it.

Many of the involved users had prior experience with autonomous and/or mobile robots and were overall pleased with the services. Intuitive interfaces and ability to relieve humans from tedious tasks were reported as positive features of these robots. In general, the involved users welcomed the service that an autonomous delivery robot can provide. They tended to be happy about being able to avoid picking up parcels, and intrigued by a robot delivery service. However, it was clear that many are worried how an autonomous delivery robot will affect pedestrian accessibility and control.

The interaction with the delivery robot should be easy and no physical contact was preferred. There were naturally subjective opinions regarding the robot's design, but the large majority of the interviewees preferred round shapes as well as eye symbols, giving the robot a personality. Despite the positive reactions to the cute robots, too much cuteness tended to decrease the perception of safety. On the other hand, robots with a clear purpose increased the perceived safety.

5. Concept development

The concept development proceeded from key value expressions found in previous phases, and was supported by inspirational boards. Above all, four especially prominent adjectives where distinguished from previous phases, being: cute, reliable, modern and harmonious. Below, one concept per key value is presented together with a summary of the key values' major tendencies.

Common to all concepts is that the user interacts with them using an app, as this was one of the preferred interaction methods according to the interviewees. This allows for minimal amount of physical contact between users and the concepts, a request spoken during interviews. App specific design and functionality is left for future development.

5.1 Concept 1

Concept 1 emanated from the key value word cute. When exploring the word cute in the design context, an innocence and harmlessness was interpreted in many objects, often portrayed through light pastels or tints of white. Chubby looking objects also conformed well to the cute expression, and references were made to babies that are less defined in their appearance. Another finding was also the association with kind animals. Even just a subtle resemblance softened the expression and led to a friendlier demeanour.

Concept 1 (see figures 5.1(a) and 5.1(b)) was designed with a rounded, inclining body shape, which is slightly convex on the front and back. Together with the big screen on the front, this was thought to give it a clear direction forward, which was also proved to be the case according to the focus groups. This concept has four horizontal compartments and four doors that open out to the sides. Inside, the compartments are divided by one solid wall in the middle, parallel to the front, and two movable walls (one on each side of the middle wall) which can change the size of the compartments by moving back and forth perpendicular to the middle wall. The compartment size changes automatically depending on the size the user's product. The minimum number of packages that concept 1 can fit is two (when the movable walls go all the way the side of the robot) and the maximum number is four.

(a) Perspective view of concept 1. **(b)** Side view of concept 1.

Figure 5.1: Concept 1.

One of concept 1's strengths turned out to be its friendly expression, especially due to the eyes. During the focus groups, having a message on the screen as means for communicating with users instead of eyes was also discussed and perceived as friendly. It was perceived as smaller and cuter than the other concepts due to its roundness and chubbiness, features contributing to the friendly expression as well. The focus groups also indicated that concept 1 could be perceived more like a pet than a delivery robot. This made it the one concept participants preferred to encounter. The fact that the technology was hidden behind the screen also got positive responses.

It was clear that concept 1 has a purpose, although less clear that this purpose was to deliver goods. Participants were positive to the clear direction of this concept (due to the screen on the front and the inclining body). This aspect was considered important in order to increase pedestrians' feeling of safety when sharing a pavement with a delivery droid. However, the fact that the shape of the body expresses direction happens at the expense of cargo space since the rounded corners and declining profile makes the cargo space smaller.

Another strength of this concept proved to be the modularity of the compartments. The participants expressed that it felt good that their compartment size could be matched to the size of their product, both since a tighter compartment was considered more protective but also because it made them feel good towards other users by not taking up unnecessary space. The moving inner walls received positive response as a means for creating modularity, however, it would be preferable if all of the inner walls could be movable so as to make concept 1 even more adaptable.

Concept 1's greatest weakness turned out to be the doors. Since the hinges on the doors are exposed to a lot of wear, their durability would need to be verified. Also, the doors sticking out to the side when open makes them vulnerable to hits and the fact that they take up more space on the pavement caused worries regarding personal injury. Further, it turned out that the ergonomics of loading and unloading sideways needed to be tested since the concept forces the user to bend down low and perform a more complicated lifting movement as the parcel needs to be pulled out horizontally first and then lifted upwards. This can exclude certain users who have difficulties bending down and lifting. However, a benefit of having side compartments is that it protects the package and the compartment itself from precipitation.

Below is a summary of the semantic differential scale for concept 1. Concept 1 was supposed to express "modern, kind, helpful, safe and communicative." As can be seen in the figure, concept 1 was perceived as slightly professional and slightly reliable, very happy and very friendly, slightly more flexible than clumsy and quite harmonious. Further, it was perceived as curious, innovative, safe, quite cute, and more durable than fragile. The fact that it was perceived as happy and friendly along with the positive response towards the eyes can be seen as a sign that it was expressed as both communicative and kind. The fact that it was perceived as innovative indicates modern attributes. People were overall positive and willing to use this concept.

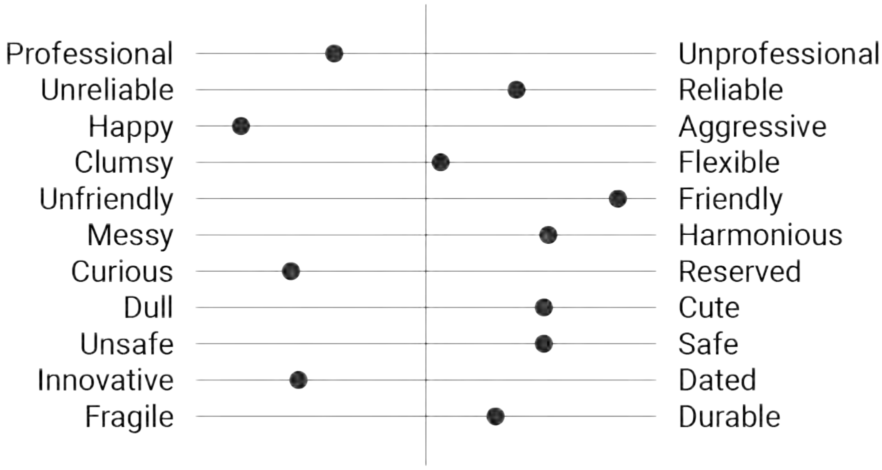


Figure 5.2: Semantic differential scale displaying average semantic scores for concept 1. The vertical line represents the centre value.

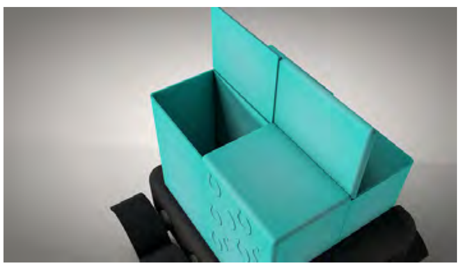
In conclusion, concept 1's strengths are friendliness, modularity, and visible direction, whereas its weaknesses include the doors, ergonomics and difficulty understanding what it delivers.

5.2 Concept 2

Concept 2 derived from the key value reliable. It was found that robustness was strongly connected to the expression, mainly in the form of shapes appearing heavy and solid, or being built by strong materials like wood and metal. Also, it appeared that honest and straight forward forms with little details but only basic geometric shapes feel reliable.

Concept 2, illustrated in figure 5.3(a) and 5.3(b), consists of a generous platform enclosed by walls on each side and a screen on the front to provide direction. Lowered onto the platform are four rectangular boxes with lids on top of each. The boxes all have a set size but are replaceable and come in different set sizes, so that there can be between one and four boxes carrying different sized cargo. The screen on the front has eye symbols and the wheels are sticking out from the side, but are positioned under mudguards.

(a) Perspective view of concept 2 including its front screen.



(b) Concept 2 compartments and how they open.

Figure 5.3: Concept 2.

Participants were positive to self-explanatory technology in public spaces and concept 2 proved beneficial for having a clear purpose and an understandable mission. The screen on the front was perceived as showing direction. It was obvious that it is a robot meant to carry goods because of the resemblance to a lorry, although, this resemblance created associations to industry. This caused some to associate concept 2 not with home deliveries, but rather with something operating in certain environments, such as in a factory. However, people mentioned that they felt comfortable understanding the robot's purpose upon seeing it.

The eyes symbols on concept 2 were of great significance for the impression it had on the participants. Because of its industrial appearance, it was evident that it needed some kind of feature to give it a personality and thereby make it look less hard and industrial. Its appearance was too square for some, even though the rounded edges somewhat softened the impression.

Regarding the boxes, the compartments and potential cargo felt exposed due to the boxes being visible, which created a fear that it may induce people to steal. The fact that they can be removed also contributed to the unsafe feeling, although removable boxes was also seen as a plus in that they can be carried into the home and loaded there.

Another weakness with concept 2 was potential ergonomic difficulties producing cargo from the boxes due to their depth and narrow, rectangular shape. As a solution, it was suggested to have a mechanism facilitating the lift.

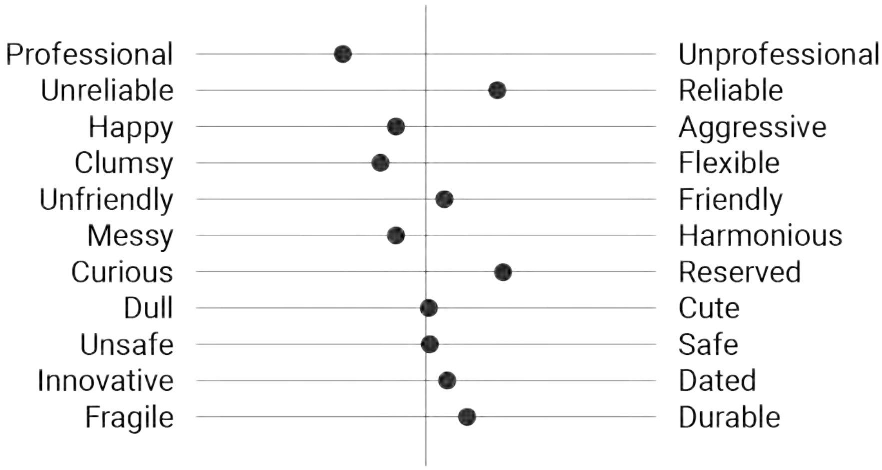


Figure 5.4: Semantic differential scale displaying average semantic scores for concept 2. The vertical line represents the centre value.

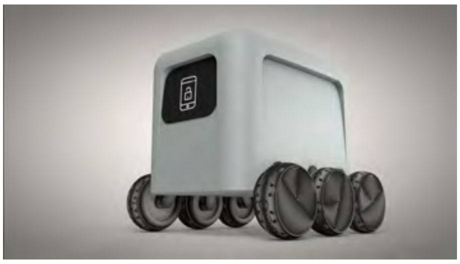
Figure 5.4 above depicts the semantic differential scale for concept 2. Concept 2 was thought to express "communicative, modular, alert, curious, and safe." Since during the focus groups, people responded positively to the eyes, this can be interpreted as a communicative property. Also, many of the first statements participants made regarding concept 2 concerned the modularity of the boxes, which proves that it expressed modularity. However, it was not perceived as curious, which probably depended on the industrial appearance and associations to factory environments. It was perceived as somewhat professional and reliable whereas the other values were more or less in the middle of the adjective pairs. The reason that it was not perceived as safe as intended was the fact that the boxes were exposed.

Overall, the main strengths of concept 2 proved to be its robustness, modularity and its obvious purpose. The main weaknesses on the other hand include the feeling that the boxes are exposed, the wheels outside the body and reaching down in the boxes.

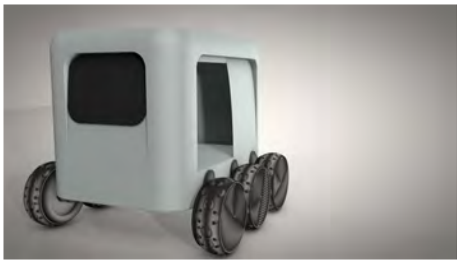
5.3 Concept 3

Concept 3 proceeded from the key value modern. When searching for common traits making up for a modern expression, straight forward forms with few yet unique details making up for a clear point of view where descried. Overall, objects connected to the expression where often rather sharp and well defined, and reinventive in some way. Also, technical properties where allowed to speak and where often focal points in modern designs.

Concept 3 has a screen on the front which shows instructive symbols, such as telling the user to unlock the robot with a mobile phone (figure 5.5(a)). It has four compartments on the sides and two jalousie doors on each side (figure 5.5(b)). It has the same size changing compartments as concept one. Concept 3 does not have mudguards on the wheels, and direction is only indicated by the screen on the front, which proved to be enough as long as the screen is visible. That is, from most angles but not straight from the side.



(a) Perspective view of concept 3 showing a symbol on the screen.



(b) Concept 3 with one door open, illustrating how the jalousie doors work.

Figure 5.5: Concept 3

Concept 3 was perceived as steady and robust due to its square shape. It was simple and intuitive in that it gave associations to a box, which proved to be positive since it made people understand what it should be used for. In addition, it reminded some participants of a lorry, especially because of the jalousie, which also contributed to their understanding of its function. Some, however, expressed that they did not associate concept 3 with anything in particular.

The opening of this concept, the jalousies, were considered smart since they disappear into the body without taking up space outside of the body. However, the jalousies were simultaneously regarded as one of the biggest weaknesses. They were considered fragile and the participants were concerned about the quality of them in terms of wear and risk of jamming. The ergonomic aspect of loading from the side was again brought up. It was suggested that the design of concept 3 could be altered in some way to make it possible to choose whether to (un)load from the side or the top. Further, discussions arose regarding the placement of the screen relative to its purpose. Placed on the front, it mainly communicates with passersby, while it should be placed at a different position if its purpose is to communicate with users collecting their product from a compartment. Having a screen with instructive symbols was considered as having some benefits over a screen with an instructive message since symbols can be more easily interpreted by people speaking different languages. However, when the robot drives, eyes were preferred rather than symbols or a screen showing nothing, for the sake of passersby.

Other strengths with concept 3 included the adjustable compartment sizes. The modular walls were favoured over boxes (like in concept two) since they adjusts themselves without human aiding.

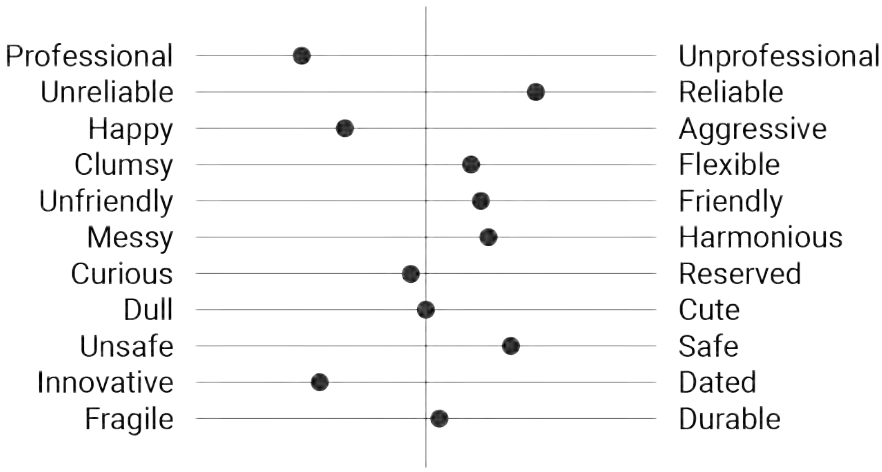


Figure 5.6: Semantic differential scale displaying average semantic scores for concept 3. The vertical line represents the centre value.

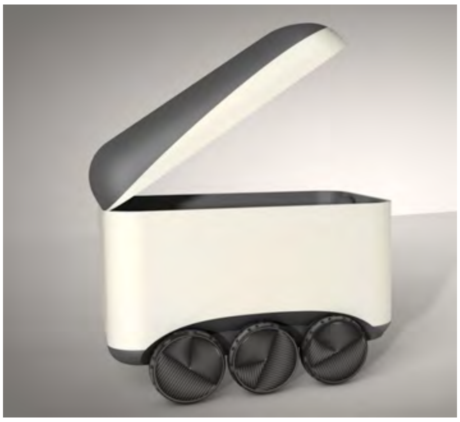
Figure 5.6 above shows the semantic differential scale for concept 3. Concept 3 was supposed to express ”sculptural, reliable, safe, steady, and smooth.” It was according to the scale considered safe, reliable, and professional. Some expressed that it was interesting with the angled sides, front, and back, although they did not directly express that it felt sculptural. Moreover, it was considered more happy than aggressive, somewhat flexible, friendly and harmonious and a little curious. It was considered neither cute nor dull. Lastly, it was perceived as slightly more durable than fragile; the boxy body was perceived as durable while the jalousies were seen as fragile decreasing the overall impression of durability.

In summary, the jalousie doors were well received, however they did not appear completely secure or hardy. Further, the concept appeared robust, stable and modern, however, the display’s position may be reconsidered.

5.4 Concept 4

Concept 4 was developed on the basis of the harmonious expression. Above all, solid and collected simple bodies where found to exude harmony, as well as objects with little internal tension and dynamic marks. For this expression especially, the colouration had big impact, and a natural palette with beige and warm greys was found to embody the feeling of harmony and comfort.

Concept 4 has a lid on top (figure 5.7(a)) and four boxes inside. The wheels are covered by the body as a mudguard to prevent dirt from staining the body. The black line on the lid indicates both direction forward and the direction in which the door will open. Concept 4 lacks a screen in order to test what effect this had on the robot's impression (figure 5.7(b)).



(a) Side view of concept 4 illustrating the top lid when partly opened.

(b) Front view of concept 4.

Figure 5.7: Concept 4

In concept 4, the goods felt well protected and hard to steal, which was considered both positive and negative. Too safe an impression had the opposite effect as it was questionable why that level of safety is needed. Another negative aspect was the difficulty of understanding its purpose, partly due to the absence of a screen and partly due to the associations it created. It was generally not associated with a vehicle but rather food and appliances. Not having a screen also made usage more difficult to understand.
It was clear that it is beneficial to highlight where the doors will open on the robot. Also, considering the opening of the robot, having a lid that opens upwards causes a large windbreak.

Having the technology visible instead of hidden behind a screen was clearly negative since this increased the feeling of being watched which was considered uncomfortable.

The positive aspects of concept 4 include easier loading since done from above, and the robust appearance. The darker markings on the lower regions also got positive remarks, since they would conceal dirt, as did the black area on top communicating direction.

The last strength mentioned was the wheels positioned under the body. The inset wheels were tied to a decreased the risk of tripping on the wheels or having garments, such as wide trousers, get stuck. Also, inset wheels were considered less vulnerable to shocks and hits from outside.

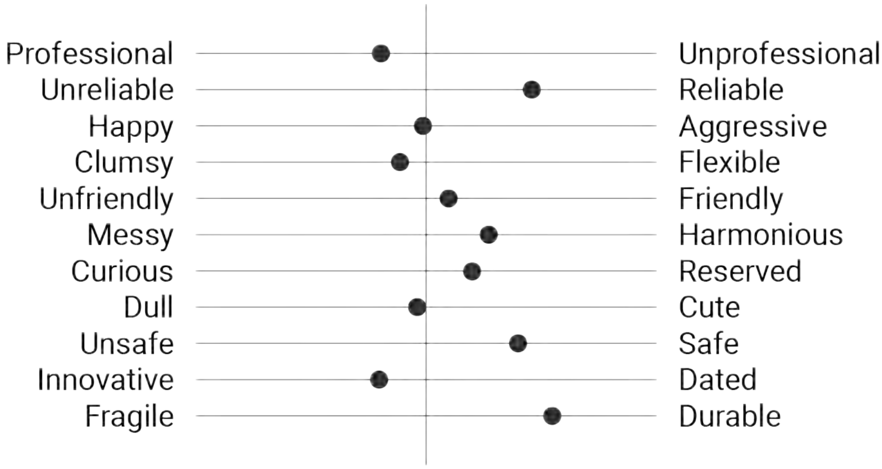


Figure 5.8: Semantic differential scale displaying average semantic scores for concept 4. The vertical line represents the centre value.

Above is the semantic differential scale of concept 4, figure 5.8. Concept 4 was supposed to express ”minimalism, clean, safe, symmetry, and harmony.” During the focus groups, it was stated that many considered minimalism an interesting approach that could be incorporated and developed in future concepts. As can be seen in the figure, concept 4 was considered reliable and safe, somewhat professional, and neither happy nor aggressive. Further, it was considered a little clumsy, a little friendly, slightly harmonious and quite reserved. It was a bit more dull than cute, somewhat innovative and durable.

5.5 Haptic assessment

The boxes in the haptic assessment can be seen in figure 5.9 below.

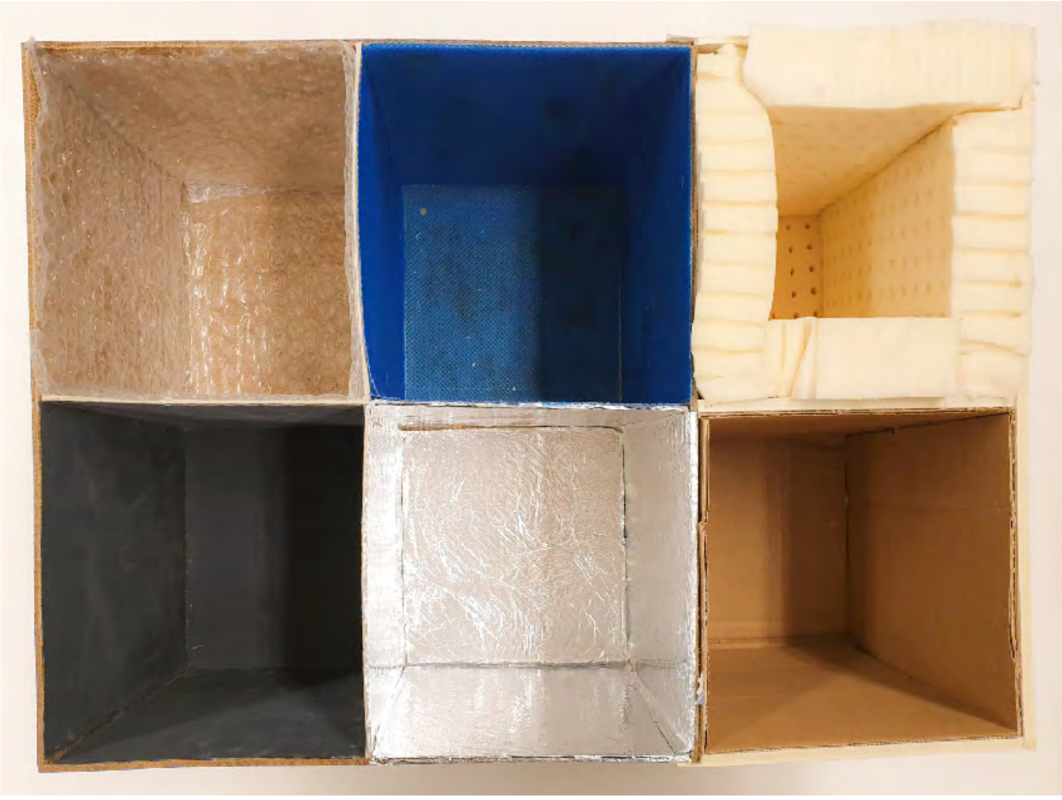


Figure 5.9: Haptic box. Upper row from left to right: bubble, blue, soft. Lower row from left to right: black, silver, cardboard.

The soft material got the overall highest number of votes, however, there were different opinions about it. The soft material was favoured for its soft, cushioning properties, although it was considered unhygienic as it was perceived as damp and dirty. There were few extreme opinions about the blue material, and people were willing to send tools and clothing in it. Due to the colour and the surface it both looked clean and felt easy to clean, although the texture made it look like it had more friction and grip than it actually had. The black box received positive feedback for its matte surface, but its texture was tied to a risk of scratching the product and a dark colour was experienced as unpleasant to put goods in. Clothing was preferred to be transported in the black box over tools and a camera, however, a few were willing to put the latter items in the black box. Most of the participants were willing to send goods in the bubble wrap box although they felt bad about it being made of plastic, especially since it was experienced as single use plastic. Further, it was perceived as fragile. Despite this, tools were the most popular product to send in the bubble wrap box followed by camera and only one person would send clothing in this box. There were mixed feelings about the cardboard box, partly it was perceived as boring and indifferent and not conforming with the rest of the robot, and partly it was considered clean since cardboard is easy to replace. The cardboard was also perceived as a deliberate choice of sustainable material. Clothing and tools were favoured to be transported in the cardboard box. The silver box was mostly immediately associated to food and therefore few people wanted to transport products in it. Dirt and stains are visible on this material, so it is possible to see whether it is clean, but despite this it was perceived as dirty due to the food reference. A few were willing to send clothing in the sliver box, but none wanted to send a camera or a tool in this box.

When debating the interior materials of the boxes, it was obvious that these must be easy to clean because they will likely be stained at some point, also dust and dirt will enter from the outside. Additionally, the participants favoured a soft and cushioning material which would allow for less or no packaging.

The results of the haptic assessment are summarised below in figure figure 5.10. As can be seen in the figure, for transporting a camera (or something else impact sensitive, like certain kinds of tools), the soft material was favoured. Overall, tools were preferably transported in cardboard or bubble wrap, and fancy clothing in blue, cardboard or black.

	Camera	Fancy clothing	Tool
Black	1	5	2
Blue		5	4
Bubble	3	1	5
Cardboard		5	5
Silver		3	
Soft	9	2	3

Total black	8
Total blue	9
Total bubble	9
Total cardboard	10
Total silver	3
Total soft	14

Figure 5.10: Haptic assessment results. The participants were allowed to place up to one vote per material and object combination. Left: number of people willing to send camera, fancy clothing and tool in each of the respective boxes. Right: total number of votes for each material.

5.6 Ergonomics test

Some observations were made during the ergonomics test. It was overall less heavy to lift from above, however, the difference was not substantial if the product weighted within the limits of what HUGO will manage to carry. It was clear that one wants to be able to see into the boxes and have adequate room to grip the product properly. Lifting from above allowed the user not to bend down as low as when lifting from the side, but on the other hand, there was less space for the legs to support the lift, which was a hindrance when lifting the heavy product with the legs. With smaller boxes, it was considered less pleasant and more tight to reach down into the box from above than to reach into the box from the side.

The placement of the boxes in relation to the ground was also tested, concluding that it was easier to (un)load the robot if the boxes were at least 34 centimetres from the ground.

(a) Lifting a light object from above with the back.

(b) Lifting a heavy object from above with the legs.

Figure 5.11: Difference between lifting a light and a heavy object from above.

5.7 Conclusions

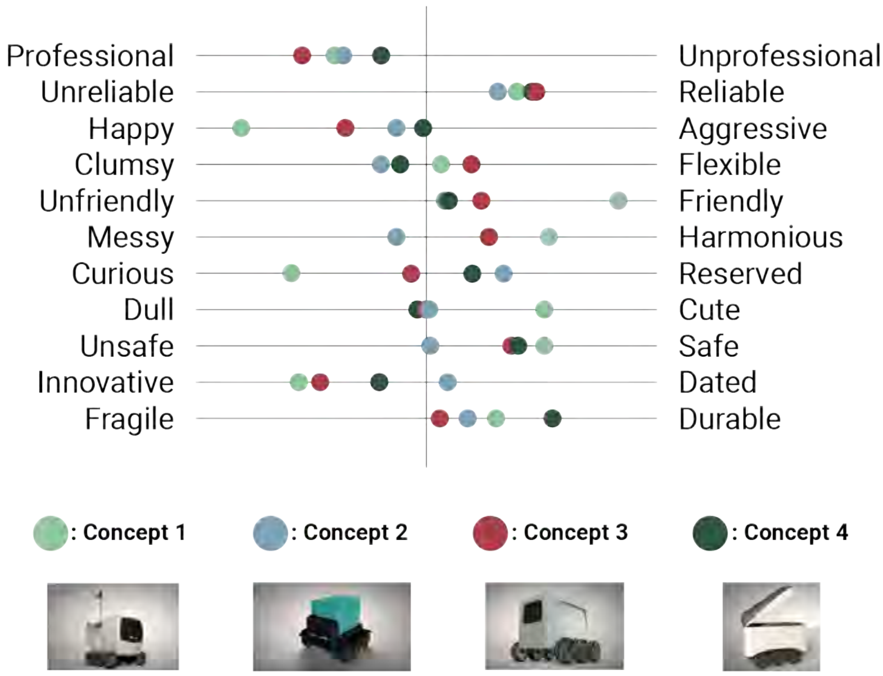


Figure 5.12: Semantic scores for all four concepts.

As can be seen in figure 5.12, concept 3 was perceived as the most professional, reliable and flexible concept. Concept 1 was perceived as happiest, friendliest, cutest, safest, most harmonious, most curious, and most innovative. Concept 4 was perceived as the most durable. Concepts 1 and 3 scored the highest on almost all the scales, therefore the design elements of these two concepts will be brought into the final design.

Regarding the robot's outer shape, soft, rounded corners were preferred in terms of design, since this made for a kinder and less aggressive impression. A clean design was further considered interesting.

When it came to interacting with the robot, automatic opening of the boxes or compartments was well received since this allows for avoiding to touch the robot. Also, automatic opening was considered to lead the user directly to the correct box which facilitates the interaction. Moreover, some users expressed that it made them feel safe in that no one had opened their box before them and touched their package. However, the boxes were considered small in size and participants felt limited in what they could send via the robot, especially since not only a product but also its packaging is space consuming. This indicated the significance of modular boxes.

People wished to clearly see into the compartments since this facilitates gripping a parcel and lets the user be certain that the compartment is clean. To see properly even in darkness, lights may be implemented into the compartments. As for (un)loading the robot, the difference between lifting from the top and from the side was not substantial ergonomically since not too heavy goods are meant to be carried with HUGO.

The screen's placement in relation to its purpose was also discussed. It was debated who it should communicate with (pedestrians and/or primary users), what it should communicate (eyes symbols, other symbols, messages) and when (all the time or only when interacting with primary users). It was concluded that a screen on the front mainly communicates with pedestrians and that it needs to be placed differently to communicate effectively with primary users as well. Further, eyes on the front is primarily an element for communicating with passersby, whereas symbols or a message aimed at the receiver is useless on the front since the primary user interactions with the robot happens from the side. A large screen was associated with a face, which gave a friendly impression. Eyes further tended to create the desired feelings of safety and friendliness as well as give the robot a personality, which many found intriguing.

A clear direction was considered important both from a perceived and an actual safety point of view, since communicating direction allows pedestrians to know in which direction the robot is heading. A number of different design elements, such as lines, angles, radii, and additional details such as a flag or a screen, contributed to conveying direction.

Further, it was evident that people want technology with a clear purpose in public spaces, and that form and functionality should correspond to the purpose, also stated by Bartneck & Forlizzi (2004). This emphasises the importance of a clearly expressed intention through the design of delivery droids.

During the workshops, people tended to comment on other areas of use for the robot, as well as on its size. A small size was considered beneficial since it would let the robot operate more smoothly on pavements. Also, a small size contributed to a feeling of safety since potential accidents would be less severe. Meeting a small robot on a pavement was further considered to create a safer feeling than a bigger one. However, regardless robot size, people were worried that it will constitute an obstacle to people with strollers, wheelchairs or walkers on narrow pavements.

The placement of the wheels under the body was well received, since this was considered beneficial in terms of both safety and design. Regarding doors, it was evident that these should not occupy space outside of the body, since this was considered to be impact sensitive, draw attention and pose a risk of injury.

6. Final design

Figure 6.1: Final project design proposal HUGO C.

HUGO C is a friendly and modular addition to the field of delivery droids. The robot consists of an outer shell, a space adaptive interior, an interactive screen, a base platform, a flag and six motorised wheels built on to the platform. Protecting the inside is four automatic sliding doors, two on each side. The system is supported by an application through which users book HUGO C, identify themselves, and open and close their assigned compartment. HUGO C's components are visualised in figures 6.4 and 6.5, and its external dimensions are displayed in figure 6.2. HUGO C is 67 cm high excluding the flag and 130 cm including it. The droid is 58 cm wide, and 60 cm long. The size in relation to an average size person, amongst other things, is illustrated in figure 6.3.

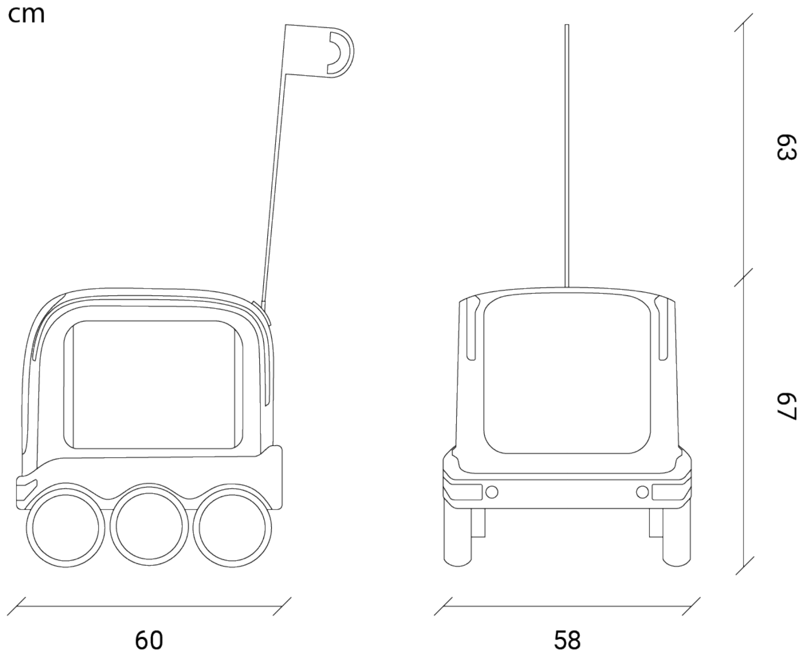


Figure 6.2: Outer dimensions of HUGO C.

Figure 6.3: HUGO C illustrated next to objects more or less frequently using pavements.

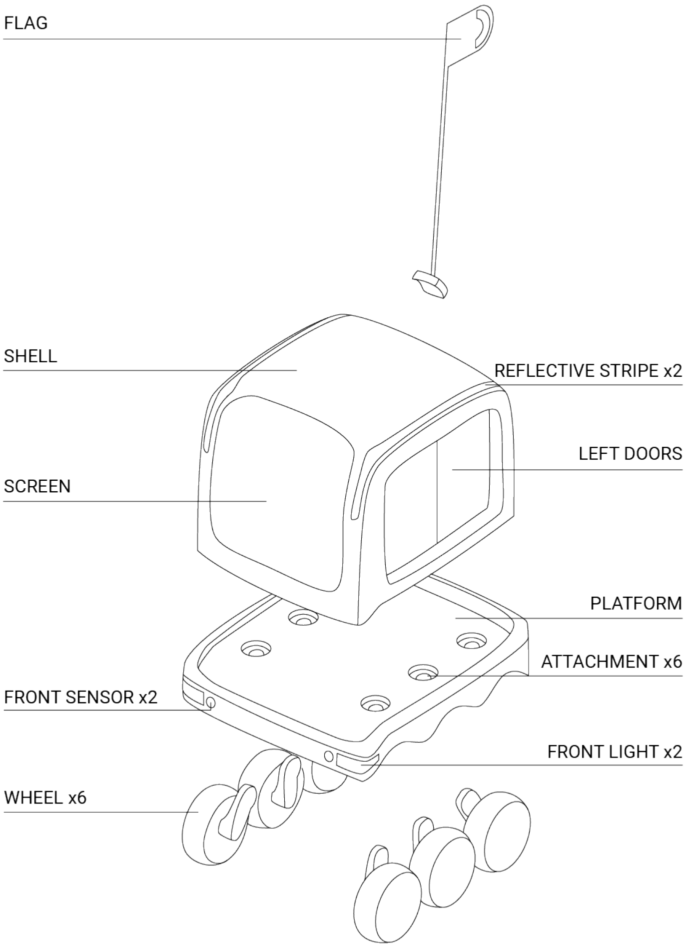


Figure 6.4: Exploded front left view of HUGO C from above.

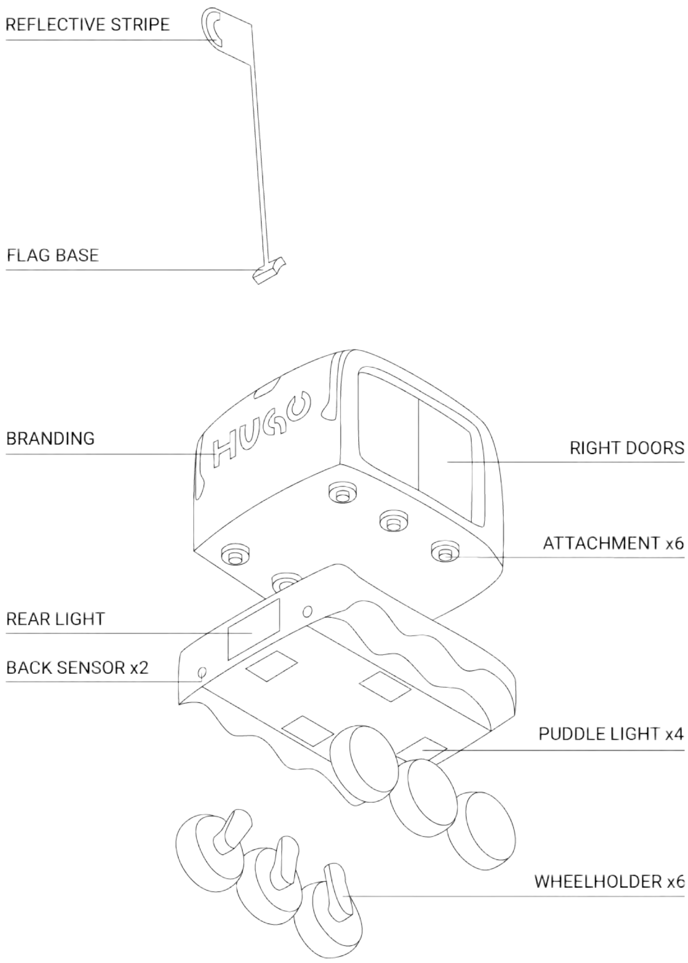


Figure 6.5: Exploded rear right view of HUGO C from below.

6.1 Construction and material

The shell is purposed to protect inner components and cargo and has been dimensioned to withstand external stress. The shell is made of acrylonitrile styrene acrylate, ASA in short, a weather and UV-resistant plastic with good colourability and high impact resistance (Prospector (2019)). It is coloured in a beige colour splattered with a darker tinted warm grey colour. A soft beige colour was chosen with the intention of softening up the overall robot expression and distance it from typical technology colour palettes, often containing colder, less natural nuances implying an artificial product nature. A splattered pattern have been applied on exterior surfaces for camouflaging dirt that HUGO C likely will be subjected to in its outdoor residency. The platform also consists of ASA and has too been tinted with splatter, however with a dark grey base and lighter top nuance. The flag contributes with a pop of colour aiming to alert HUGO C's surroundings of its pavement exploits. To bypass any too intense warning associations, the nuance was lightened up and infused with yellow and magenta tints. Further, this led to a fresh and modern colour, not conforming to visual standards of robots per say, but instead translated as a contemporary and vibrant shade, filled with joy whilst being full of contrast. A colour palette can be seen in figure 6.6.

Interior wise, the insides of the compartments are coated in dark grey rubber with a textured, frictional surface to conceal dirt and secure cargo, see figure 6.6. Since it was proved important in the haptic assessment to have surfaces that appear clean, the interior area is textured in a way making it easy to clean, while not being too frictional for the walls to move along it. Underneath the rubber, there is a thin layer of cushioning foam, suppressing hits on loaded items, since the haptic assessment emphasised that shock absorbing materials were favoured by users.

The front section, holding most measuring instruments, is covered with a substantial screen surface made of Plexiglas, also called PMMA. PMMA is durable, colourable and able to assume double curvature shapes (Nordic Plastics Group, n.d). The plastic is dyed with a two way gradient, going from translucent black on top to almost transparent when crossing the measurement instruments and back to a darker tone on the bottom. For the sake of the cameras' and lidar's ability to assess their surroundings, the plastic needs to be close to transparent in front of them.

Figure 6.6: HUGO C colour palette.

6.2 Form and expression

When designing the final concept, the silhouette and overall shape was major dimensions to investigate. In all user involvement activities, participants have regarded the gestalt in areas of expression and perceived attitude. Therefore, it was of great importance to accomplish a proper form and favourable exterior in order to obtain acceptance amongst users and passersby. Firstly, the look of HUGO C is purposed to be extrovert and curious, seeking contact with its surrounding. Hence, the profile is tilted slightly upwards, creating an alert silhouette with a subtle direction. Secondly, to further soften the expression, and achieve the cute look consistently favoured by most attendees during the focus groups, the front and back as well as the outer lines of the main body have been rounded. Also, the overall expression has been kept subtle not to disturb or affect surrounding people and environments too greatly, conforming with the criteria of not causing any uneasiness. See figures 6.7 and 6.8 for renderings of HUGO C.

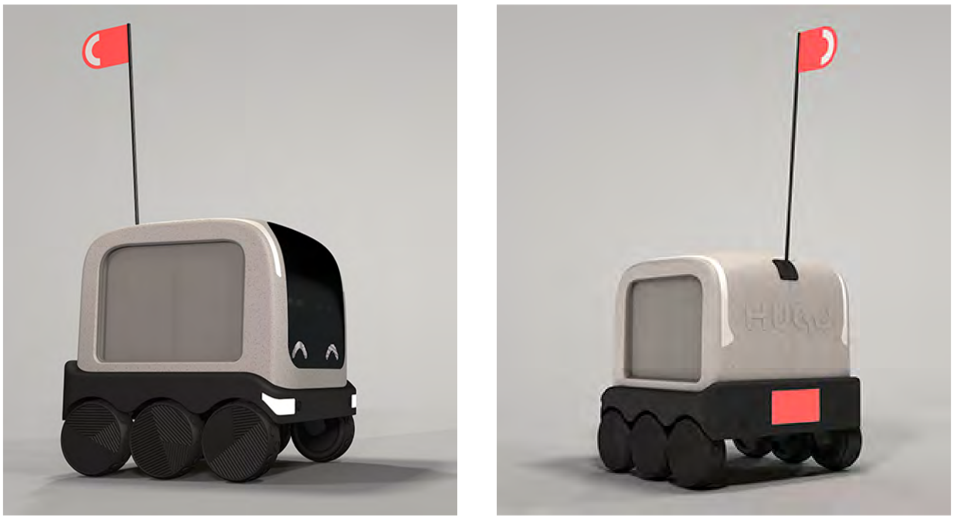
In accordance with Somers et al. (2018) and general durability concerns spoken by interviewees, it was important to obtain trust and ensure security in the product design. The outer shape was therefore kept simple, resembling a solid with few critical construction points. Envisioning cross country vehicles and their enlarged lower framing communicating sturdiness, the bottom platform was added. Apart from aesthetic motives, the platform also constitutes the mudguards, a feature greatly appreciated by consulted test users. Having wheels incorporated in the body is also arguable from a function standpoint, minimising stains and splatter from beneath thus maintaining cleanliness.

A prominent component is the screen covering the majority of the robot's front side and a small section of its top. Due to multiple user inputs referring to the screens of phase two concepts as faces, the screen surface was enlarged and exaggerated to fully meet the association. Considering Duffy (2003), and the significance of anthropomorphism in socially active robots, the face reference and human resemblance will be favourable for HUGO C when encountering and interacting with secondary and primary users. Above all, focus group participants ascribed the face domain and eye symbols human or pet trait definitions, even thought their design has fairly little in common with facial demeanour of people. Apart from the screen, little human imitation has been performed given the risk of entering the uncanny valley and not attaining social acceptance.

Since the screen was perceived as the face of the robot, the remaining front was also influenced by the facial concept. Hence, the placement of sensors, headlights and reflective stripes had to be carefully managed, not to cause disadvantageous allusions. For instance, placing components straight beneath the screen made them look like mouths and led to an exaggerated expression. Moreover, some parts tended to assume the role of eyes, thus requiring thoughtful composition and placement. Therefore, the circular required front sensors had to be hidden, and was preferably positioned onto the dark platform. Initially, the reflective stripes were intended to connect beneath the screen, but where instead cut midway due to the mouth dilemma. The headlights had to be rather square for not appearing as human traits, and where designed in agreement with the platform curvature.

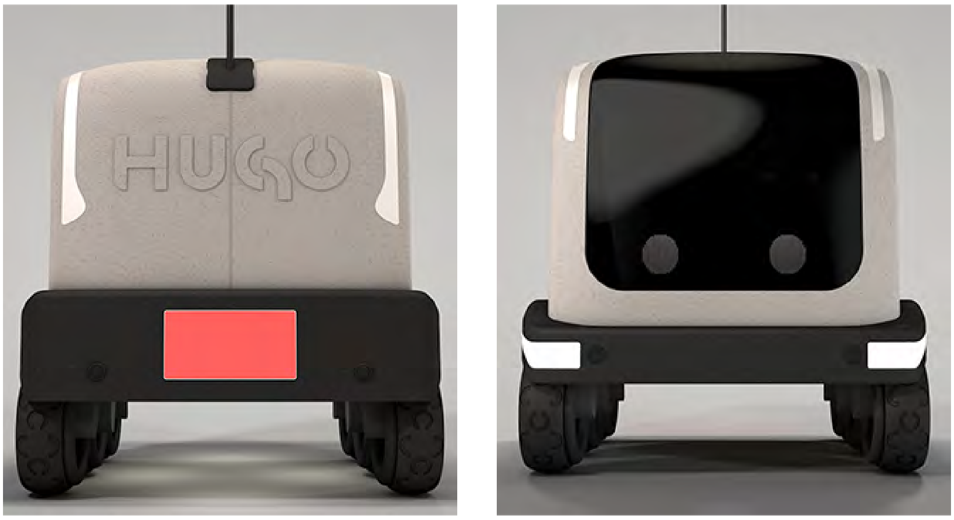
Hiding away most technical components, the screen is intended to serve an important functional purpose precluding feelings of surveillance easily generated by lenses. It also conceals the lower LED bars constituting the eye symbols, and the higher ones used for communicative lighting, whilst protecting all fragile components placed behind it.

A concern spoken by Berge and the HUGO team touched upon vehicle affinity, and the perceived car resemblance in particular. While it was important to project the shipping and delivery purpose of HUGO C onto its gestalt, a car replica was unsolicited. Accordingly, the form was developed in contrary to the standard look of a car, somewhat rendered with tendencies of trucks and busses instead for still conveying the core purpose. The contours, for instance, can be interpreted as bus like. As can the big screen, resembling the front window of long distance busses. Although HUGO C's headlights resemble the ones on a car, their needed light spread was cardinal and prioritised.



(a)Front side view. (b)Back side view.

Figure 6.7: HUGO C, form and appearance.



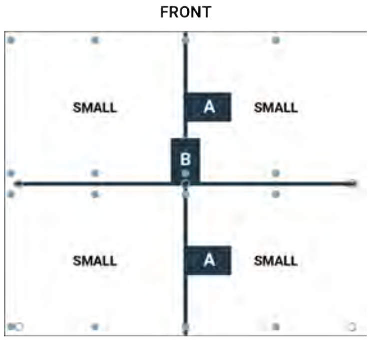
(a) Back view. (b)Front view.

Figure 6.8: HUGO C, form and appearance.

6.3 Modularity

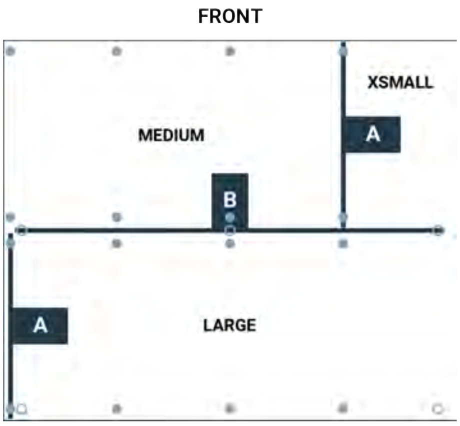
In its unaltered state, HUGO C has four compartments separated by three movable inner walls, two short ones and one long. The two short walls are parallel to the robot's sides whereas the long wall splits the robot's body in parallel with the front and back sides (figure 6.9(a)). The inner walls allow for a total of five different sized compartments (see 6.9(b) and figure 6.10) and nine different compartment compositions, of which four examples can be seen in figure 6.12. HUGO C's internal dimensions and absolute cargo capacity, can be seen in figure 6.11.

(a) Section view and compartment orientation.

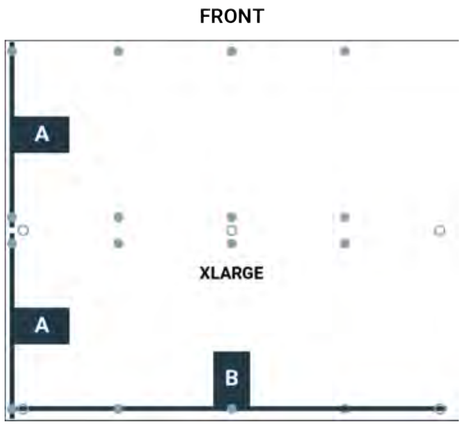


(b) Overview of the standard position with four small compartments.

Figure 6.9: Standard compartment position.



(a) Medium + extra small + large set up.



(b) Extra large set up.

Figure 6.10: Different inner wall set ups.

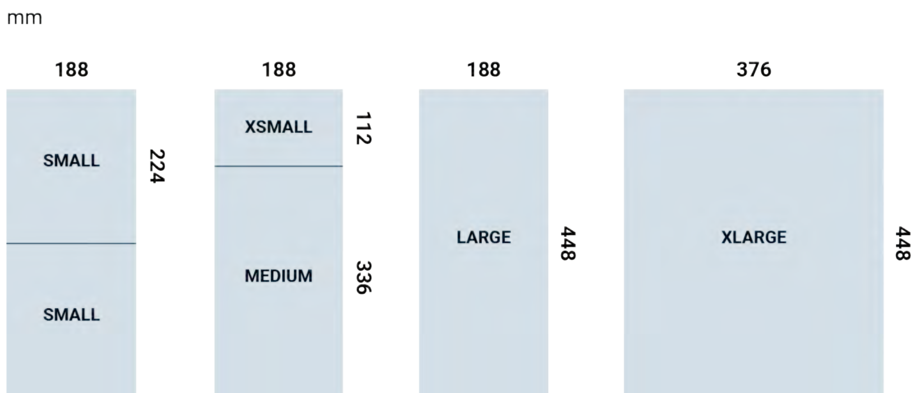


Figure 6.11: Compartment measurements in millimetres, and possible constellations.

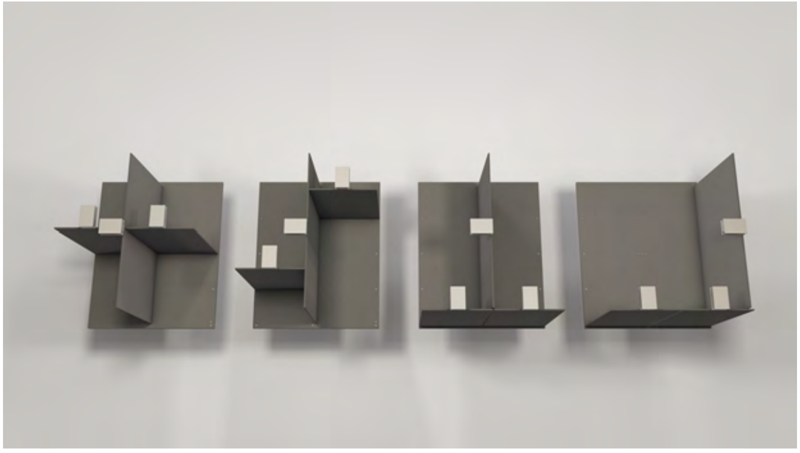
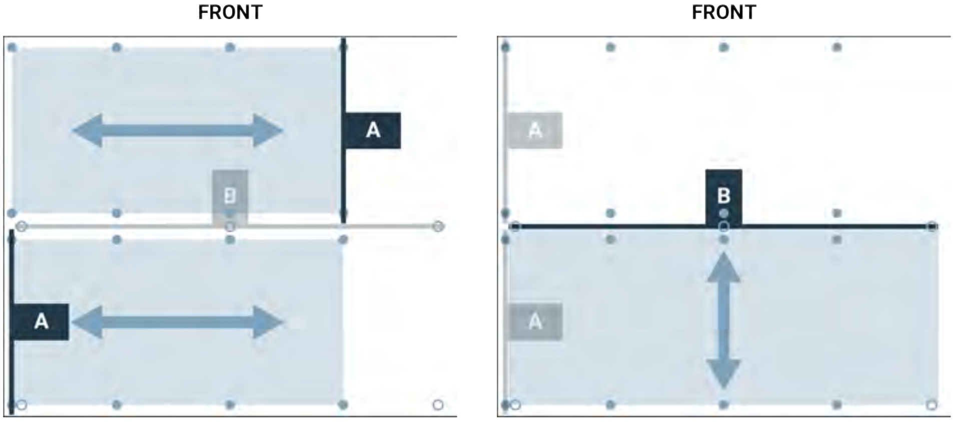


Figure 6.12: HUGO C's modular compartments as created by the movable inner walls. From left to right: Four small compartments, two extra small and medium compartments, two large compartments, and one extra large compartment

The walls move by linear motors attached to the top of the walls. They only move when the sliding doors are closed so that the robot is ready for the user to load upon arriving. The user experience was further considered better when the user does not see or hear the walls moving. Their movements are illustrated in figures 6.13(a) and 6.13(b). The mo-tors allow the short walls to stop at four different positions on each half of the robot's body. When the motors stop, pegs rise from the floor locking the walls into position so as to prevent deformation due to items inside the compartments sliding and pushing on the walls. Figure 6.14 illustrates a pair of pegs in their locked position. The middle wall only moves in one direction, see the rightmost example in figure 6.12. When the cargo space is maximised like this, only the doors on the robot's right open since the short walls block the doors on the left side.

In figure 6.13 the movement ranges of the walls are illustrated, the blue dots in these figures represent the different positions where the walls stop and the pegs lock them. The short walls (A) move all the way to the robot's doors in one direction, since the motors hinder them from moving all the way in the opposite direction, and the long wall (B) moves to the very back of it.

The need for cargo capacity varies, since people send many different sized items. Modularity provides the option to transport several things at the same time, or just one, depending on the user needs. Besides, if one user has a very small item, the cargo space can be adapted to this item without much restriction to what other items can be sent. In figure 6.15, commonly sold and rented items listed in chapter 2.1 have been placed in HUGO C, illustrating the wide range of objects fit for HUGO C deliveries.



(a) Range, A walls. (b) Range, B wall.

Figure 6.13: Movement range of the two small walls (A) and the big wall (B).

Figure 6.14: Section view of a wall, illustrating the pegs in a locked position.

Figure 6.15: Example of items possible to send in HUGO C, from left: Sunglasses, books, headphones, toys, blender, small camera, tablet, electric drill, game console, a pair of shoes and a briefcase.

Overall, modularity was well received in the user involvement and movable inner walls also got positive response as a means of creating modularity. However, modularity happens at the expense of durability since the moving parts are subject to wear. Hence, to optimise the modularity prerequisites, the possible amount of inner walls settings was kept restricted. In this way, fewer lock points could be made stronger and the construction was able to be supported by the fixed mechanical pegs.

6.4 Door design

Considering criteria and insights gained throughout the project, sliding doors where picked as final opening solution. The focus group attendees reviewed them as space efficient, and had few random associations. Apart from user feedback, the modular criteria and resize ability also implied certain opening requirements. Above all, the doors have to enable the modularity behind them and unseal its corresponding compartment, regardless their size.

In regards to the modular compartment setting, the sliding doors where also assessed as the best option. To suit all possible compartment varieties, the robot is equipped with four equally large doors, two on each side, moving sideways. When the total cargo space is divided into two or more compartments, the four doors correspond to separate compartments, see figure 6.16. However, as seen in the same figure, when the cargo space solely consist of the extra large compartment, both right sided doors will be opened for parcel access. Having the most opening actions from the right side is an deliberate decision based upon the right sided traffic, and the increased likelihood of it being the side on which the user approaches from its front door.

Noticing concerns involving endurance, some measures have been taken. To strengthen the construction core, the doors are made of stainless steel. For aesthetic reasons they have been covered with a silicone film, softening the appearance of the robot. Silicone was also added as a seal around the jalousie doors, preventing dirt from accessing the construction. When closed, each door is secured with two stainless steel locks, one at the top and one at the bottom. They are mounted onto the robot's inside, and aim to sustain any physical stress that may strike the two sides.

The doors travel in rails positioned above and beneath them, reaching across the front and the back of the robot's body. In other words, when a compartment is open, its appur-tenant door stalls either in the back or front depending on the position of the compartment positioning. The rails are connected in the back and front, but since no opposite door pair ever will be opened simultaneously, the chance of doors meeting or colliding is absent. The doors' sliding movement is shown in figure 6.17.

In order to minimise effort and physical contact with the robot, the doors where designed to be automatic. Multiple interviewees and focus group participants found touching the robot adverse, and favoured automatic measures. The back end of the doors are endowed with small linear motors pushing and pulling them along the rails. Furthermore, having automatic doors was also a feature allowing the product to indicate what compartment users should attend.

Figure 6.16: The sliding door in the three possible positions as seen by the user.

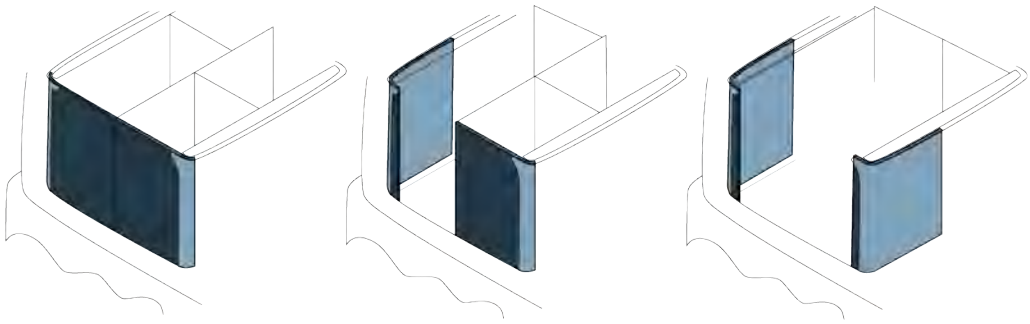


Figure 6.17: Section view of the sliding doors in the three possible positions, from the left: closed, one door open and two doors open. The dark colour illustrates visible parts, whereas the light colour shows what becomes hidden in the interior.

6.5 Technical components

HUGO C is equipped with a number of technical components in order to travel in unfamiliar and changing environments. There are four cameras and one lidar on the main body, all positioned in the front and at an operational height (see figure 6.18). The platform accommodates four sensors, two placed on the front side and two placed on the back (see figure 6.19). Together, these gadgets detect and measure distances to surrounding targets. The number and positioning of measuring instruments included in the final design is based on criteria from Berge.

Beneath the robot's outer shell, all seven linear motors operate. Linear motors are precise and silent in their practise, and are often used for sliding operations (Wikipedia (2019)). Although linear motors can operate on curved paths, the ones designated for this project follow a straight line in one axis. There is one small motor for each sliding door positioned at the top of the doors' rear part. The three inner walls are also equipped with one motor each.

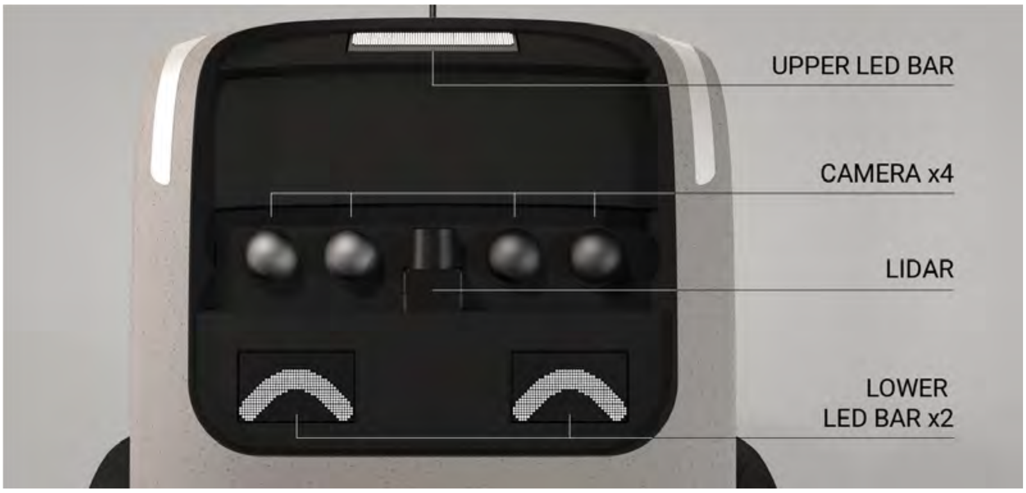


Figure 6.18: Equipment placed behind the screen - measuring instruments and LED bars.

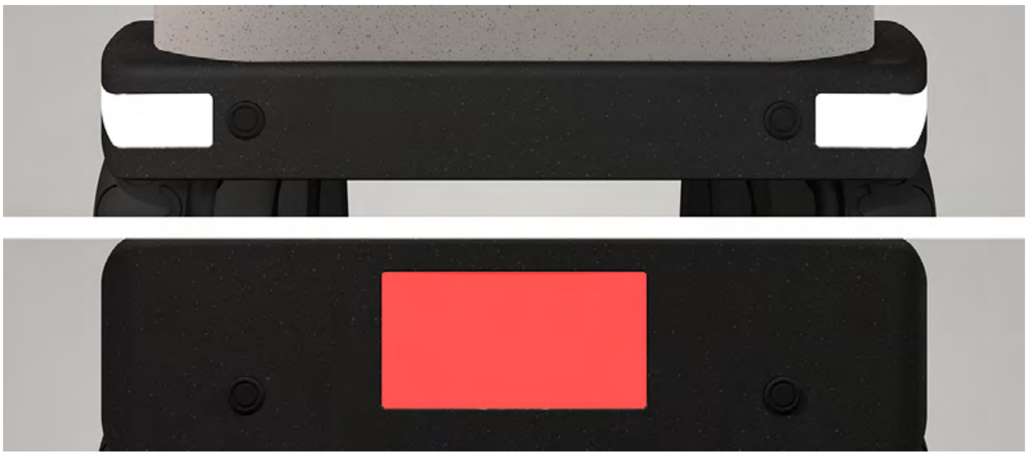


Figure 6.19: At the top: Two front sensors and two head lights. At the bottom: Two back sensors and the rear light.

6.6 Communicative elements

HUGO C communicates movements, actions and presence through illumination, eye symbols and features on its body. Concerning lights, their main function is to transmit movement and ensure awareness of HUGO C in various environments. They also fulfil technical requirements by facilitating proper navigation and advancement in public spaces. The robot has two headlights directing white light forward, and one rear light glowing red to increase the robot's visibility for pedestrians and other road users encountering HUGO C on the street (see figure 6.19). The headlights bend slightly around the front corners of the platform, so as to also cast light towards the sides and increase the robot visibility from all angles. Underneath the platform, the robot has four white puddle lights for night use, one along each side. When driving, the front puddle light is directed forward, lighting up the ground to provide the front sensors on the platform with sufficient lighting, and to further communicate the HUGO C's path. When reversing, the rear puddle light works in the same way for the same purpose. When the robot is standing still, all four puddle lights light up pointing downwards, indicating for road users that the robot is not about to move. For light placement, see figures 6.4 and 6.5.

Apart from exterior lighting, there are four internal light sources intended to assist the primary users in (un)loading the compartments during all hours of the day. Due to deliberate placement (see figure 6.20), these lights will always illuminate all possible compartment variations regardless sizing. These lights were implemented since, during the focus groups, it was clear that people preferred to see clearly into the compartments since this increased the feeling of comfort and perceived safety.

To add yet another communication channel, three sets of LED bars have been placed beneath the screen, illustrated in figure 6.18. The two lower ones are intended for illustrating eye symbols, and the one placed at the top of the screen is meant for feedback. HUGO C has two kinds of eye expressions; a resting one and an alert one illustrated in figures 6.21(a) and 6.21(b). The resting pair of eyes are mainly meant for the primary user, the customer of the delivery service, and are intended to communicate serenity and satisfaction. The alert pair of eyes are instead devoted to secondary users, conveying surrounding awareness. The feedback light, visualised in figures 6.22(a) and 6.22(b), will blink whenever a command is given in the application as an indication of successful contact between the different touch points and a well attuned system.

To further support the visual design impact during darker hours, reflective stripes have been added. The two major ones outline the upper part of the droid and illustrate were it begins and ends. In case the lights are turned off for any reason, the reflective stripes are a necessity for late hour visibility. Beside the big stripes, smaller ones have been added to the flag. With branding in mind, they embody the letter C, as in HUGO C. As regards the flag, its main objective is to alert HUGO C's surrounding of its presence and motions.

Figure 6.20: The four interior light sources, placed at each corner of the compartment space.

(a) Resting eyes.

(b) Open eyes.

Figure 6.21: Eye expressions of HUGO C.

(a) No feedback.

(b) Feedback.

Figure 6.22: Feedback lamp, different settings.

7. Discussion

The focal point of the thesis project was to investigate prerequisites, attitudes and criteria for a delivery droid fit for collaborative consumption. By means of user involvement in several steps and procedures, the process gave rise to substantial findings. Most importantly, the users of collaborative services are mostly positive towards the inclusion of robots in last mile deliveries. Further, what consumption habits and preferences are needful to account for in future designs have been stated. In summary, we have found ways to render the criteria into a complete final design, demonstrating how needs can be translated onto these kinds of robots.

By establishing the current customer attitude and market acceptance, we have proven a place for HUGO C and demonstrated the potential of delivery droids. This is indeed a prospect area within the delivery development field beneficial to investigate further. Moreover, endorsed with the criteria list covering service and product design, we have declared what aspects to be taken into account when designing a delivery droid system in order to make for expedient prerequisites and smooth human machine interactions. By combining insights into a final design, we have exemplified how criteria can be merged into practice, determining in what sections the different criteria were preferably met, and detecting where more work needs to be put in future developments. In all, we have confirmed the potential of delivery droids, and enabled more guided product improvement in future droid projects. Since the product is fairly new and little targeted research about droids exist, the findings presented above are substantial additions to the user centred delivery market progression.

Broadening the perspective, the project's outcome may conduce improvements in the field of last mile delivery. Foremost, it indicates a change in our way of consuming, urges new logistic systems to appear, and old ones to acclimate. Project specifically, HUGO C illustrates a way to remove the main pain point of last mile delivery - the pick up. Compared to the recent last mile addition in Sweden, the pick up points, HUGO C brings value to the process of parcel pick up when offering home delivery with amended parameters. From urban and environmental points of view, HUGO C also demonstrates ways of improvements, in case it is chosen instead of fossil fuelled vehicles. When so, HUGO C may foster a less crowded city centre, while reducing the amount of emissions from motorists. Evaluating HUGO C's market position in relation to the studied robots in chapter 2.3.1, it is somewhat unique. All other robots operate B2C, whereas HUGO C is intended to fill the logistic gap of C2C transfers. Nonetheless, no studied delivery droid has provided loading as flexible as HUGO C's, deriving a unique selling point in its modular offer.

As part of the project aim, the design process has originated from a collaborative concept. In ways, found criteria and the final design proposal is somewhat unique for that particular context. Most especially, the compartment modularity and flexibility in use is strongly connected to the width of items included in collaborative consumption. By enabling a wide range of cargo, HUGO C conforms well to the collaborative market where few resources are excluded. Also, the material selection and colour palette of the compartments' interior has been founded on the fact that worn and untidy objects will enter the cargo space, and probably bedraggle the surfaces. Compared to B2C transactions, where most delivered items are brand new, the collaborative consumption calls for a more hardy composition. Hence, these particular surfaces have been covered in an easily cleaned and camouflaging material. Further, the proposed service structure and product interaction has been kept to a minimum when trying to ensue Böckmann's (2013) advice about convenient and simple collaborative services.

Despite the collaborative viewpoint, some finding correlate to a more general droid design framework regardless field of use. The proportions and product volume for instance, are aligned with a standard pavement and encounters thereon, and can therefor be looked upon as apt guidelines for delivery droids in general. All measures taken to improve product visibility, foremost the illuminating details and the flag, should be given parts in any delivery droid that aims to operate amongst pedestrians and motorists.

Anthropomorphic qualities, favoured by Duffy (2003), are also relevant to consider in all delivery droids for social approval. To better bridge the gap between human and machine, future related developments should benefit from humans' tendencies of rationalising objects and living things through inherited mechanisms. Utilising these propensities will certainly facilitate encounters of, and interplay between, users and all sorts of delivery droids in our physical and social space. Additionally, by imitating features of delivery antecedents thus communicating the task of these droids in accordance with Bartneck and Forlizzi's(2004) claim, the interpretation of the product will be simplified and the decoding aided. Reasonably, achieving an easy and correct translation of a product is needful for all objects residing in human territory, and even more for new product introductions seeking social acceptance.

Although the study treated essential problem spaces and research areas, some limitations can be noted. Foremost, needful user validation and multiple iterations of the presented design has been excluded, and is ultimately essential for concept credibility and further research orientation. Especially for a product generated from emotional feedback and aesthetic expression, extensive verification is required. Considering the system of HUGO C comprising both service and product, the project has focused mostly on physical design. Despite collecting valuable service design criteria, and showcasing a possible service context, little effort has been performed on service design itself. Since the physical product is but a component serving a larger delivery system, it needs to conform to whatever service it partakes in. Above all, touch points and the sequence and occurrence of events may have impact on design features. For example, HUGO C's charging circumstances are yet to be decided, and may lead to new product criteria and and need for redesign. The capacity of the service, and the relation between supply and demand may too affect HUGO C. Perhaps, the droid will need to await bookings and stall in public spaces whereas considerations need to be put on how HUGO C ought to appear in its residency.

Furthermore, criteria covering interfaces, for instance intuitiveness and few digital touch points, had to do with the application design and was not addressed at all. However, since the application will have an important role to play in all HUGO C communication, it should be payed great and meticulous attention in prospective projects. Determining what touch points should be digital verses physical is one major task, and what safety gates to include is another.

Moreover, the limited amounts of users involved is notable and a disfavour for project legitimacy. The majority of user input was similar and proved to not include any extreme user types or opinions. Hence, utmost attitudes did not emerge, but will nonetheless be present in future HUGO C encounters. Tracing these would likely have brought acute criteria, crucial to account for for the certitude of HUGO C in real settings.

As regards limitations and valuable insights from the project, future areas of research may be recommended. The acquiring of a real size prototype is urged for thorough investigation of users' product perception and physical interaction, and for veridical verification. Further, the sequence of loading and unloading should be tested and observed, both in terms of ergonomics and under influence of environmental factors. A careful market analysis investigating local supply and demand is also recommended for optimisation of cargo space and modularity range. For certain, the theoretical need and benefits of modularity have been defined, however the actual requisites for collaborative consumption in Gothenburg might differ from what is proposed. Also, further evaluation of environmental impact is in order to underpin the concept of delivery droids, and their impact on the climate debate. Whereas theory claims delivery droids will decrease environmental impact, this statement needs thorough calculations to demonstrate evidence.

A general recommendation for all future delivery droid development is to approach it in an alert and iterative manner. The collaborative consumption is progressive and its content is likely to evolve, evoking new problems to solve and needs to accommodate. What HUGO C facilitates today may not be what is needed tomorrow. Fact is, delivery droids are a fairly new addition to the last mile development and has not fully found their identity. As more concepts are introduced, the product family will develop and improve, ultimately forming their own product language. When this happens, delivery droids will conform to a common semblance that will aid the design of future concept. Also, as these droids are emerging, so will government laws and regulations. Most certainly, new requirements will occur that are to be accounted for.

8. Conclusion

The project as a whole resulted in a product proposal for a modular delivery droid, called HUGO C, which is suitable for collaborative consumption particularly due to its modularity. The modularity makes HUGO C unique among current delivery robots and allow for transportation of a wide range of goods that circulate on the collaborative market.

There is little research about delivery droids available to the public, but we have contributed to the development of delivery droids in Sweden by determining certain criteria for a robot to be accepted in public space and provide a positive user experience. It was further found that the market may be ready for delivery droids since many are overall positive to the implementation of autonomous delivery droids in Gothenburg, however, there is simultaneously a worry about lost pedestrian accessibility and control. However, because of the lack of research about autonomous delivery droids, this project indicates a need for more research highlighting acceptance and the potential of robots as a delivery method.

Several factors significant for a positive last mile delivery user experience were defined along with collaborative consumption experiences and habits. By offering convenient delivery suited to the users' needs, HUGO C may lower the threshold for users to take part in collaborative consumption while making the collaborative market more available and removing the pain points of picking up parcels. We hope that HUGO C can constitute a sustainable delivery alternative that decreases pressure on last-mile delivery. Concluding, we have added to the development field of delivery droids, but more research is needed.

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