

Interactive Robotic Vacuum Cleaner

Master Project in Industrial Design by Dmitrij Juzovitski

2011



ABSTRACT

This report initially asks the question of why Robotic Vacuum Cleaners are not a regular part of our everyday lives. The concept of a completely automated robotic aid to help us with our chores seems, at glance, an attractive proposition. Interviewing various groups of users suggests that most robotic vacuum cleaners do have some technical problems like limitations in suction power and inability to handle long strands of hair. But, surprisingly, the typical users did not seem to mind, in fact most users were very happy with their robots.

In stark contrast, interviews with people with little or no experience with robotic vacuums reveals a far more sceptical approach. Mainly, this group exposed a trust issue, where a majority feared that the robot would be uncontrollable and would cause problems if and when it went unsupervised.

Therefore the main focus of this design project, amongst others, was to provide a feeling of control to the user. The result allows for a big measure of control over the robotic vacuum cleaner, while still keeping its autonomy. This is achieved with a design concept utilizing a hand recognition system that was inspired by research into our relation and interaction with pets.

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ISRN: LUT-DVIDE/ EX--11/50146-SE

CONTENT

ABSTRACT.....	1
ABBREVIATIONS.....	3
PART 1: FAMILIARIZATION.....	4-17
1. INTRODUCTION.....	4
2. AIM AND METHOD.....	5
3. BACKGROUND.....	7
4. MARKET.....	12
PART 2: RESEARCH.....	18-35
5. INTERVIEWS.....	18
6. FINDINGS.....	20
7. DISCUSSION.....	34
PART 3: EVALUATION.....	36-45
8. FOCUS AREAS.....	36
9. DEMARCATION.....	44
PART 4: IDEATION.....	46-95
10. DESIGN PROCESS.....	46
11. ADDITIONAL RESEARCH.....	56
12. FUNCTION ANALYSIS.....	62
13. DESIGN BRIEF.....	64
14. IDEATION.....	66
PART 5: RESULT.....	96-115
15. ACKNOWLEDGMENTS.....	116
16. REFERENCE.....	117
PART 6: APPENDIX.....	118-140
APPENDIX A.....	119
APPENDIX B.....	120
APPENDIX C.....	121

ABBREVIATIONS

RVC = Robotic vacuum cleaner
TVC = Traditional vacuum cleaner

Group 1 = Robotic vacuum cleaner owners
Group 2 = Traditional vacuum cleaner users
Group 3 = Manufacturers and distributors

All names of interview participants are written in initials for the disclosure of the interviewees.

PART 1: INTRODUCTION AND BACKGROUND

WHAT IS A ROBOTIC VACUUM CLEANER?

1. INTRODUCTION

I went into this project very open-minded, with nothing but a hunch that the field of robotic vacuum cleaners would be interesting to explore from a design perspective. I had no previous experience of RVCs, in fact I had never even seen one before the start of this project, and generally speaking this seemed to be the case with most people I came in contact with. This is part of what initially drew me to this project; the notion that if technology permits it, why is there not a robotic vacuum in every household? The idea of automated cleaning aids is - as I discovered - an old one, and should presumably appeal to almost everybody that do not consider cleaning a fun hobby. By exploring peoples mind-sets to RVCs I wanted to get to the root of what was keeping them from reaching our homes in mass number, to then try to apply a design perspective to what I found.

But the road to the final result was a long one, and at times very diffuse. Ultimately it taught me the value of really listening to peoples various opinions and read between the lines to find answers.

2. AIM AND METHOD

This reports aims to discover what specifically is keeping RVCs from having a stronger presence in people's homes. Secondly, the goal will be to improve upon the RVC and develop a design concept centering on a number of chosen problem areas.

To get a grasp of the basics of the robotic vacuum cleaner as a product, the first step will be to familiarize myself and the reader to areas like history, technology, price and the current market situation. Before establishing a design brief, a thorough investigation into people's mindset toward RVCs is to be explored. This initial research will be aimed at both owners of RVCs, traditional vacuum cleaner users as well as manufacturers and distributors. After pinpointing potential problem areas, an evaluation of the research is to be constructed to help in classifying the importance of the different areas. This will be followed by additional research focused on the chosen problems, if needed. At this stage a design brief will be constructed, entailing specifics on how to improve the RVC based on the research. The design brief will be realized through either a physical model or a 3D-CAD of the concept, depending on what is determined to be most communicative for the chosen concept.

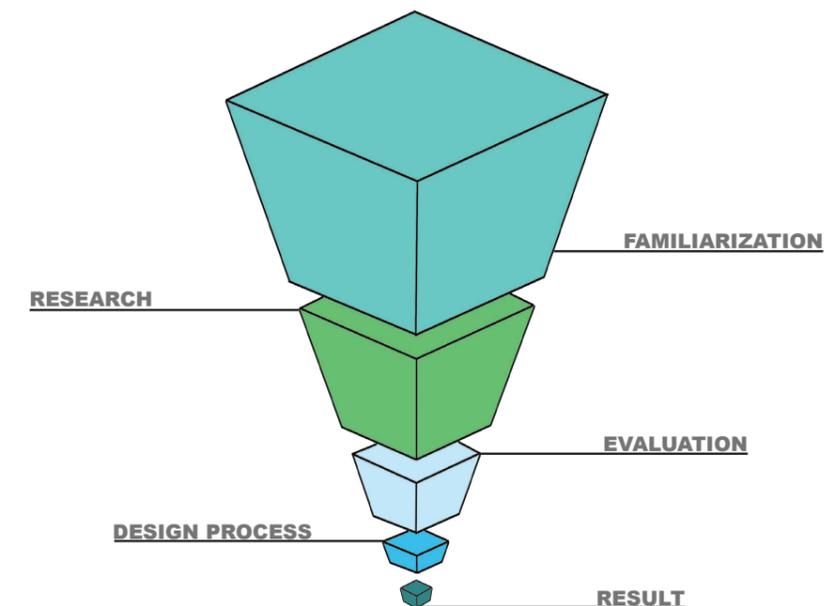


Figure 1. Funnel chart describing a general plan of execution. Each step leading down to the result should gradually narrow the scope.



Figure 2. Collection of popular RVC's, Manufacturer from top to bottom: Neato, Samsung, Electrolux, LG.

3. BACKGROUND

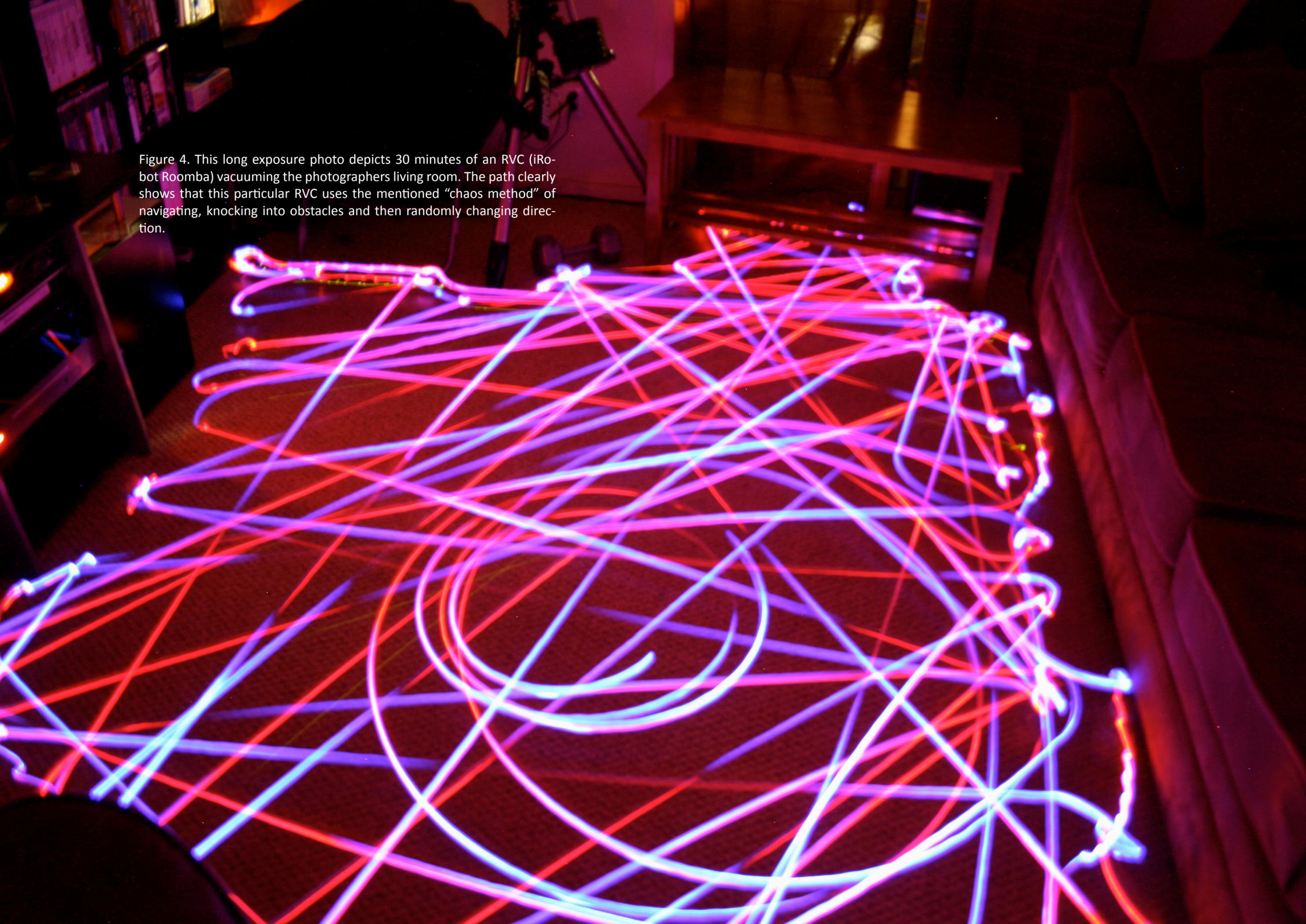
The field of automated household appliances has been in rapid development for many years. The last decade has seen an upswing in the commercialization of non-industrial service robots – with mainly cleaning robots finding their way into many homes. The robotic vacuum cleaner, which this thesis centres around, is one such example that has increased in popularity due to advancements in technology. But the technology is still in its infancy and is in constant state of development and in need of improvement; not the least from a design perspective.

3.1 What is a robotic vacuum cleaner?

While the broad public seems to have a general concept of what a robotic vacuum cleaner is, there is still scepticism towards the concept and how the product actually works.

Generally speaking a RVC is a small device that uses different sensors and algorithms to navigate– and vacuum – a floor space. For instance, the cheaper robotic vacuum cleaners clean the room randomly; and when doing so, they usually bump into obstacles and walls softly to then randomly change direction (Grinten et al., 2007). More expensive RVCs tend to have infrared-, optical- or sound sensors to navigate a room, creating a more planned cleaning pattern. This also enables some RVCs to avoid dangerous obstacles like stairs. Optical sensors can also indicate situations like when the dust-bin is full, and additionally they also help the robotic device understand the level of dust on specific areas where the extra attention and effort is necessary. Typically, the RVC is charged at a charging station located centrally in the cleaning area. Some robotic vacuum cleaners can charge themselves automatically by returning to the charging station when the battery is running low. To be able to clean in corners and close to walls, RVCs utilize rotating brushes that brush the dirt into the centre of the device where the suction is the greatest. Most RVCs are low, to enable cleaning under various furniture, and typically round in shape. The roundness helps in programming the robots, because it is easier to determine that the RVC will not hit anything when it spins around its own centre axis. (URL-7)

Figure 4. This long exposure photo depicts 30 minutes of an RVC (iRobot Roomba) vacuuming the photographers living room. The path clearly shows that this particular RVC uses the mentioned "chaos method" of navigating, knocking into obstacles and then randomly changing direction.



3.2 A brief history

The idea of personal robot aids is an old one, ever present in literature and movies. One of the earliest examples can be found in the Greek poets Homers legendary work the Iliad where a three-legged self-navigating table is created by the god Hephaestus (Iliad XVIII, 700bc). Some millennia later, in the 1950's, Isaac Asimov wrote of unruly slave robots that rise up against their creators (I, Robot, 1950). More recently, many film adaptations depict robots as servants; Ridley Scotts "Blade Runner" (1982) and Disney's Wall-E (2008) are but a few such titles. In the last decades though, personal robots have started to shrug off their science-fiction trappings and are becoming very much a technological reality (URL-5).

More than 25 years ago, large companies in Asia, North-America, and Europe had already started developing mobile robot systems for various cleaning tasks. The Tomy Dustbot, seen in the picture, is one such example. This battery driven mini vacuum robot was one of the first of its kind in 1985, and came equipped with edge sensors and a non-functioning broom (URL-4). The robot can be seen as archetype for automated cleaning robots during the 80's. The manufacturers typically gave the robots human or animal characteristics, often giving them faces with lamps for eyes. Some might argue that these robots were nothing more than gadgets, without any substantial suction power.

Although most of these early systems remained as prototypes, the idea of using robots for cleaning tasks has not lost anything of its attraction and faces an increasing interest. The technology has since long been at a stage that allows mass production of cleaning robots (Prassler et al. 2000).

First prototypes (Hitachi, Sanyo) of the modern RVC were already presented around 1991. This suggests that the technology was there and one could have expected to see these prototypes as products on the market very rapidly. However this did not happen; another decade had to pass before the first actual products were announced in 1999 and it wasn't before 2001, when Electrolux launched the Trilobite 1.0, that RVCs actually reached the market (Prassler et al. 2000). This was followed by a stream of other companies launching their products in the following time period. The Electrolux Trilobite was introduced at a very high price (more than a \$1000) and did not really get the attention of the marketplace. It was not until well into 21th century that RVC's began to pick up momentum, when iRobot released a low cost series called Roomba (URL-3).



Figure 5. The Tomy Dustbot from 1985

4. MARKET SITUATION

Service robots are relatively new to the market in the personal sector, therefore market value specifics can be hard to estimate. Because of the rapid growth of the market, numbers quickly become outdated. Additionally, studies on the subject are few in number. "The Springer Handbook of Robotics", published 2008, estimated the market size of regular household vacuum cleaners to be 20 million units in the U.S alone for 2003. For comparison, the ratio between domestic cleaning robots sold worldwide from 2002 to 2006 and regular vacuum cleaners sold in the U.S. alone during the same period was about 1:40. Conservatively estimated, this ratio may be around 1:400 or worse worldwide. While this can be interpreted as a failure to encroach on the market shares of regular vacuum cleaners, it also means a huge potential for the market to expand in the future, should the product become more popular. Prassler and Kosuge exemplify this in the "The Springer Handbook of Robotics" (2008, page 1279):

"If only 2% of all domestic vacuum cleaners sold per year were robots this would mean a growth of 800% for the robotic vacuum cleaner market"

The 2005 World Robotics survey by UNECE (United Nations Economic Commission for Europe) reported on estimates of some 4,5 million units of domestic robots (vacuum cleaning, lawn-mowing, window cleaning and other types) being sold worldwide for the period 2005-2008, with an estimated value of 3 billion dollars. See figure below for details. Note that both reports exclude cleaning robots for professional use, which would significantly raise the market values.

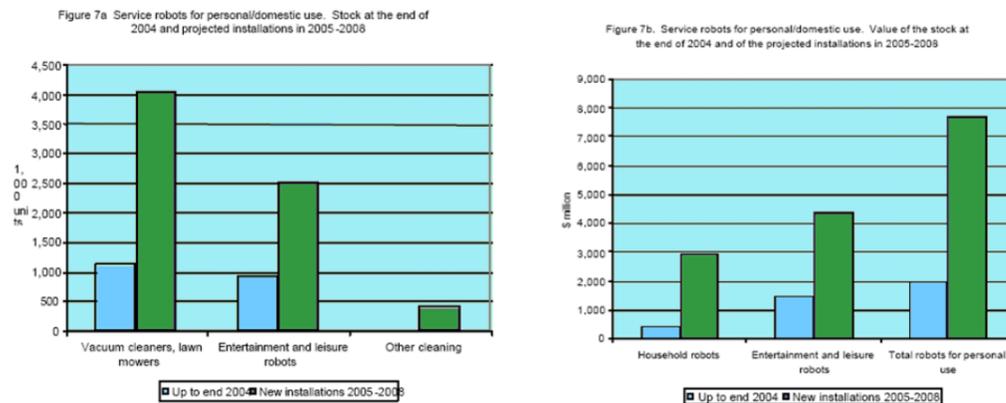


Figure 6. Sales projections for the period 2005-2008, UNECE, 2005

Newer studies coincide pretty well with older estimates. The IFR (International Federation of Robotics) Service Robotics 2010 report estimated that about 5.6 million service robots for personal and private use had been sold up to the end of 2009. With an average price of US \$400 per unit (URL-1) the cleaning robot market may be valued to US \$400 million in 2009. Most of the sold units were cleaning robots and the IFR claim that about one million vacuum cleaning robots were sold in 2009, this is 7% fewer than in 2008. Remarkably these numbers break the trend of a usually steady market growth, the reasons

are not stated (at least not in the preview of the full report) but it could presumably be due to the global financial situation during the period. The IFR projects that sales of all types of domestic robots in the period 2010-2013 could reach some 6.7 million units.

A forecast from WinterGreen Research (2010) provides a look even further into the future. They anticipate cleaning robot sales of US\$ 2 billion in 2016, which means 4 million domestic cleaning robots sold internationally in that year alone. If that estimate holds, that is a 400% increase in only 7 years, when compared to the Service Robotics 2010 report.

Finally, the JRA (Japanese Robot Association) rather remarkably envisions the growth and value of the personal robot industry to be in the region of 50 billion dollars a year worldwide by the year 2025 (Koray Özsoy, 2010).

4.1 Brand/product overview

As mentioned, the robotic vacuum cleaner industry has a short history. In spite of this, the market already includes a myriad of brands, with giant corporations like Sony, Electrolux and Samsung participating. There are at least 20 brands of RVCs and with approximately a 100 different models available. The American based company iRobot seem to be the clear market leaders, with more than 10 million units sold in the past 10 years, much due to the popular and low-priced Roomba series (URL-1).

According to WinterGreen Research (2010) the market leaders in 2010 included companies like Matsutec, Roboking, Metapo Cleanmate, Electrolux, LG and the aforementioned iRobot corporation. These are but a few of the active market participants, see appendix B for WinterGreens full list. A majority of the world's leading electronic companies are either active on the market, or have plans for prototypes, which is quite significant for such a relatively small industry. Recently, there has also been an abundance of Chinese companies manufacturing low-cost, "no-brand" RVCs for redistribution through various channels (URL-2). These manufacturers are too numerous to account for, but could become important factors as the general trend sees prizes plummet.

Reports on price span differ, depending on what brands are included. Grinten et al. (2007) report on prices ranging from €350 to 3500€ but that must exclude some lower priced brands. "The Springer Handbook of Robotics" (2008) points out that there are some RVCs readily available from US\$ 100. A quick amazon.com search currently shows that the P4920, a basic RVC by the company P3, can be bought for a regular price of US\$70 (URL-6). According to some sources, this model is the cheapest product on the market that can still be called a RVC (URL-2). On the higher end of the price spectrum we have companies like German Kärcher and Swedish Electrolux whose only models cost around €1800 and €1350 respectively. See next spread for overview.

Figure 7. Brands and price span



iTouchless



Evolution, Mint



MetaPo CleanMate



iRobot, Roomba 610 Professional



No brand,
Chinese manufacturer



iRobot, Roomba 530



Samsung, Navibot



Electrolux, Trilobite 2



P3, P4920



Neato XV-11



LG, Roboking



Kärcher, Robot Vacuum

Price span
(US dollar)

50-100

150-300

500-900

1800-3000

(all prices are approximate)

4.2 Brand differentiation and technology

The brands try to differentiate between each other not only through price but also technology, which is interrelated. The biggest factor when it comes to price seems to be what sensor system the product uses. The less expensive ones, like the IRobot Roomba, tend to use the “random” approach of room recognition, bumping into obstacles and changing direction. The more expensive brands usually have more advanced sensor systems, optical sensors and sound mapping are two examples, which raises the price of the product. New sensor systems are created frequently by the major market participants, with the trend being hybrid systems that use multiple types of sensors to orient the room (Hema et al. 2009). Additional functions vary between different models. Some examples are infrared sensors that can help the RVC to avoid staircases, indicators showing the dust-bin capacity and remote controls allowing for control at certain range. These kind of extra functions, as well as virtual walls, are what separate the lower priced RVCs and the higher priced ones.



Figure 8. Illustrations from Samsung showing the features of their Navibot robot. The picture above shows Navibot using infrared sensors to avoid steep drops.



Figure 9. Limiting the cleaning area with virtual walls.

PART 2: RESEARCH PHASE

INTERVIEWS

5.1 Research objective

An exploration of existing research showed that there is a body of relevant studies and interviews on the user oriented robotic vacuum cleaner experience. In fact, some acquired studies are so extensive and deep that there was no reason to try and outdo them. But most of this encountered research did not contain the source interview material, but rather elements which the authors thought interesting to highlight as well as evaluations and discussions. I wanted a more direct source of information, and therefore set out to do some interviews of my own. This also gave me the opportunity to customize the interviews to cover what I thought missing from currently available studies.

5.2 Method

Several interviews were conducted with RVC owners to gain a deeper, first-hand understanding, of what problems could arise when using the RVC. Another goal was to get a better knowledge of the social relation users build with their cleaning robots. To understand the discrepancy in cleaning habits between RVC-owners and people with regular vacuum cleaners, interviews were also done with the latter group, for comparison. It was also interesting to look into how perceptions of automated cleaning aids vary between the two groups. For that reason questions about RVCs were asked even to interviewees without any experience on the subject. Also, something not covered in the research I could find was the perspective of the manufacturer and distributor. Although these are second hand to the user himself, their point of view could expose important issues. For clarity, the interviewees are split into three groups and will be referred to as *Group 1: RVC-owners*, *Group 2: users who vacuum traditionally* and finally *Group 3: Manufacturers and distributors*.

I determined that a qualitative approach, as opposed to a quantitative, was better suited for the purpose of these interviews. The reasoning behind this was that some of the issues above like the constructed social relationship between user and robot, were thought to be hard to access with a shallow approach and needed deeper insight. Some questions were intentionally left broader and slightly ambiguous with the intention of making the interviewee reflect, as well as to try to avoid overly short and straight answers.

Because of the availability of good research on similar subjects, the findings in the interviews will be compared to existing studies throughout the next sections. This is to validate, or add to, interesting points in the result.

5.3 Limitations

The number of participants who owned a RVC and were ready for more thorough interviews turned out to be limited. To add body to the research I therefore extended the interviews to mediums more suited for a quantitative approach, namely internet based forums. The quality and reliability of these interviews could be questioned, but the results turned out to be valuable additions. Also because of limits to the number of participants in Group 1, a spread of age groups could not be achieved. Most RVC owners that were interviewed are were not far of the 30 year mark. The results of the interviews could therefore be influenced by basically containing only one generation. For example: many of the answers point to the participants not having any technical problems setting up their RVCs, something that might not have been true for a different age group. Gender spread in the RVC- owner group was relatively even with about 40 percent female and 60 percent male. Household and living arrangement varied, with some living in small apartments and others in bigger houses, some having children and some not, this was true for both Group 1 and Group 2, and somewhat irrelevant for Group 3.

The transcriptions are based on notes from the interviews. Interesting parts of interviews were often noted down in full, but are subject for variation in language and de-

tail. The answers were without exception all translated from Swedish, meaning quotes cannot be guaranteed to be exact, but are always true in general intent. For the full interviews please see appendix C.

Due to the small number of interviews done the result cannot be presumed to represent all RVC users and other interview groups, but should rather be used to pinpoint interesting problems and opinions.

6. FINDINGS

The results point to RVCs being perceived as more of a compliment to the traditional vacuum cleaner (hereafter TVC) as opposed to a replacement. 6 out of 7 RVC owners say that they already had a functioning vacuum cleaner at the time of the purchase, and were not on the look out to replace their regular vacuum. KL, age 30, writes: *“We had a traditional vacuum cleaner and wanted to test a RVC.”*

Additionally 6 of 7 RVC owners say that they have to use both the RVC and TVC to some extent. The general consensus seems to be that the TVC is still needed for certain cleaning tasks, but to a lesser extent than before purchasing the RVC. *“I often use both [RVC and TVC] when cleaning. I use the RVC maybe three times a week, and compliment with the regular vacuum cleaner when needed.”* - MB, age 27.

Some go as far as to say the TVC is almost replaced by their RVC: *“We more or less only use the Roomba [RVC brand]. We use it twice a week to cover the whole apartment. We very rarely have to use the traditional vacuum cleaner.”* - KL, 30. But most seem to agree it is needed on occasion.

Interestingly, the interviews show that RVCs being more of a compliment to the TVC is a worry for some of Group 2. MW, age 25 stated that: *“...you should not have to vacuum manually if you have one of these things [referring to RVCs].”*

In most cases the frequency of cleaning activities went up after the introduction of a RVC into the household. Although specific questions on the frequency of usage was not asked, it regularly came up in interviews. The RVC was often used several times a week. One interviewee on an internet based forum with the username Grape added: *“In my case the Roomba meant that I ran an automatic vacuum three times a week. This can be put in relation to the fact that I, as a sloppy bachelor, vacuumed maybe once every two weeks before I got the robotic vacuum cleaner.”*

Studies confirm that an automated vacuum cleaner changes the cleaning habits of users. The autonomy of a RVC allows for multitasking, meaning that users can do something else while the floor is being vacuumed. In addition, because cleaning using a RVC can be done with minimal physical effort, both opportunistic and planned cleaning activities increase (DiSalvo, Forlizzi 2006).

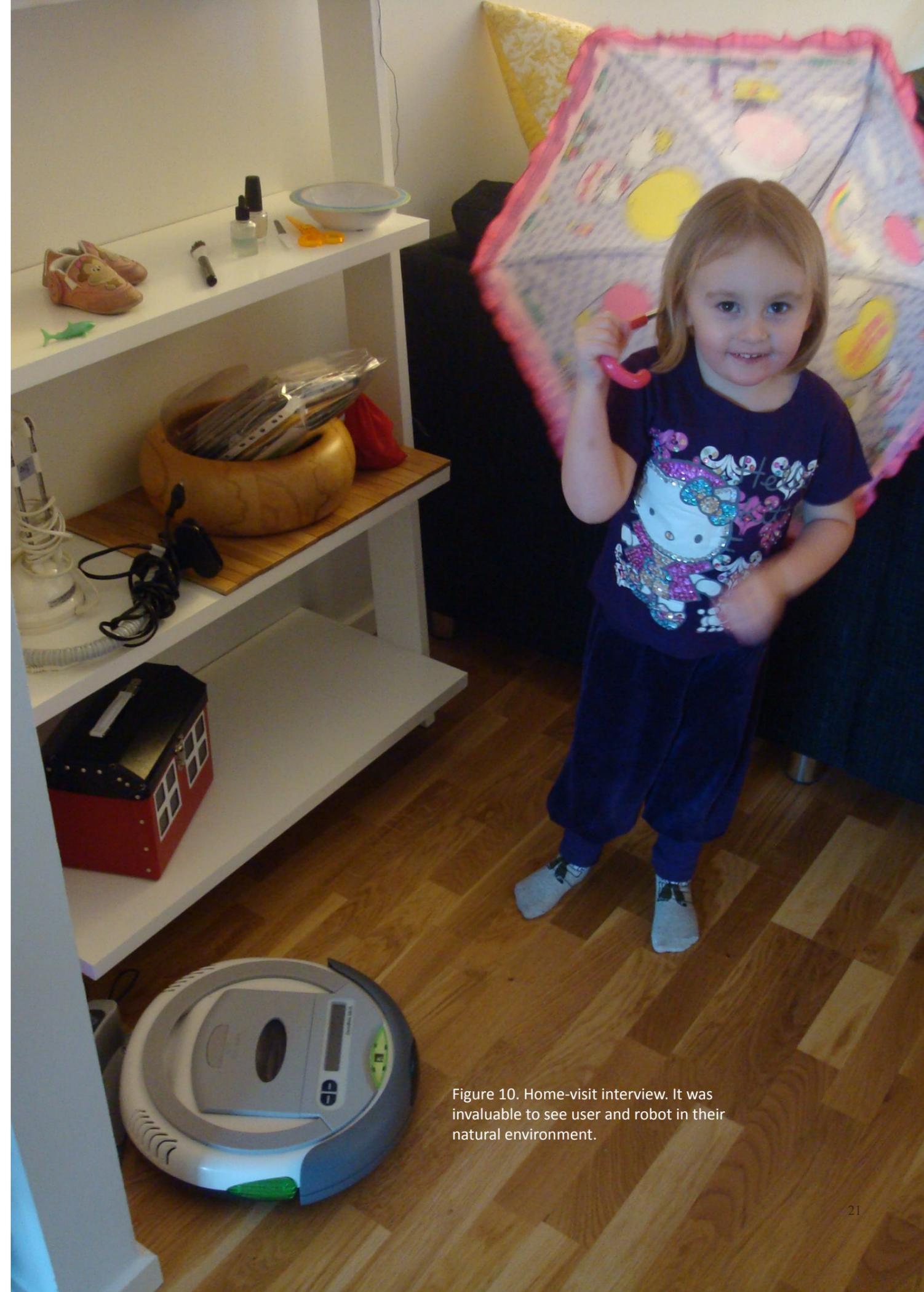


Figure 10. Home-visit interview. It was invaluable to see user and robot in their natural environment.



Figure 11. The RVC sometimes gets stuck and needs human assistance.

A participant in the same study (DiSalvo, Forlizzi 2006) explains:

“Well, there is really no reason for us not to just turn it on. It takes no effort. So we might just as well have it going you know like every other day or something, instead of using it just once a week.”

When asked how long it takes for the RVC to vacuum their living space, many of the users were unsure. The reason seem to be twofold, firstly most do not take an active role in the vacuuming, usually spending that time on something else. Secondly about half of those interviewed had the RVC programmed to vacuum when they were away from home. The answers range from 30 minutes to 1 hour and even up to 4 hours. This variation can obviously also be due to differences in living space and arrangement, brand and model. Answers were also in a very uncertain manner. MB: *“I think it takes something like 30 minutes [for the RVC to vacuum]. Sometimes it takes longer but I do not know why.”* And Grape: *“If I guess; about one hour or so. The RVC vacuums when I am not at home so I have a bad perception of how long it takes”.*

Preparation before activating the robot vacuum turned out to be a necessity for most of the RVC owners. The preparation most commonly included picking up things like clothes from the floor, placing chairs on tables and folding up carpets. KL: *“We try to pick up loose items from the floor, including kitchen chairs which we put up on the kitchen table. But that doesn’t take more than a couple of minutes per time”.* Even though nearly all of them had to do some preparation most were insistent that it was not much trouble, shown in this comment from HT: *“...this [preparing] did not take more than 3-5 minutes though; I did not find it very cumbersome at all”.* Ja-Young Sung et al. (2007) reports similar findings in the study *“My Roomba Is Rambo: Intimate Home Appliances”*. The study shows that while RVC users hoped that their robot would be reliable, they did not expect it to work flawlessly. Further, they took on extra work to increase their robots odds of working well. The participants tolerated the automated cleaning robots potential for flaws, although they tried to mitigate the possibility of failure through preventative measures.

Concerning the topic of preparation one interviewee, AV, simply said that *“Yes [I have to prepare] a lot. I have kids and therefore Lego.”* He went on to mention that he would rather have a device that automatically sorted Lego, than the automated vacuum cleaner he owned. Another participant mentioned that when she did not prepare for the cleaning the robot often ended up needing assistance. MB:

“Often what happens when I don’t do any preparation is I have to watch after it [the RVC] so it doesn’t get stuck or something. I end up lifting it up sometimes and putting it down on the spot I want it to clean.”

When comparing the level of preparation needed with Group 2 who vacuum traditionally, some similarities can be found. Participants from the latter group also affirm they have to do some preparing before vacuuming, SÖ a 25 year old student: *“I pick up some stuff; small carpets, put up some chairs and hang up my guitar, that’s about it.”*



Figure 12. Upper: Hair and other things often get stuck in the brushes.
Lower: Getting under furniture like beds is often not a problem.

Others state that they do not do any preparing, but have to move some things around when vacuuming.

Another question asked was that of the RVCs potential functional problems. Some brought up the quandary of long hairs getting stuck in the wheels and brushes of the device. HT: *"If someone in your household has long hair, it tends to get stuck underneath the robot, I had to remove those hairs manually myself."* One interviewee, AV, was especially vivid when pointing out this flaw:

"Those who constructed the Roomba apparently do not have 65 cm long hair. Then they would have discovered that the hairs twist themselves into the wheels and small brushes so they can hardly turn, and that makes the battery run out very quickly. Furthermore, it is almost hopeless to get rid of the hairs, not even with the small knife that you get with the product does it work."

It has to be mentioned that while some of the other RVC users were not bothered to the same extent by this; maintenance did seem to be a reoccurring issue.

Emptying the robot vacuums dust container had to be done on a regular basis. Some even meant that it was something that had to be done after every vacuum, while other did it every two or three runs. KL: *"...you have to remember to empty the dust bag after each time, and clean the brushes every two times."* One participant, MB, said she had problems understanding the procedure of emptying the dust container: *"The dust bag is also filled up and I don't know how to empty it!"* While AV adds that the dirt container is hard to empty without spilling the dirt back out on the floor.

On the topic of accessibility the participants mentioned the RVC getting stuck on certain thresholds. HT explains that his Roomba RVC got stuck on some of the bigger thresholds in his apartment, but could handle smaller ones. On those occasions he had to physically lift it over the obstacle. He also had to lift to, and from, the second floor because the RVC naturally cannot cope with stairwells. In most cases the interviewees had some pieces of furniture that their RVCs could not vacuum under. This commonly included sofas and heavy stationary pieces of furniture like cupboards. Again, the benefits of the RVC seemed to out-weight this issue, and the interviewees were prone to compare with their traditional vacuums. JL writes that: *"Yes, if the furniture is too low it does [have trouble]. But it can get under our bed, which our traditional vacuum cannot."*

Next the RVC owners were asked if they were bothered with their products sound level. Some were not certain of the answer due to often not being present during vacuuming, as was the fact when asked of time expenditure. KL: *"It is relatively loud. But as I said, we are rarely home when it vacuums, so it doesn't matter much."* While others yet again compared to the TVC when describing the sound level, or as one interviewee puts it: *"Well...of course it makes some noise but about as much as my regular vacuum."* [MB] and: *"Probably not louder than an ordinary, cheap vacuum."*

But the sound could be perceived as disturbing when you are at home, if you are not actively participating in the vacuuming when the RVC is on.” [Grape]. The latter comment seems to imply that annoyance to noise is enhanced when not actively contributing to the sound. Some participants in Group 2 mentioned sound as a problem as well. Kristel, aged 44, says that: “It [vacuuming] is not the most fun thing to do. And it is pretty noisy; I usually turn the music up a lot. This leads to me not hearing anything else, like the phone or someone calling for attention.” The TVC owners describe the noise as bothersome, but entirely natural and therefore acceptable; “vacuum cleaners and noise, you cannot have one without the other”.

The participants were also asked if it was complicated to understand the RVC and get it started. The interviews pointed to the RVC-owners coping well with the technology. More than a few remarked on the ease of which they set up the device. Grape: “Nope, unpack it, press start and it gets going.” Others were quick to point out that while it was an easy process, it could be due to their affinity with new technologies. “...but then again I usually have an easy time with technical things like this, and I work as an IT-consultant.” [KL]. “...although I would like to say that I typically do not have any trouble with these kind of technical things.” [HT].

The interview asked if the participants feel in control of their RVC when it is vacuuming. What control meant was not defined and it was interesting to see the participants answering in varying ways. For some the question was confusing and therefore not answerable, others referred to the ability to contain the RVC to a specific area. KL: “We have towers [IR-boundaries] that limit it to a room/area until it’s done and it then continues to the next room, so I think we are in control.” ND: “Yes [you have control], if you have been careful to enclose it in the room.” Another interesting take on the matter came from JL:

Q: Do you feel in control of the RVC when it is vacuuming?

A: Not at all. But it is fun that way! I think we sort of see the RVC as a pet.

Or as one participant put it, the RVC seems to sit “somewhere between a pet and a home appliance” which will be discussed later.

The charging station has to be placed so it is accessible for the RVC, and preferably centrally in the household. Therefore, the majority of the users had their RVCs stored out in the open, often in the living room or kitchen, and seemingly mostly out of necessity. A number of them hinted that they had tried to hide the device in one way or the other. HT:

“[I stored it] in the open, because it had a pretty big charging station that it had to return to. But I tried to hide it a little behind a piece of furniture, so it was not overly visible.”

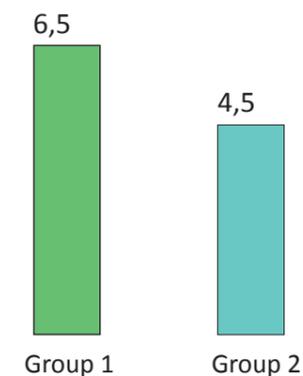
JL: “It [charging station and RVC] is placed in a corner and is not easy to see, if you are not standing right next to it.” Moreover there were remarks on the characteristics of the charging station itself. AV: “The charging-station is a dust collector in itself; addi-

tionally it is in the way in the only place we can put it. The instructions say that the RVC should always be charging when it is not in use, but that boulder of a charging station is something you do not want to have standing anywhere visible.”

As a follow up to the above the participants of the interview were asked if they showed visitors the RVC. 4 of 7 were inclined to show it to house guests, and were happy to give demonstrations. Grape: “As I said it is placed right in the open which often leads to a discussion and a quick demonstration if I have guests that have not seen one before.” Some answers indicated that there is a novelty to the product that makes it entertaining, at least at first encounter. ND: “Absolutely. It often makes appearances at after parties!”

Ja-Young Sung et al. (2007) notes that RVC-owners characterized the process of watching over their RVCs as a form of entertainment, watching and wondering whether it would avoid obstacles. Some almost made it sound like a spectator sport. The study goes on to describe that RVC-owners were prone to market the product to people around them: “Our participants lead us to believe that Roomba [RVC brand] adoption by word of mouth is how a healthy percentage of people come to own these technologies.” (p. 156)

Lastly, all participants from Group 1 were asked to describe their feelings on vacuuming with the RVC. Group 2 were asked to describe their feelings on vacuuming in general. In addition the participants were asked to add a numeric value on a scale from 1 to 10, where 1 is horrible and 10 wonderful, to allow for comparison. Group 2, the TVC owners, gave an average numerical value of 4.5. While the RVC-owners answered with an average value of 6.5, two points above Group 2.



MB: “6, it works pretty well.”
JL: “10, we love our Roomba!”

KI: “3, I do not like it very much but it has to be done!”
SÖ: “I actually like my vacuum cleaner, so it’s pretty good. I would give it a 6”

Figure 13. Group 1 and 2 numerical comparison.



Figure 14. Some projected pet attributes onto their robots vacuum cleaners.



Figure 15. Carpet vacuuming was a worry for Group 2.

5.2 Additional findings – Group 2

Apart from what is discussed in above section there were some things of note in the interviews with the regular vacuum cleaner users i.e. Group 2, mainly focusing on the expectations of the participants regarding RVCs.

Firstly, all of them answered to have no experience with RVCs, which was a requisite for participation. Although some freely said to have encountered similar products briefly. For instance, after the interview MW did recall that she knew someone who had a pool cleaning robot and that they have had some problems with it.

This was followed by inquiring if they had ever seriously considered purchasing an RVC, upon which no one said they really had. The reasons varied – but mostly the participants said the thought had simply never occurred to them. YA: *“Nope, It [a purchase] has never really been a possibility and I have never thought of it.”*

KI: *“No I have never seen one [an RVC], and do not know how they work.”*

Already at this stage a few brought up concerns on the functionality of the RVC. SÖ explains: *“No I have not [considered a purchase]. The idea kind of makes me paranoid. I feel it could accidently pick up small valuable things that you forgot on the floor. And I don’t really know how well it would be able to handle my apartment.”* MA: *“No, never. There would not be a lot left of it after my pets were done with it, I would presume. I have never thought of it.”* Yet another few simply said that they did not think they needed such a product. MW: *“As I said, I have a small room and it [the RVC] is not something I think I really need.”*

The next part consisted of the participants being asked to explain what they thought the RVC could – and could not – accomplish. This took some prodding as some of them understandably did not feel they could give an educated answer. But once encouraged numerous reservations became apparent. One of those was the price factor, with many raising concerns that the RVC would be overly expensive. MW: *“Even though I do not know for sure, I believe that a good RVC is very expensive, and if there are cheap ones they are probably nothing more than gadgets.”*

Of the more practical issues a couple of them wondered how it would handle their carpets at home. SÖ: *“It should be able to sense when it is on a carpet and change the vacuuming accordingly.”* KI: *“Is it able to handle carpets? If you have old, valuable carpets it needs to vacuum in the straw direction as not to damage the carpet”* It was not only carpets that the participants suspected would be in harms way of the RVC, another worry was furniture being bumped into and damaged. SÖ: *“It would probably collide with table- and chair legs so I would worry it would leave marks.”* Almost all of them asked themselves whether the RVC would be able to get over their thresholds, and under and around the furniture in their homes, often saying that it would probably get stuck all the time in their house.

The participants mentioned the need for flexibility in a vacuuming device, something they did not believe a RVC could provide. The flexibility was said to be needed to ac-

cess all the nooks and crannies of the house as well as to allow for “off the floor” vacuuming and dusting. Both of which seem to be based on the presumption that the RVC should be a replacement for the TVC, which is discussed in the previous section. Many wondered if it was able to clean in the corners and how the mapping worked, worrying that it would not cover the whole floor space. KI: *“Does it work in a systematic way? I have a very open planned apartment, would it only clean a little here and there if it could not be contained in one room?”*

There were many more reservations, or rather questions, on the functionality of the RVC - ranging from sound levels and pet hairs to getting run over by the robot. Many times the answer ended in the participants stating that: *“it would probably be easier to just do it on your own.”* MW: *“...I also think you do a better job when vacuuming manually than a robot would.”*

SÖ: *“Honestly, for me, I think it would be more energy efficient to just vacuum manually.”*

But maybe most interestingly was the mention of how they would relate to a RVC if they had one. Some of them mentioned that they would probably follow the RVC or check up on it periodically so it did not do anything harmful during its round, a few even saying they would be on edge when it vacuumed. SÖ: *“I would not want it to take too much time to vacuum because I don’t think I would be able to relax while it was going around the apartment. I think I would follow it around to see that nothing bad happens, or maybe position myself on a piece of furniture as to not ruin anything in its programming. And I would definitely have to test it thoroughly a couple of times before trusting it to vacuum my home.”*

KI: *“If I do not look after it, how do I know if it really makes the floor clean?”*

5.3 Findings - Group 3

An investigation of 5 major home appliance/electronic stores in the shopping centre Nova Lund, Sweden, showed that only two of the stores carried any form of robotic vacuum cleaners. Whether this is indicative of the situation at other locations cannot be assured, but all the visited shops were major, nationwide chain-stores.

One of the stores, ElGiganten, did not have any RVCs in stock, making it an order-only item. While the other, MediaMarkt, at the time only had one copy of a RVC available to buy on the spot. ElGigantens range consisted of two models of Samsungs Navibot, with the price ranging from 3800SEK to 5000SEK. When asked about the difference between the models, the salesclerk seemed hesitant: *“I am not entirely sure; I think the more expensive one has more programs.”* MediaMarkt had a range of iRobot Roomba robots (4600SEK-6500SEK), and the salesclerk referred directly to the manufacturers’ homepage when asked about the model specifics. Both agreed that the less expensive models were the best-sellers, the MediaMarkt salesclerk adding that this is true for most other home appliances as well.

They were asked why there were no RVCs in-store upon which the salesclerk from MediaMarkt replied:

“You know, we had a demonstrational Roomba set up in the store a while back, it went around vacuuming in a small area. People got curious and I do recall sales going up. But sales space is limited, so we had to make room for other things.”

To get an estimate of the sales volume relative to regular vacuum cleaners the salesclerks were asked what the sales ratios between these are.

ElGiganten: *“That’s hard to estimate! Maybe 500 regular ones for one RVC.”*

MediaMarkt: *“I would say maybe one to a thousand. I have sold maybe an average of one a month since I started working here.”*

The interviewees were asked who the typical customer buying a RVC is, if they had to generalize. Both agreed that buyers were usually educated on the purchase, and had looked it up on the internet. The MediaMarkt salesclerk also adding: *“Well, if I have to say something it would be that it is typically bachelors or families with a couple of children that come looking for automated vacuum cleaners .”*

The seller at ElGiganten went on to say that she saw a RVC as a complement to a TVC and reflected that this was a potential problem in a sales argument: *“When people come in and are looking for a regular vacuum cleaner I have a hard time recommending them a RVC as an alternative. A robotic vacuum does not really offer the same kind of suction and cleanliness. I say the same thing to customers looking for a small hand vacuum, it’s more of a complement... Maybe it is discouraging for some to buy a complement that is relatively expensive.”* Later in the interview she revealed that they actually use the Samsung Navibot RVC to keep the shop tidy, and that it worked well for the big space, which in a way clashed with her earlier statements.

The MediaMarkt seller had some things he thought needed to be improved for the RVC to sell better; namely that it would have to be cheaper and have bigger dust containers: *“...another thing people often mention is that it is tedious to empty the dust bag frequently and they have to do it pretty often. So bigger dust containers would be good.”*

Additionally, a telephone interview was conducted with the manufacturer Kärcher. The brief conversation showed that their only model is priced at 15000SEK, well up in the highest price ranges that exist for personal-use RVCs. They only sold about 25 units in Sweden throughout 2009 and when asked about this the interviewee, who was responsible for sales in Scandinavia, commented:

“I think the technology is too expensive as it is right now, maybe it is something for the future. The same goes for robot lawn mowers.”

7. DISCUSSION

It is evident from the interviews, that in general, RVC users are pretty positive of their product. There are many instances where they face the RVCs flaws with a positive attitude. Flaws that might not have been tolerated in any other household appliance are sometimes overlooked by the Group 1 interviewees. The novelty of the product at times shifted the vacuuming experience into an experiment, where potential positive outcome was a plus, while the negative results were expected.

As discussed before, there were tendencies in the Group 1 user group that should not be overlooked. An apparent common trait was the age similarities of the participants in this group. Although the quantity of interviews was few, it can be argued that it was no coincidence that a majority of Group 1 participants were around the age of 30. This, combined with the fact that many seemed technologically inclined, paints the picture of a group that is susceptible to - and interested in - new technologies. This might be another reason to the answers being forgiving and positive, the reason of the purchase often times being out of curiosity as opposed to necessity. The fact that many of them even market the RVC to others can be seen as proof of their approval, whatever the reason may be.

In stark contrast the interviewing of Group 2, which had a more even age spread, tells of an entirely different mind-set. The participants of this group, who mostly had no familiarity with RVCs, were sceptical of the capabilities of an automated vacuum cleaner. Between them, they accurately pinpoint some of the problems that an RVC encounter, without any previous knowledge of its workings. For instance, many questioned if the RVC was able to handle thresholds and whether it would get stuck on obstacles in their homes, which the RVC-owners confirm are real issues. But the Group 2 participants also state numerous problems that the RVC is actually adept at handling, hinting of preconceptions that might be hard to get rid of.

Indeed, some of them even say they would not trust the RVC working in their homes, at least not without their supervision. Not only does this expose a trust issue but also the need for control over the machine. This complies entirely with a number of studies. For instance, Sung, Christensen and Grinter (2009) write of this in the study "Sketching the Future: Assessing User Needs for Domestic Robots":

"...our findings suggest that the design of domestic robots needs to provide a certain amount of human control over a robot's intelligence. As much as people wanted the robot to perform tasks with quality without supervision (i.e. working autonomously), they desired to assure its compliance by restraining the decision-making power."

Based on the interviews it might be these issues that need to be addressed, and the traditional vacuum cleaner users that need to be convinced, as opposed to the more forgiving group that already own RVCs.

7.1 An analogy

To simplify, or put this into another context, one could liken the outlook of the two groups with the general opinion of television when it was a new innovation.

Metaphorically, Group 1 would be the people who bought the first black-and-white TV's and were awed by the moving picture. It did not matter to them that you could only barely see the contents on the screen. While group 2 would be those that did not see the point in moving pictures, when the radio brought them all the information and entertainment they needed. They might also have argued that there was only one channel on the television anyway, likewise some might say that today's robot vacuums are "one-trick-ponies".

Therefore there might be no point in convincing the people who were first in line to buy their TV-sets of the greatness of television. The challenge may instead lie in convincing the second group that there is indeed something good to watch on that one channel.



Figure 16. Old television set.

PART 3: EVALUATION

IDENTIFYING FOCUS AREAS

8.1 Evaluating the research

The information gathered from the research will be a base for deciding what direction to take for the design project. This chapter will try to filter all the research and extracting some areas of interest. It will also assess which of these areas are relevant, important and doable.

8.2 Remarks

There are plenty interesting things to pick up on from both the initial research and interviews. For the sake of clearness, the number of focus areas will be limited in this evaluation. The initial list will be funnelled through the next couple of sections until only a manageable amount remains.

Basically, the points on the list can be split into two categories. One of the categories is based on current general complaints RVC-owners had of their robots. The other category tackles a less specific set of problems revolving around the needs, expectations and misunderstanding of Group 2. Although many of the areas qualify for both categories.

Note that, already at this stage, some areas are coupled with initial ideas for solutions - or even described through a solution. This reflects my general thought process at this stage.

8.3 Areas of interest - brief explanations

Flexibility

The answers of Group 1, the RVC-owners, easily established that a RVC was in no way a replacement to a traditional vacuum cleaner. It simply cannot do all the things a TVC can, mainly reaching places off the floor and provide the same kind of suction. The TVC users, Group 2, also seemed to imply that it was important to have a vacuum cleaner that was flexible and could work in various situations.

MB (Group 1): "I often use both [RVC and TVC] when cleaning. I use the RVC maybe 3 times a week, and complement with the regular vacuum cleaner when needed."

MW (Group 2): "...you should not have to vacuum manually if you have one of these things [referring to RVCs]."

Accessibility

Most users were surprisingly fine with the RVC regarding where it could and could not vacuum. But that does not change the fact that there are some areas that the robots have a hard time with. To mention a few: cords, very thick carpets, very high thresholds, chair legs and some corners.

Maintenance

This was maybe the biggest concern of the RVC-owners, and what led to the most frustration. Problems included hair getting stuck in the brushes and wheels, which was troublesome to remove, and very frequent emptying of the dust bin.

KL (Group 1): “...you have to remember to empty the dust bag after each time, and clean the brushes every two times.”

Charging station

Answers implied that, generally, users tried to hide bulky charging stations to some extent. Doing this is quite hard, considering the charging station has to be located centrally in the living area.

HT : “[I stored the RVC] In the open, because it had a pretty big charging station that it had to return to. But I tried to hide it a little behind a piece of furniture, so it was not overly visible.”

Distance remote control

Many of the RVC-users had the RVC operational while away from home, leading to the conclusion that some distance control would be useful.

Valuables

This was mainly a concern of Group 2, that if they were not looking after the RVC it would suck up small things of value from the floor.

Limiting cleaning area

Some of the RVC-users suggested that they sometimes had to rearrange their furniture to keep the RVC out of certain areas. While there are existing solutions, like IR-borders, it might be worthwhile to look into other options. There were also worries from Group 2 relating to this.

Physical interactivity

At times there seemed to be a need for the user to assist the robot manually, picking it up when it gets stuck and relocating it is one such example. Very few of the existing RVC's have any grip or handles suggesting this would be standard practice.



Figure 17. Upper: The RVC and traditional vacuum have to coexist?
Lower: The charging station - home of the RVC.

Communication

Based on the interviewees of Group 2, the traditional vacuum cleaner users, the RVC seems to have some severe communication issues. For one, some perceive them as potentially harmful and uncontrollable - even before trying them. So any potential solution would have to solve the issue not only functionally, but also at an image level. In other words the RVC would not only have to behave and function friendly but also *seem* friendly from the first encounter.

SÖ: *"It would probably collide with table- and chair legs so I would worry it would leave marks."*

Also, the interviewees asked themselves whether the RVC would actually work properly, and how they would know if it really did work when it was in use. A solution would therefore have to clearly communicate efficiency.

KI: *"If I do not look after it, how do I know if it really makes the floor clean?"*

Controllability

Part of the communication problem mentioned above. Many described worries of feeling "helpless" if the RVC was let to vacuum their homes; with the only direct way of controlling it being to run up to it and pressing the off button, or in some few cases carrying a remote control with you. Establishing a more intuitive and fast way of control might help ease this feeling of discomfort.

SÖ: *"I would not want it to take too much time to vacuum because I don't think I would be able to relax while it was going around the apartment. I think I would follow it around to see that nothing bad happens, or maybe position myself on a piece of furniture as to not ruin anything in its programming. And I would definitely have to test it thoroughly a couple of times before trusting it to vacuum my home."*

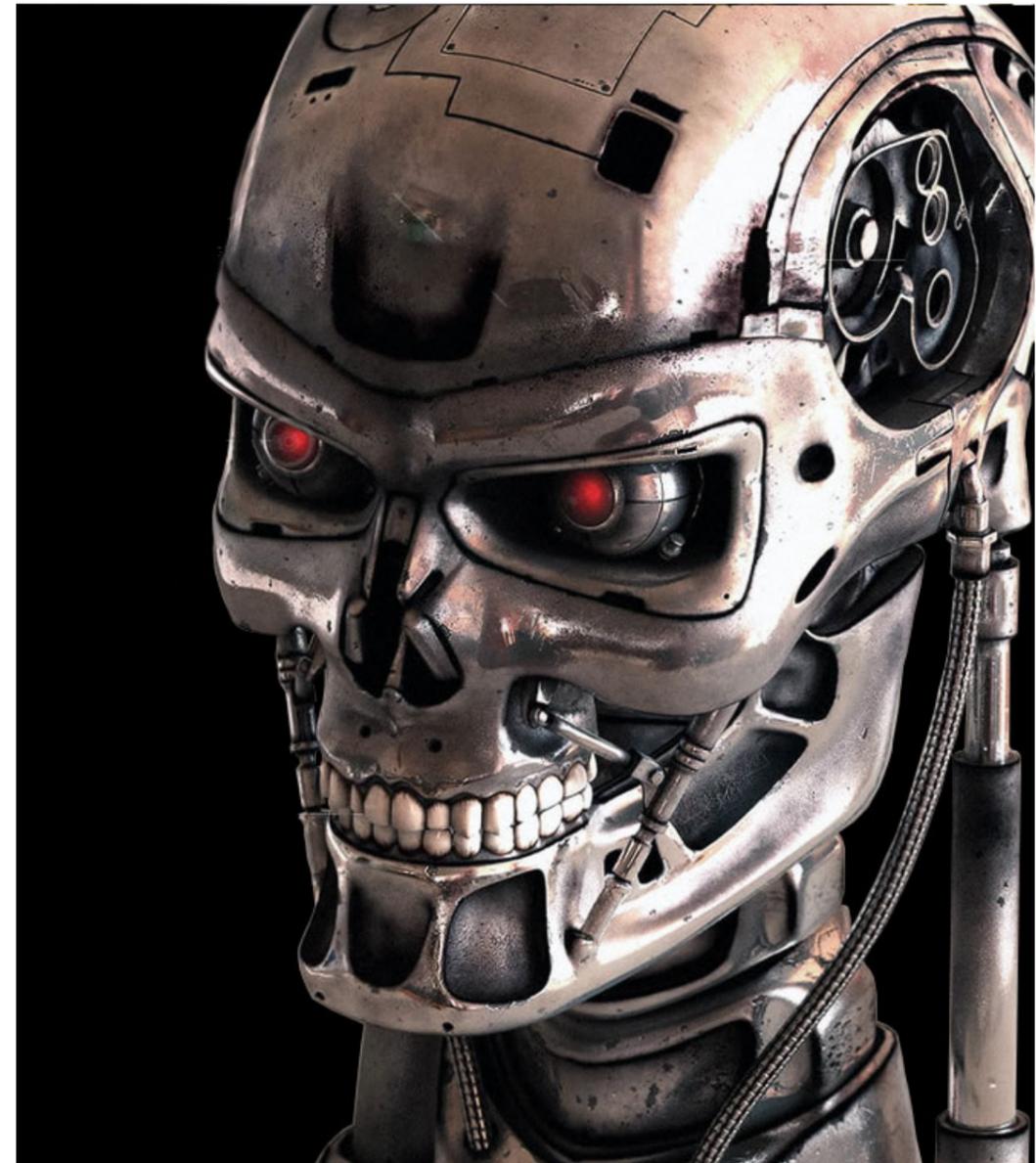


Figure 18. Killer robot - do robots have an image problem?

Figure 19. List of focus areas. Some areas were split into under-categories based on possible solutions.

Flexibility “two-in-one”
- combining the RVC and regular vacuum?

Dustbin
- Dust capacity and easy emptying/
automatic dust emptying

Distance remote control
- providing control from afar

Charging station
- blend into environment

Maintenance
-hair filter/removal, pet hairs

Accesability
-under furniture, over thresholds etc.

**Communication of
realiability and unharfullnes**

Valuable things
-filter/detection

Communication of effectiveness
-show aquired dust amount?

Limiting the cleaning area
-vacuum borders

Physical interactivity
- lifting, moving

Give control to the user
-find the right level of control

9. DEMARCATION A

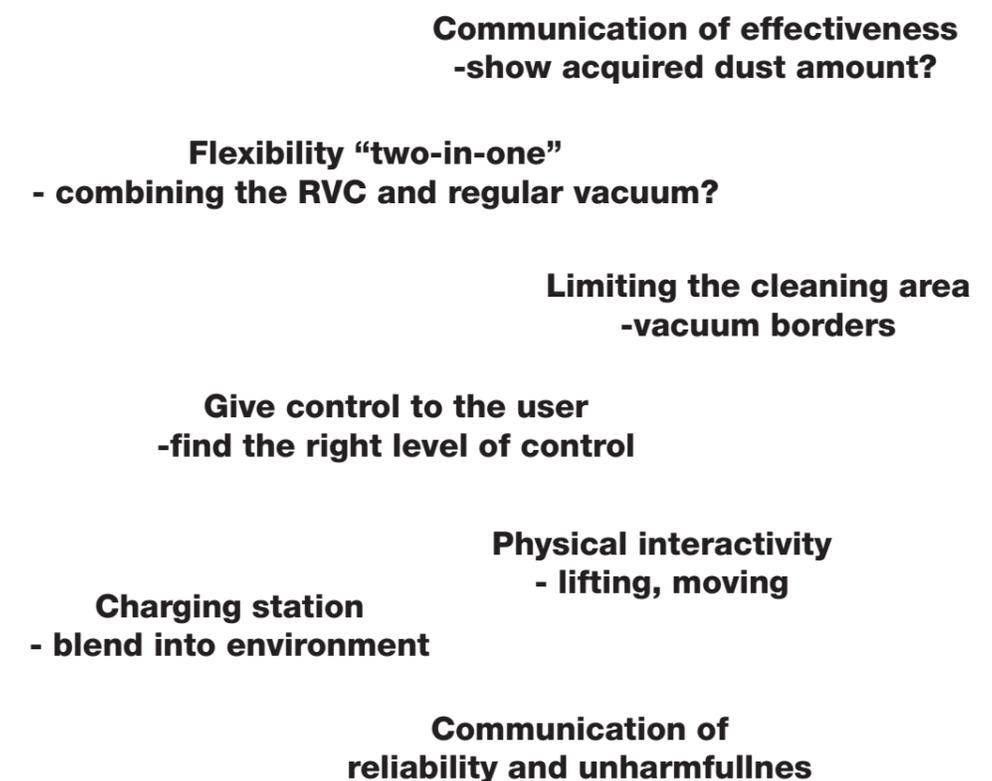
Firstly, some of the problem areas are very technical in nature and may or may not be suitable to take on from a design perspective. For example, maintenance problems, like hair getting stuck in the wheels and brushes of the RVC or dust bin capacity, was found to be one of the biggest concerns for RVC-owners. Although this might be the kind of problem that is discouraging people from using RVC's, one has to wonder if it is a problem more suited to the skills of engineers and the likes. Technical solutions that help the RVC to cope with accessibility problems like cords and thresholds may be important, but could also be entirely dependant on technical progress that only time can bring.

I am not ruling out that some of these problems can be circumvented with good design thinking, but for the sake of this design project other areas were prioritized. Another reasoning for this demarcation was mentioned in the section 5.4 discussion; namely that it might be more interesting to see to the expectations of the "non-convinced" than to take on very specific functional problems.

To again make the comparison to the TV analogy presented in 5.5:

It might be impossible for me to make the TV screen bigger and sharper or invent the colour TV (i.e advance technology). But, what I can attempt is to make the content of the TV-show better.

Figure 20. Remaining focus areas after demarcation



PART 4: IDEATION

DESIGN PROCESS

10.1 A bumpy road

Through this chapter the design process that led me to the final result will be presented. I will attempt to be as communicative as possible; to layout a chronology and establish a clear line from start to finish. But note that the ideation was never particularly simple or straight even in my own mind - part of which I believe lies in the organic nature of forming ideas. Many of the thoughts and ideas were processed parallel to each other, often times jumping back and forth between each other and in time.

10.2 Brain storm

Every established focus area will at first be brain stormed around separately. This is to get a better picture of what can be incorporated into the final design, because there are too many factors to consider for the complete picture to emerge straight away.





Figure 21. Scribbles and sketches

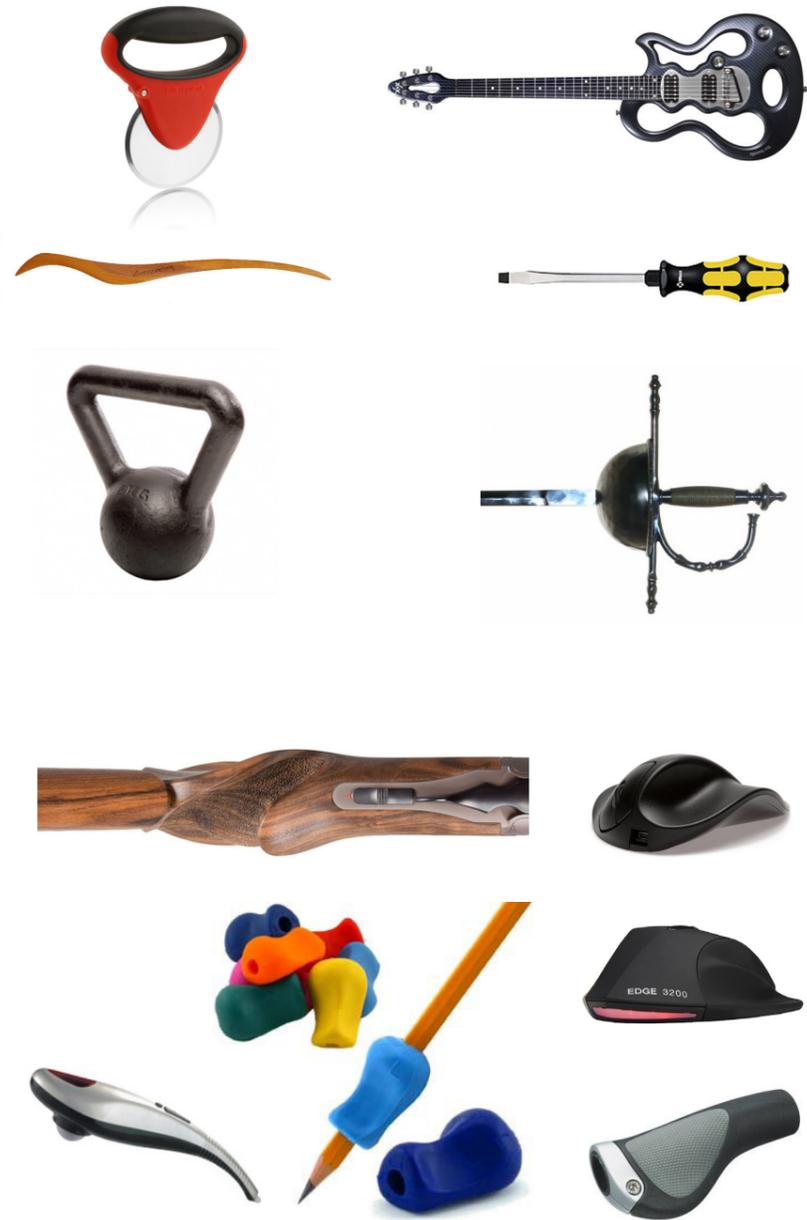
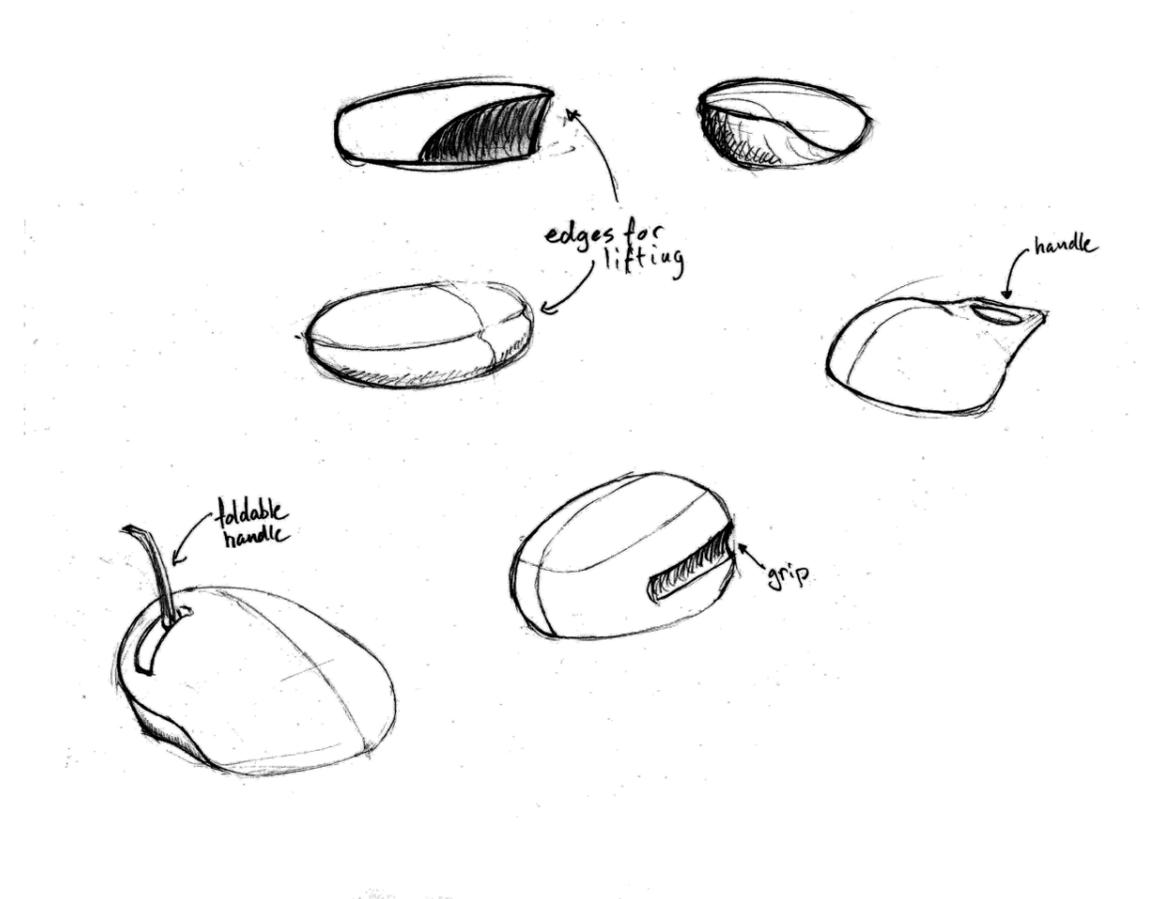
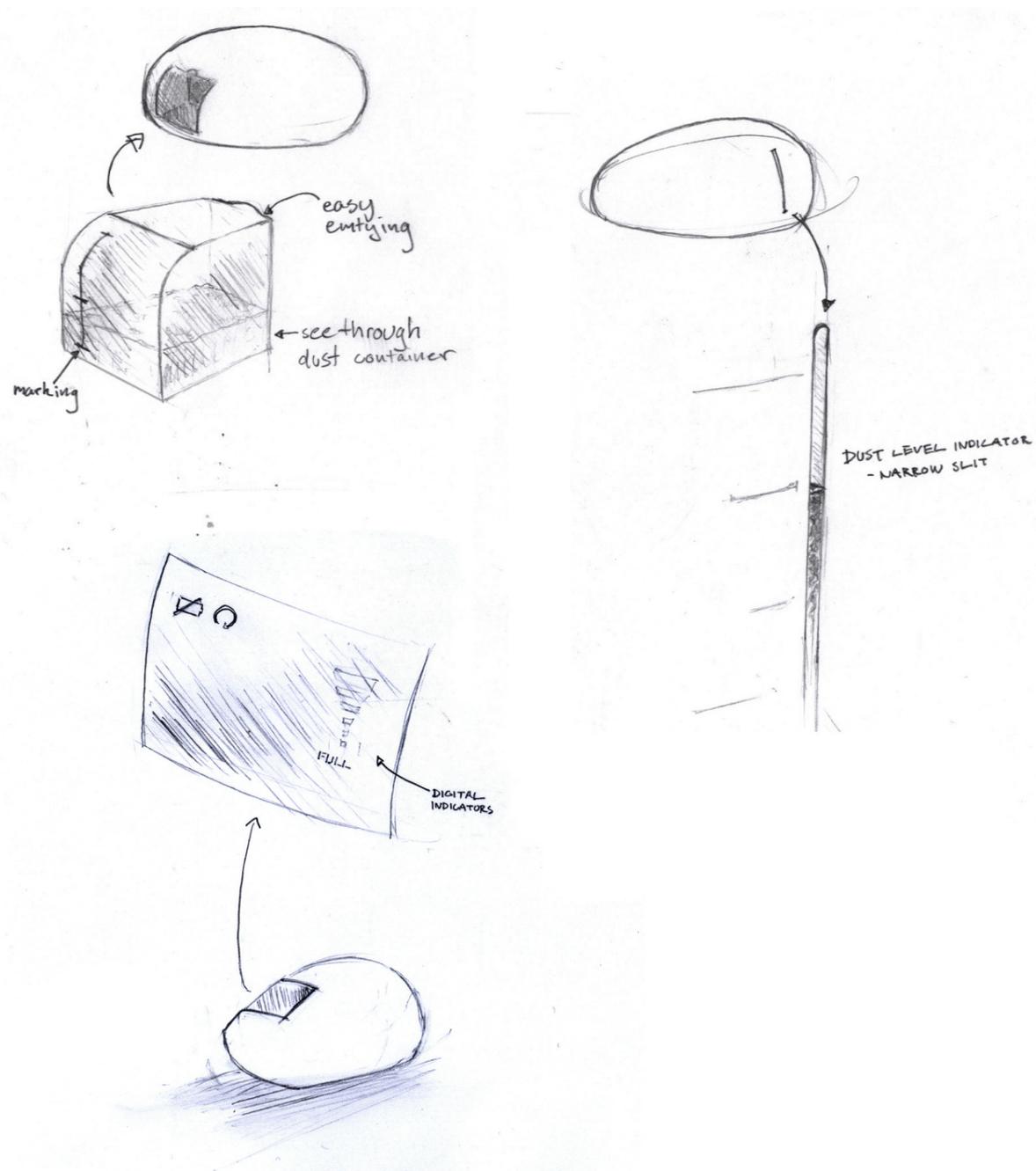


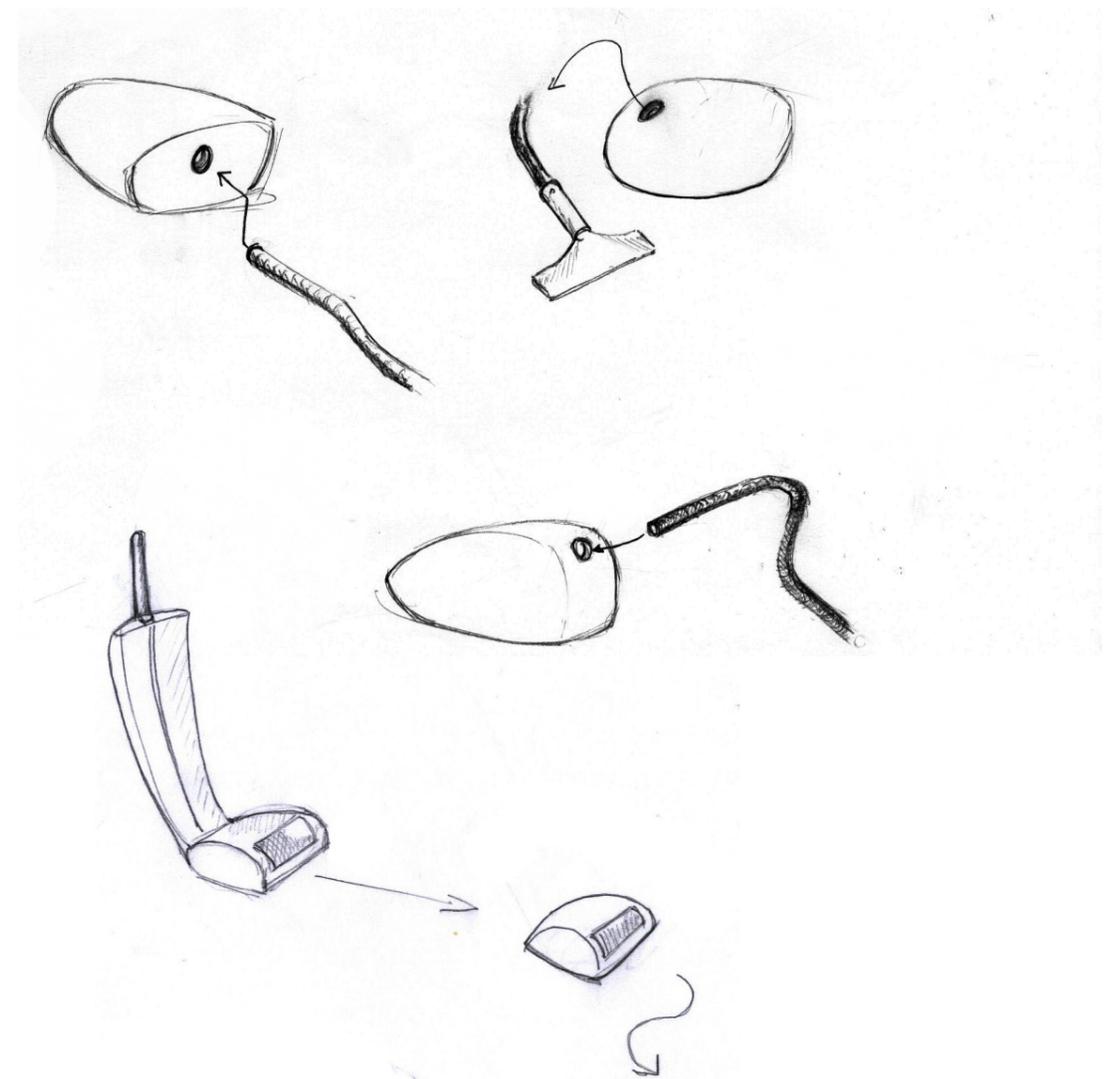
Figure 22. Inspiration for communicative physical interaction.
Upper: handles. Lower: grip



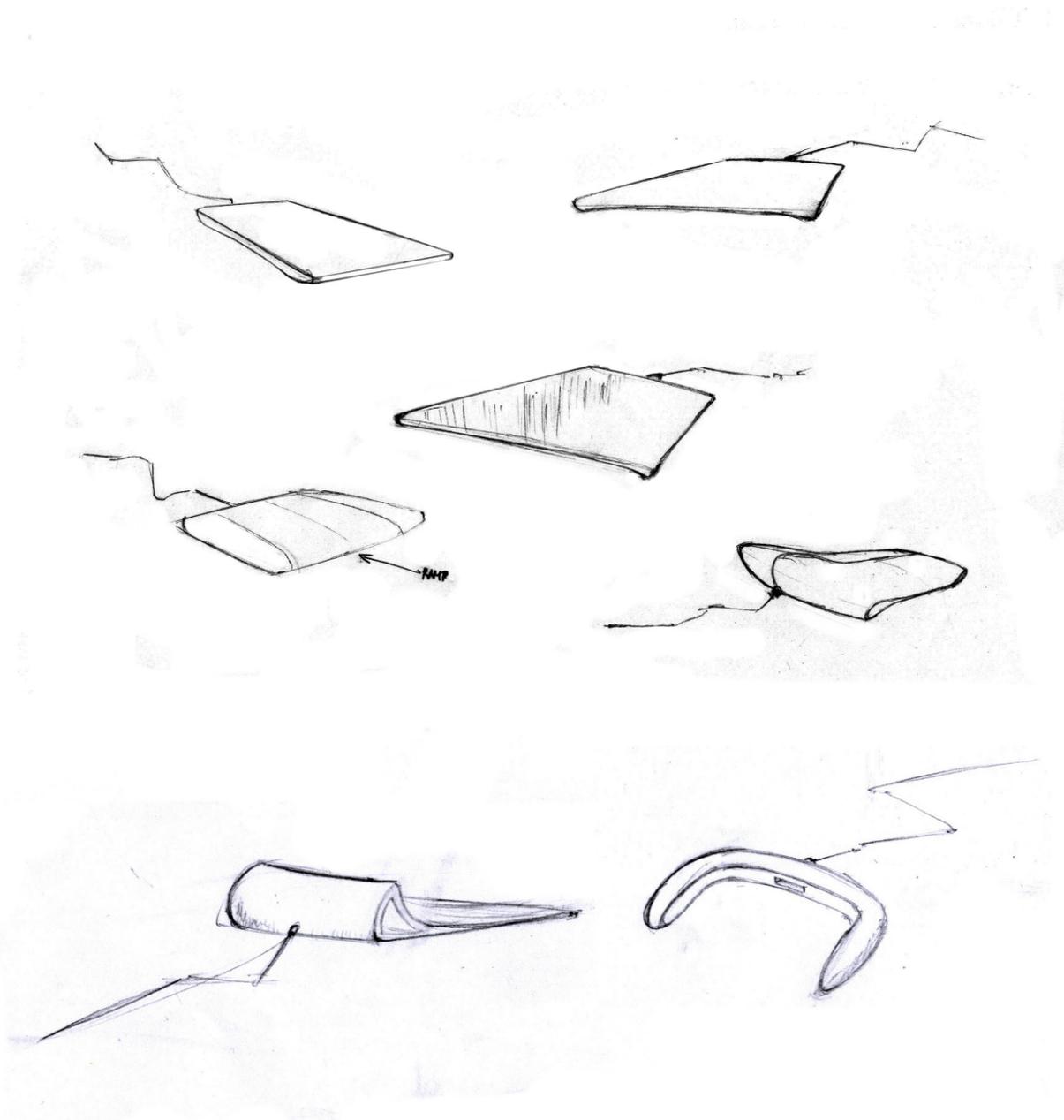
Physical interaction. Initial ideas for physical interaction. Basically, two different concepts: applying a handle or making some kind of grip or edge that would provide help when lifting the RVC. Handle could also be foldable as seen in the sketch.



Communication of effectiveness. Showing the collected dust would be a very clear way of communicating that the RVC is actually vacuuming your floors. Left sketch: See-through dust container would expose the contents. Right sketch: A narrow slit showing the dust level in the container is a more discrete option. Lower sketch: Digital representation of dust levels.



Two-in-one (flexibility). Upper: Simply attaching a vacuum hose when needed would enable the RVC to work pretty much as a regular vacuum. Lower: Pillar vacuum with detachable RVC at the push of a button.



Charging station. Upper: Induction charging station, inspired by dog mats.
Lower: More traditional RVC chargers.



Figure 23. Dog mat, inspiration for charging station

11. ADDITIONAL RESEARCH - control

One of the more important areas seemed to be establishing the right level of control over the robot. I imagined that the level of control we have over pets is very similar to the level of control you want to have over a RVC. You want to be able to control it when you need to, but still leave it the freedom to do its own thing when unsupervised.

Can the way we relate to pet animals be translated to how we relate to RVC's? And if so, is there a way to mimic the way we control and relate to pets? The link between pet and RVC seemed to be well established in many RVC-owners minds already, which led me to conduct an interview with a dog owner.

My goal was to examine how dog and owner interacted, mainly when the owner gave commands to the dog, and in what way the owner exerts control over the dog. In other words what the dog did was not nearly as important as how the owner intuitively carried out commands. I gave the owner a list of commands I thought were transferable to a RVC, like "stop", "stay" and "come here", and asked her to carry out those commands to the dog.

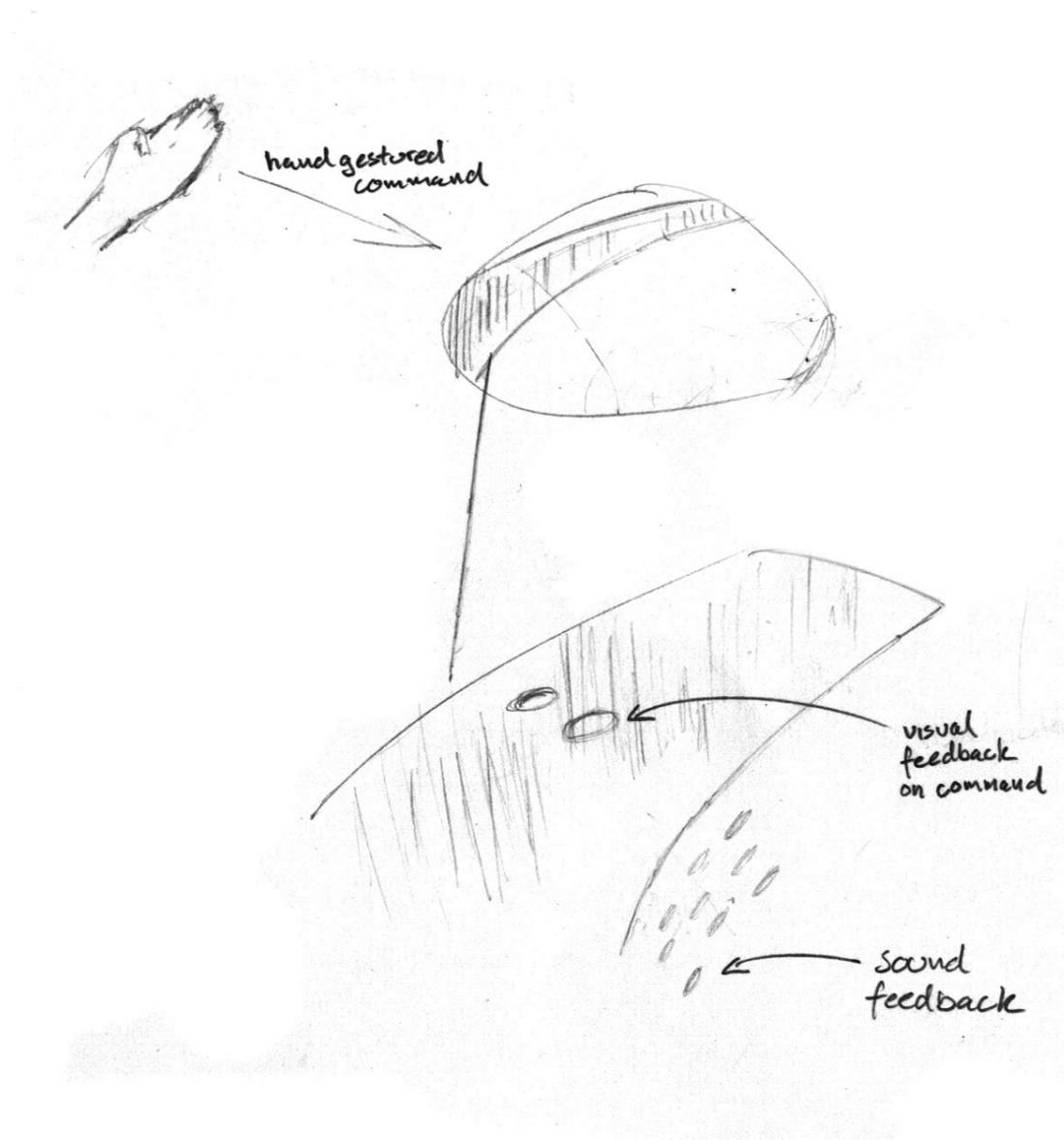
The tools the owner used to control the dog was body language and voice. The intuitive and very exaggerated hand gestures she used inspired me a lot, after all body language is our most natural way of communication.



Figure 24. Strong body language.



Figure 25. Stop command given to Ted the dog.



Giving control. Hand gesture control concept. The RVC is given a hand gestured command and responds with visual or sound feedback, telling the user that the command was registered. The feedback will communicate when the user has the RVC's attention and when a command has been understood, but not specifically what command was given. This is to reflect the dynamic human-pet relationship discussed above.

11.1 Technology

Gesture recognition systems are emerging as a completely viable technology. Recent examples of motion capture being implemented can be seen in game consoles like the Xbox Kinect and sign language recognition devices (URL-8).

To allow for a 360 degree intake of commands, a *omnidirectional* camera can be used (Fiala and Basu, 2004). This camera utilizes mirrors to create a 360 degree field of vision very suitable for this purpose, see below for picture.



Figure 26. View of an omnidirectional camera from the ground.

11.2 Demarcation B

Having explored some different possibilities, additional demarcations were needed.

The idea of a flexible RVC that can function as a regular vacuum cleaner, by attaching a hose, seems good at first glance. But the fact is that a RVC will never give you the same suction as a regular vacuum and you will still have to go grab the hose each time you need it. It would be somewhat dishonest to the concept of a robotic vacuum to try and turn it into something it is not, and you might end up with something that is neither a good RVC nor TVC. Therefore this idea is discarded.

Regarding the see-through dustbins to communicate efficiency, the question arises whether or not the user actually wants to see the dirt that their vacuum picks up. So this idea is also discarded, at least until a more tasteful solution is discovered.

12. FUNCTION ANALYSIS

Having gotten an initial grasp of the elements that need to be implemented, a design brief to clarify the project is to be constructed. First a function analysis is made, to help in prioritizing the different aspects and ideas that have arisen during the research and brain storm. See next page.

FUNCTION ANALYSIS

Interactive Robotic Vacuum Cleaner

MF= Main function N= Necessary D= Desirable

Allow	Vacuuming	MF
Be	Automatic	MF
Allow	Human control	N
Allow	Remote control	D
Be	Interactive	N
Communicate	Interactivity	D
Give	Feedback	N
	<i>visual feedback</i>	N
	<i>audio feedback</i>	D
Be	Responsive	D
Be	Round	N
Allow	Lifting/moving	N
Communicate	Physical interactivity	D
Be	Ergonomic	D
Provide	Grip	D
Be	Cleanable	N
	<i>Hair removal</i>	D
	<i>Filter for valuable things</i>	D
Allow	Carpet vacuuming	N
Have	Dust container	N
Allow	Automatic dust emptying	D
Communicate	Dust level in container	D
Communicate	Effectiveness	D
Communicate	Trust	D
Look	Unthreatening	D
Communicate	Move-pattern/direction	D
Provide	Ability to limit cleaning area	D
Be	Child/pet safe	D
Avoid	Obstacles	N
Avoid	Level-changes/staircases	N
Be	Chargeable	N
Be	Automatically chargeable	D
Be	Versatile/multifunctional	D
Integrate	with traditional vacuum cleaners	D

13. DESIGN BRIEF FOR INTERACTIVE ROBOTIC VACUUM CLEANER

This project's main focus will be to implement interactivity in a design concept of a robotic vacuum cleaner, with the purpose of providing the user with a feeling of control over the robot; to reduce feelings of estrangement and helplessness towards the product.

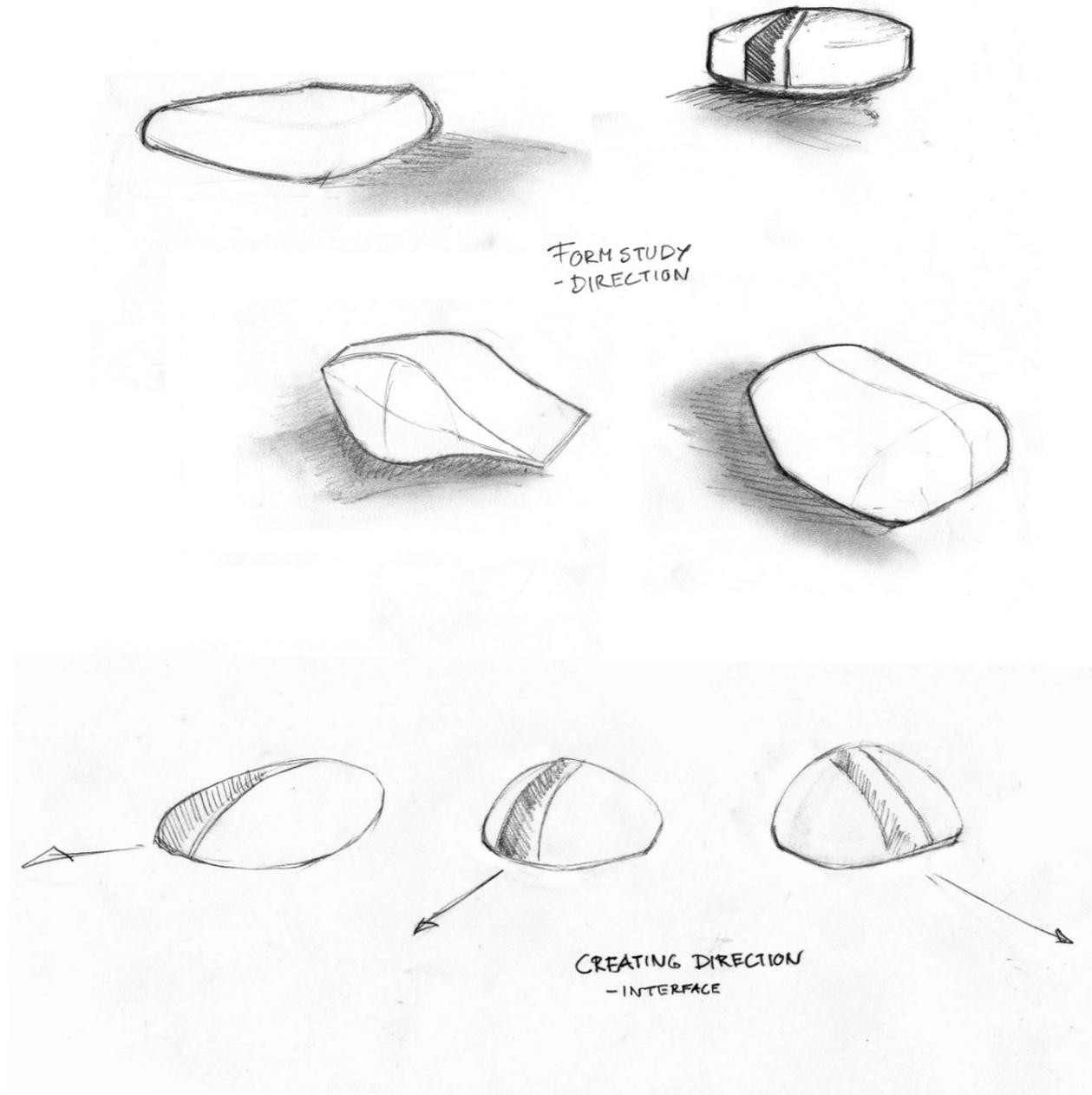
This is to be achieved by implementing a hand gesture recognition system that will help the user to smoothly interact with the robotic vacuum cleaner. The system is to be inspired by human interaction with pets - to create a system that is dynamic and intuitive to the user. Additionally, the robotic vacuum cleaner should be responsive to its user's commands, and provide visual feedback to decrease potential confusion.

The concept should also allow for - and communicate - physical interaction. Meaning the user should feel no hesitation to lift and move the robotic vacuum cleaner when needed.

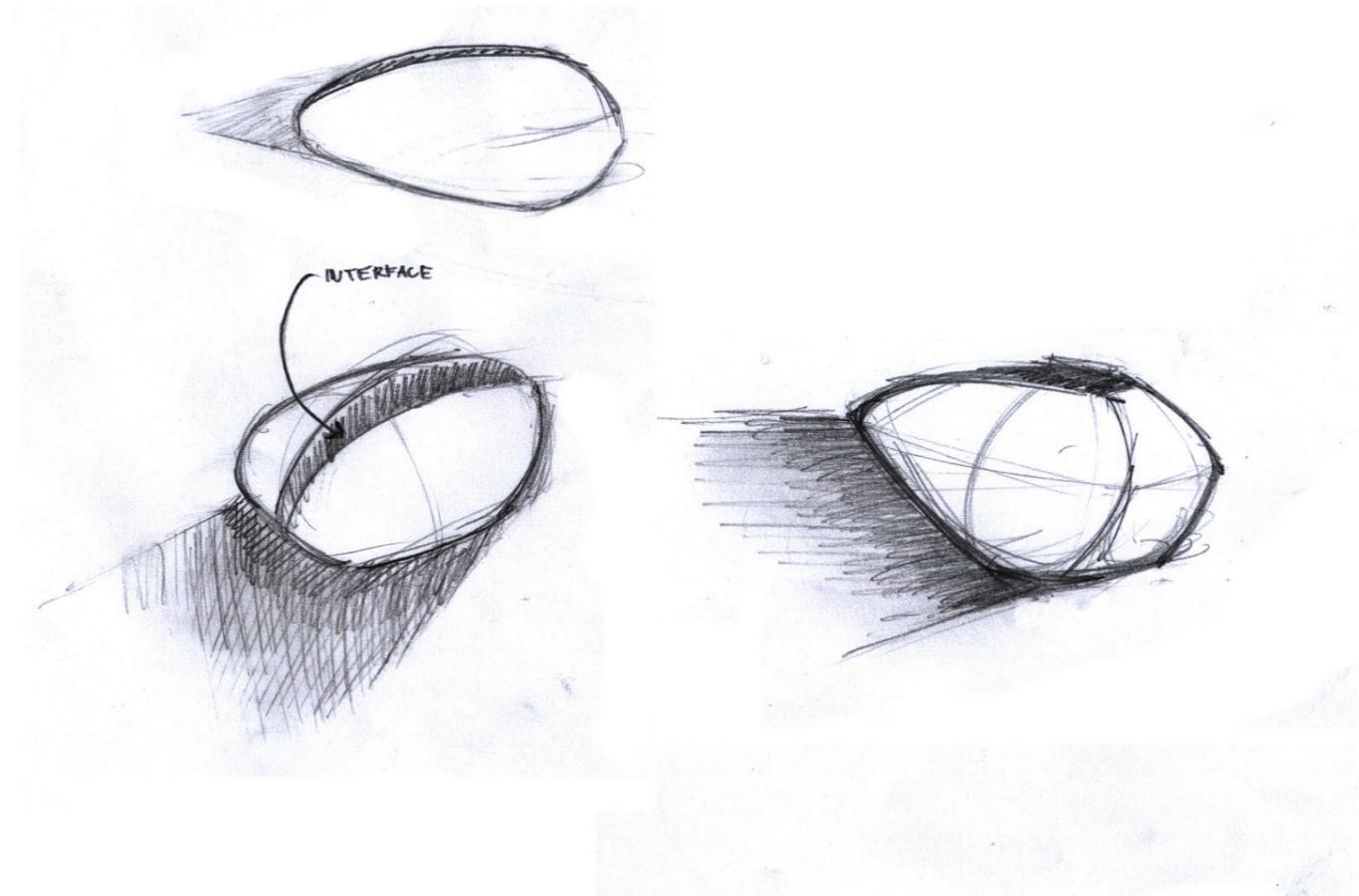
The robotic vacuum cleaner should be designed in a way that it does not feel threatening or otherwise harmful to the user and its environment. It should have no sharp edges or other details that could be interpreted as potentially damaging. It should at all times be apparent in which direction the robotic vacuum cleaner is moving.

Lastly, the robotic vacuum cleaner's charging station should be discrete and accessorize well with the product.

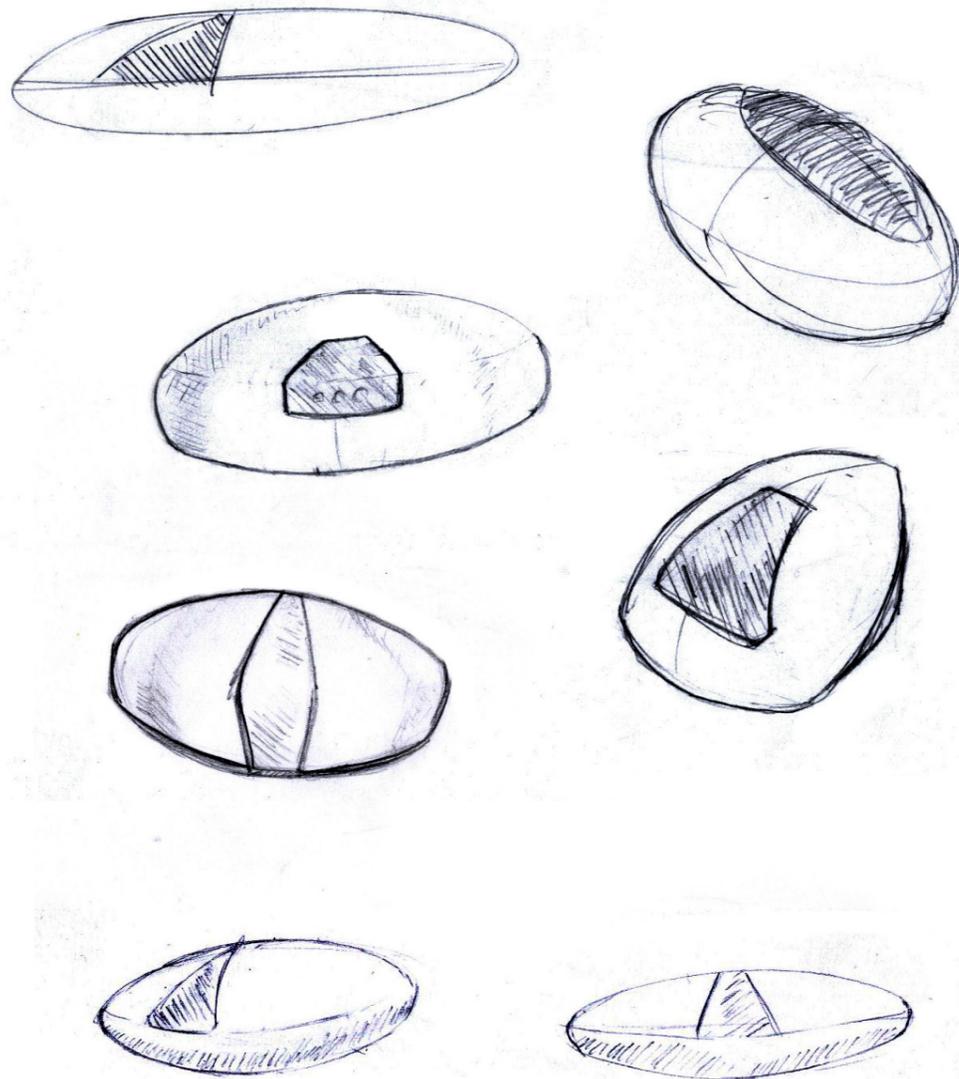
14. IDEATION



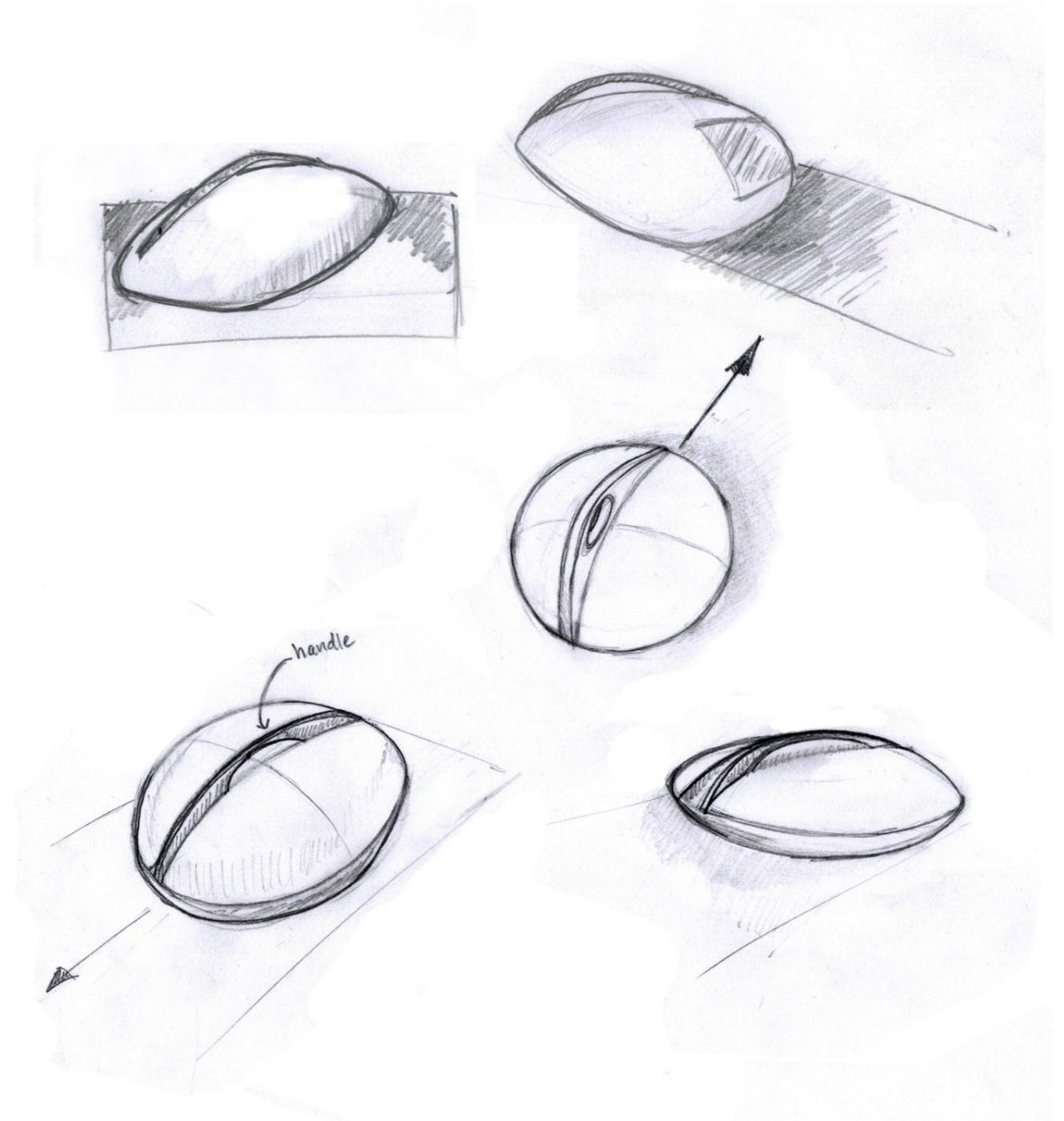
Form study - creating direction. First thoughts on the form of the product. It was eventually decided that the product should be "roundish" in shape for several different reasons. Therefore I explored ways of enhancing direction, like utilizing the interface, that would give feedback, as a directional indicator as seen on the lower end of this page.



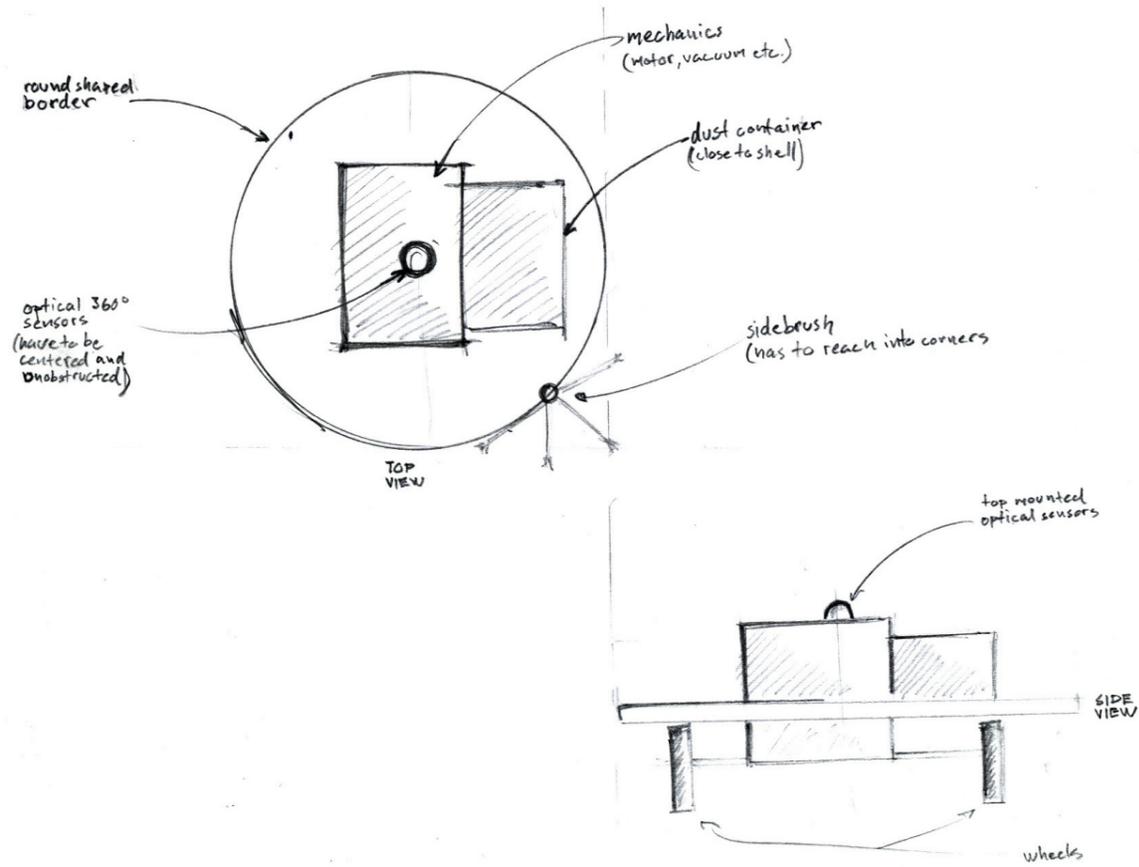
Directional interface. Further sketches on incorporating a directional interface.



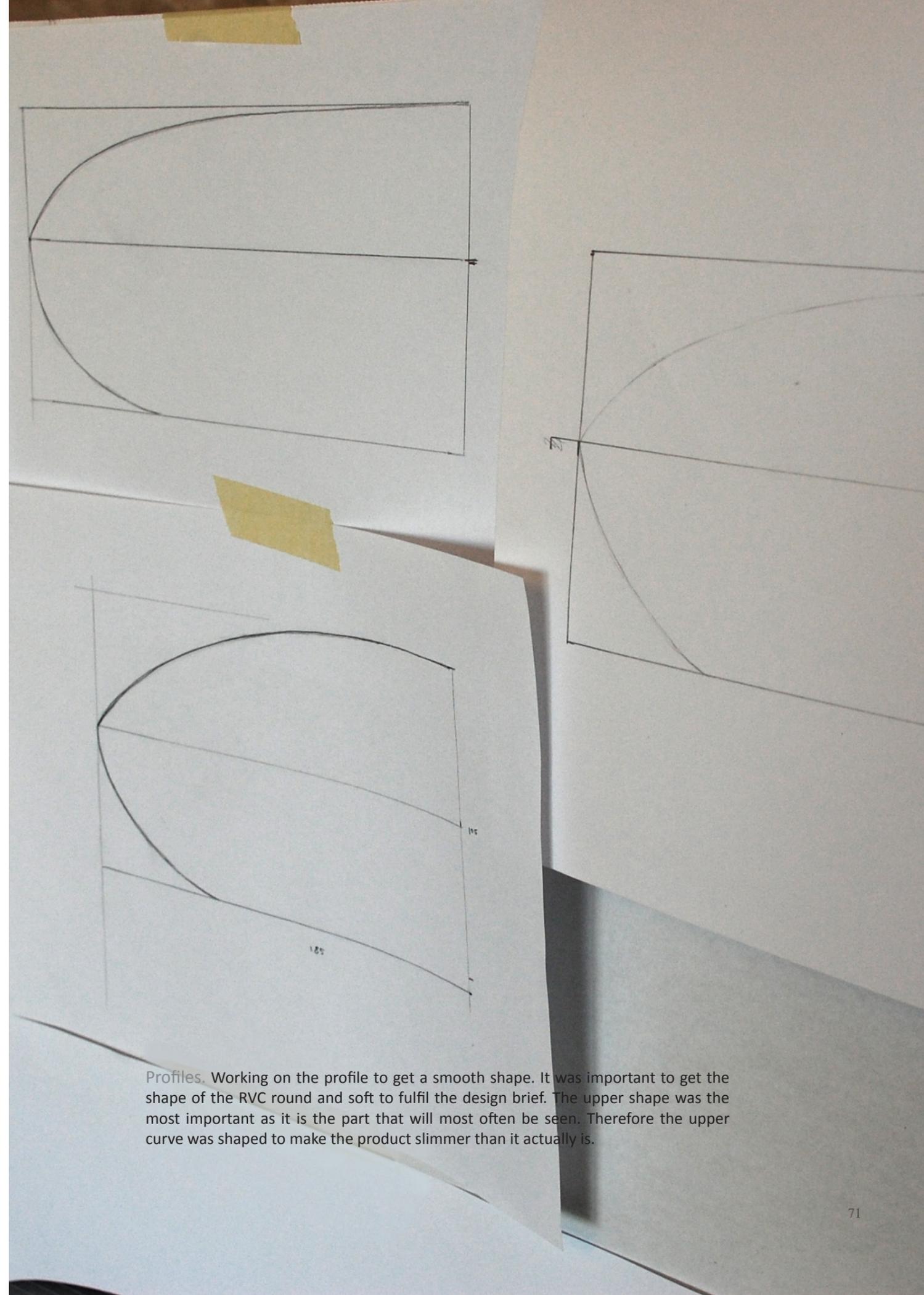
Rounded. Moving towards a rounder shape.



Handles. Another option for communicating direction would be to incorporate a directional handle, as seen in the sketches above. This concept was later discarded; the handle would simply add too much height to the RVC. I also questioned whether it was actually wise to too strongly suggest the physical interaction. Potential users might interpret the RVC as less automatic because of the distinct handle.



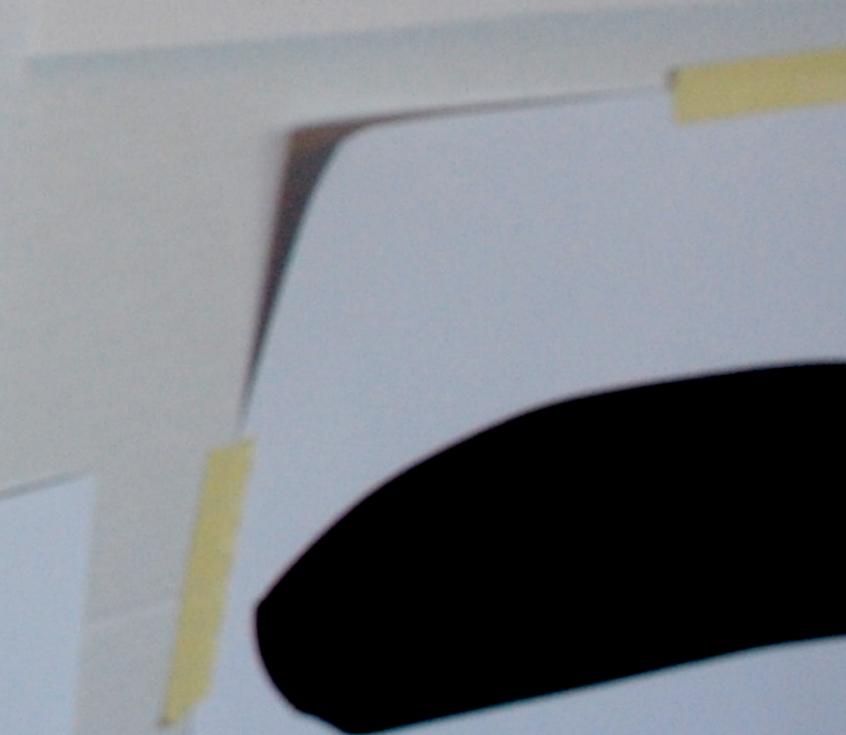
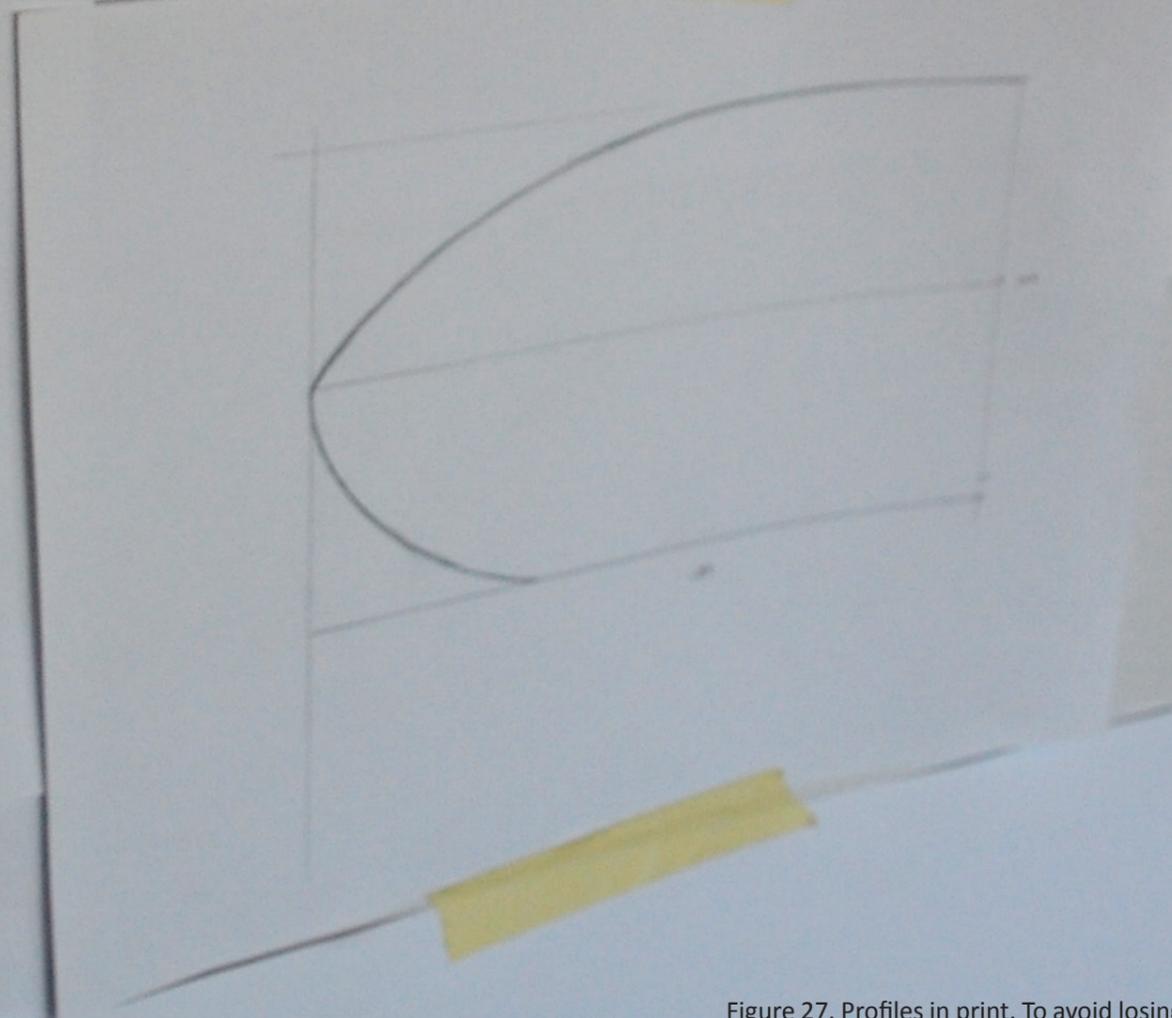
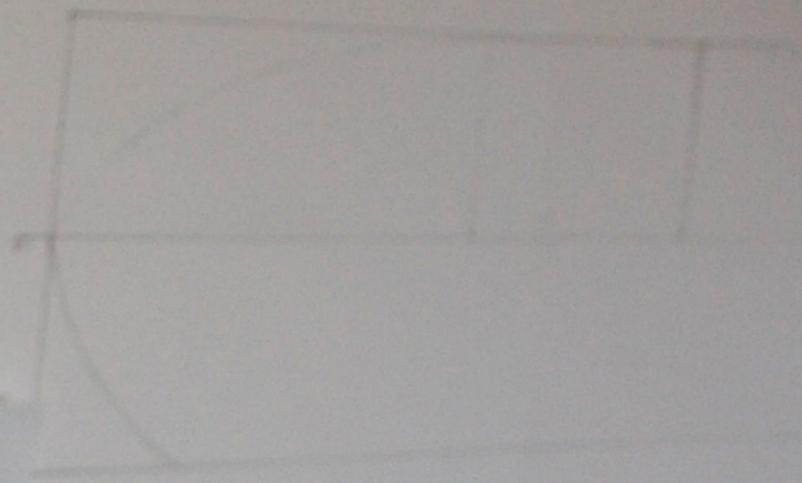
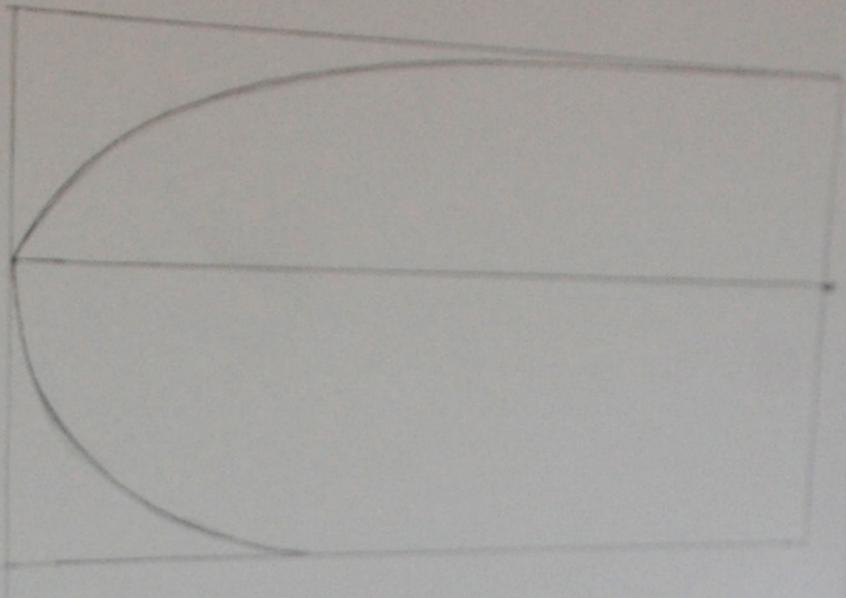
Overview of some of the things that have to be incorporated into the design. One of the things to note is that the omnidirectional camera with mirrors needs to be placed on the top and centre of the RVC to work efficiently, so that part needs to be open or covered with a see-through material.



Profiles. Working on the profile to get a smooth shape. It was important to get the shape of the RVC round and soft to fulfil the design brief. The upper shape was the most important as it is the part that will most often be seen. Therefore the upper curve was shaped to make the product slimmer than it actually is.

ain function N= Necessary D= Desirable

Vacuuming	MF
Automatic	MF
Human control	N
Remote control	D
Interactive	N
Interactivity	D
Feedback	N
visual feedback	D
audio feedback	D
Responsive	D
Lifting/moving	N
Physical interactivity	D
Ergonomic	D
Grip	D
Cleanable	N
Hair removal	D
Filter for valuable things	D
Carpet vacuuming	N
Dust container	N
Automatic dustemptying	D
Dust level in container	D
Effectivness	D
Trust	D
Unthreatening	D
Move-pattern/direction	D
Ability to limit cleaning area	D
Child/pet safe	N
Obstacles	N
Level-changes/staircases	N
Chargable	D
Automatically chargeable	D
Versitile/multifunctional with tradiotional vacuum cleaners	D



Provide for physical interaction #
 Hair filter/removal
 Carpet handling
 Automatic dust emptying
 Versitile/multifunctional
 with tradiotional vacuum cleaners #

Figure 27. Profiles in print. To avoid losing the concept of scale and size all the work on the profiles was done in 1:1 scale. Everything done in the computer was periodically printed out.



Encasing shape. Because the top part would at all times be visible it should in some way be protected from impact and scratches. The lower part on the other hand will only be seen if the RVC is lifted up, which should be rarely, and can therefore be made with a sturdier finish. For that reason the lower part was made to be sort of a “bumper” for the upper part. Above you see inspiration for this - things that convey the feeling of one shape encasing the other, the acorn being one such example.

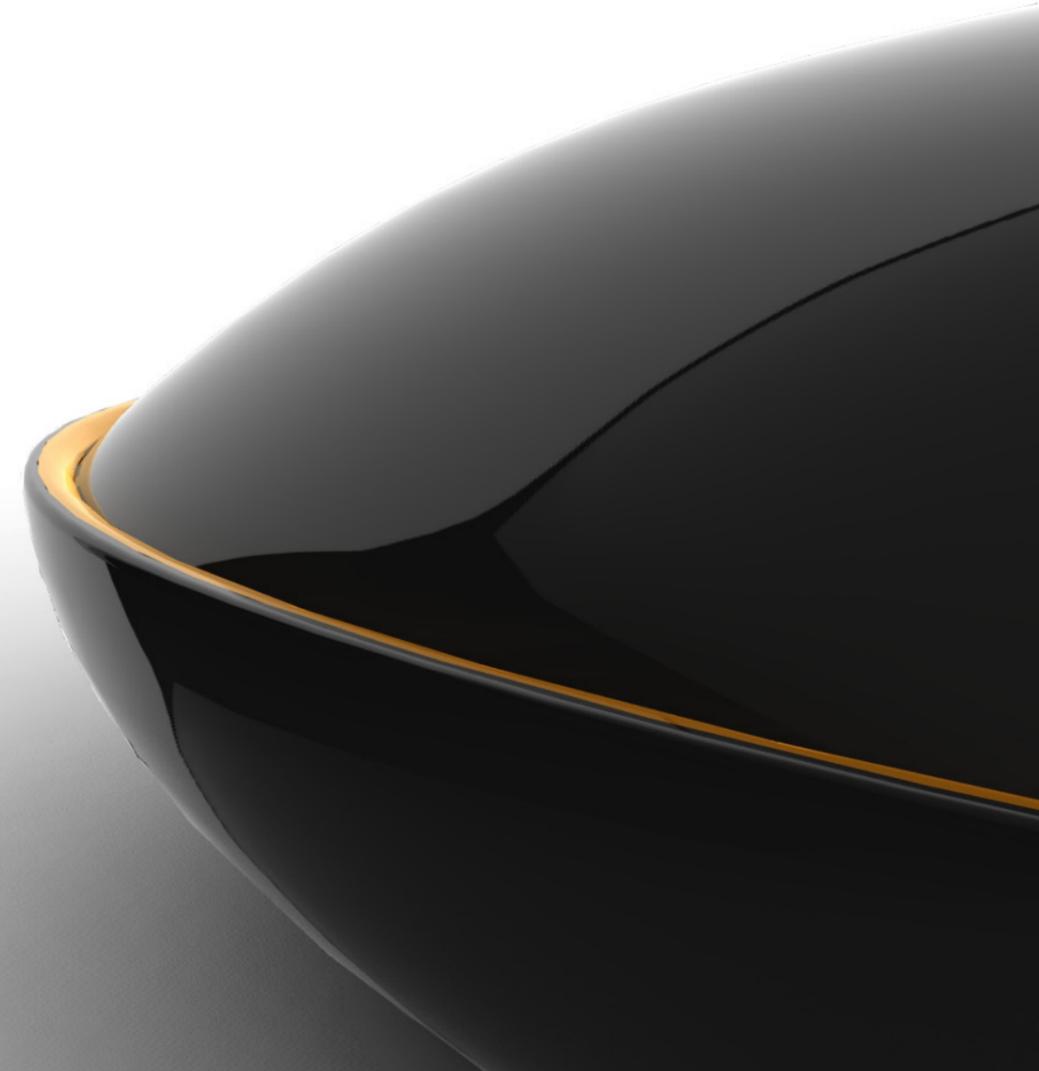
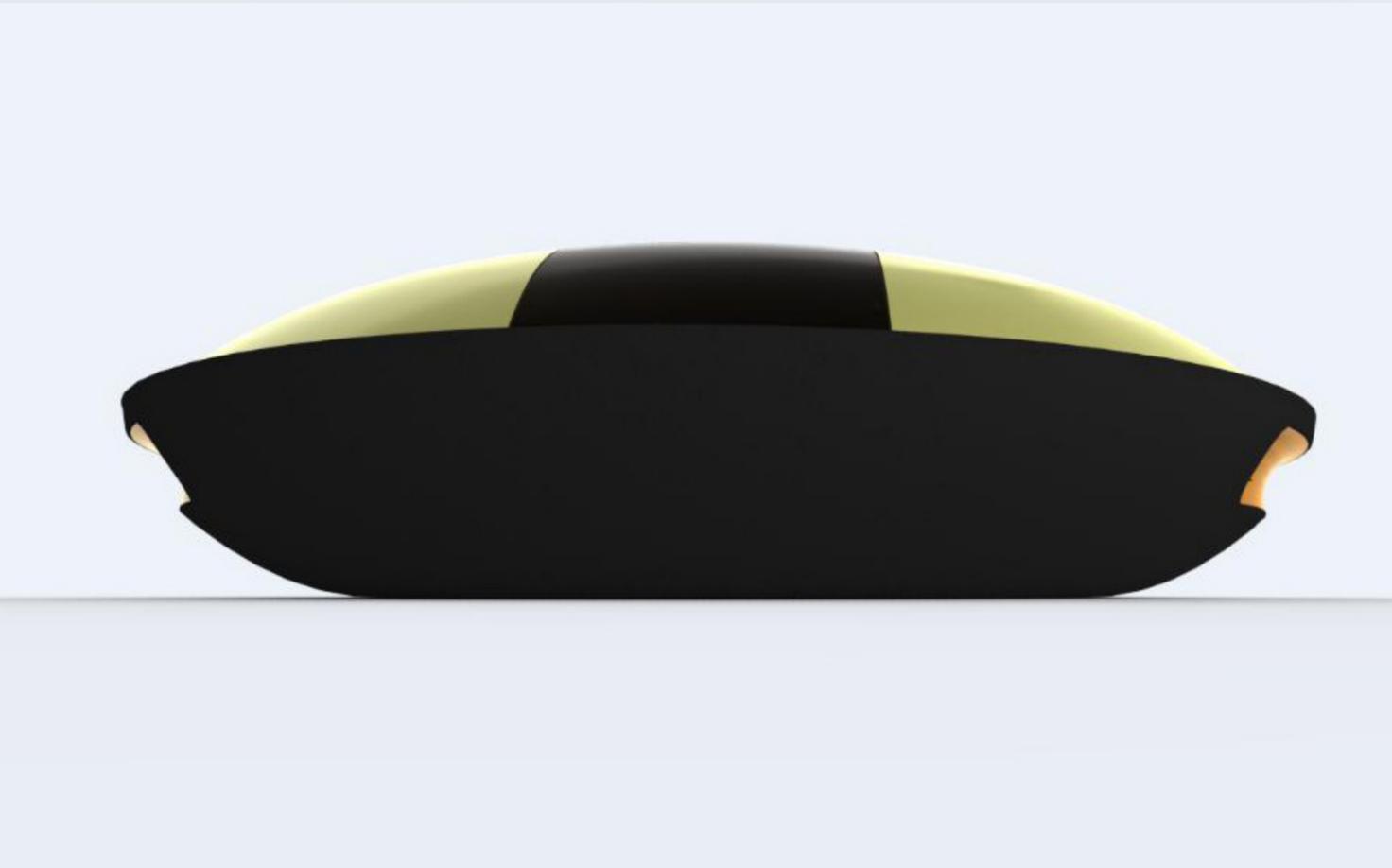
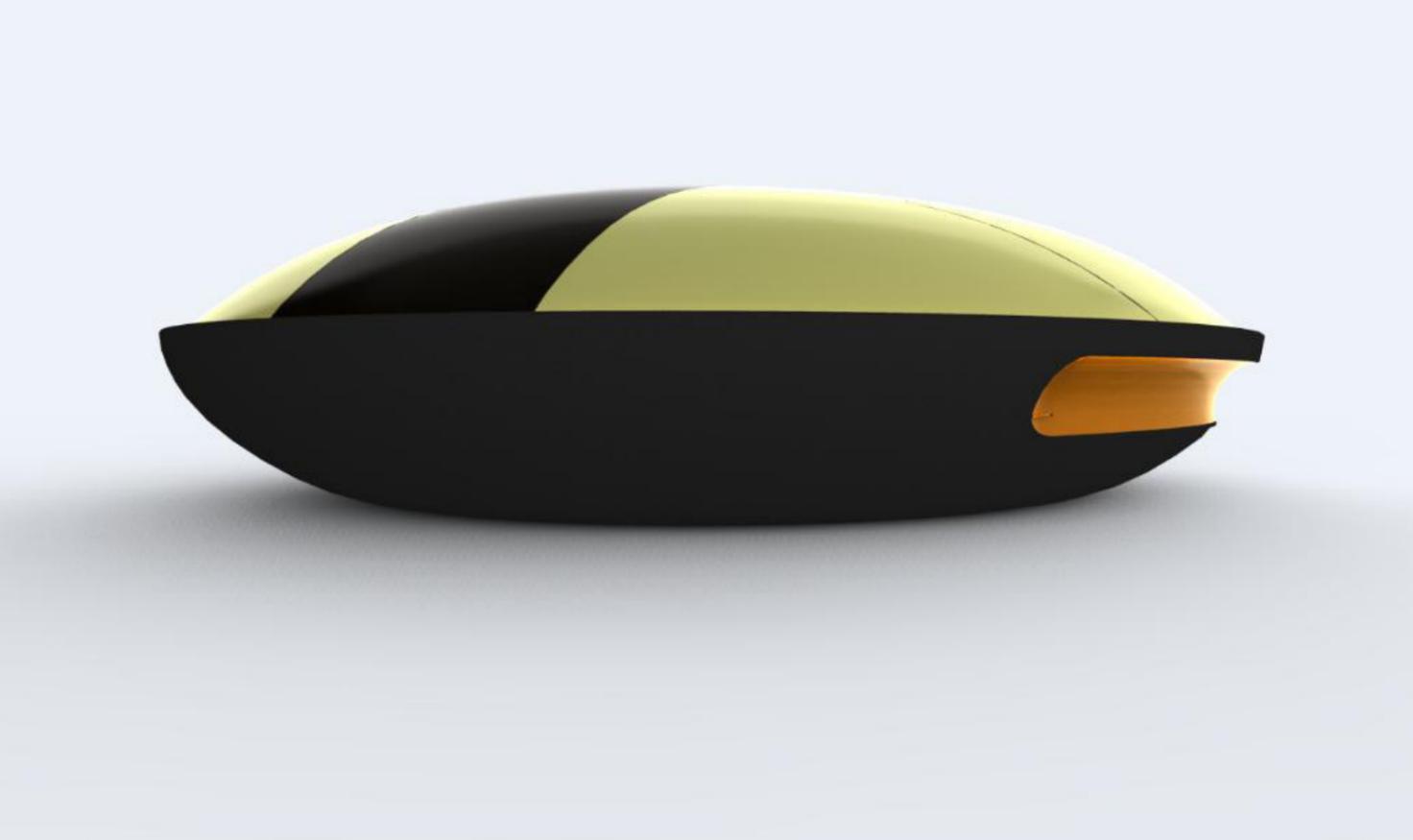




Figure 28. Sketch models based on the profiles were made to get a clearer idea of the full shape. The model in the back also roughly shows the encasing shape discussed above.



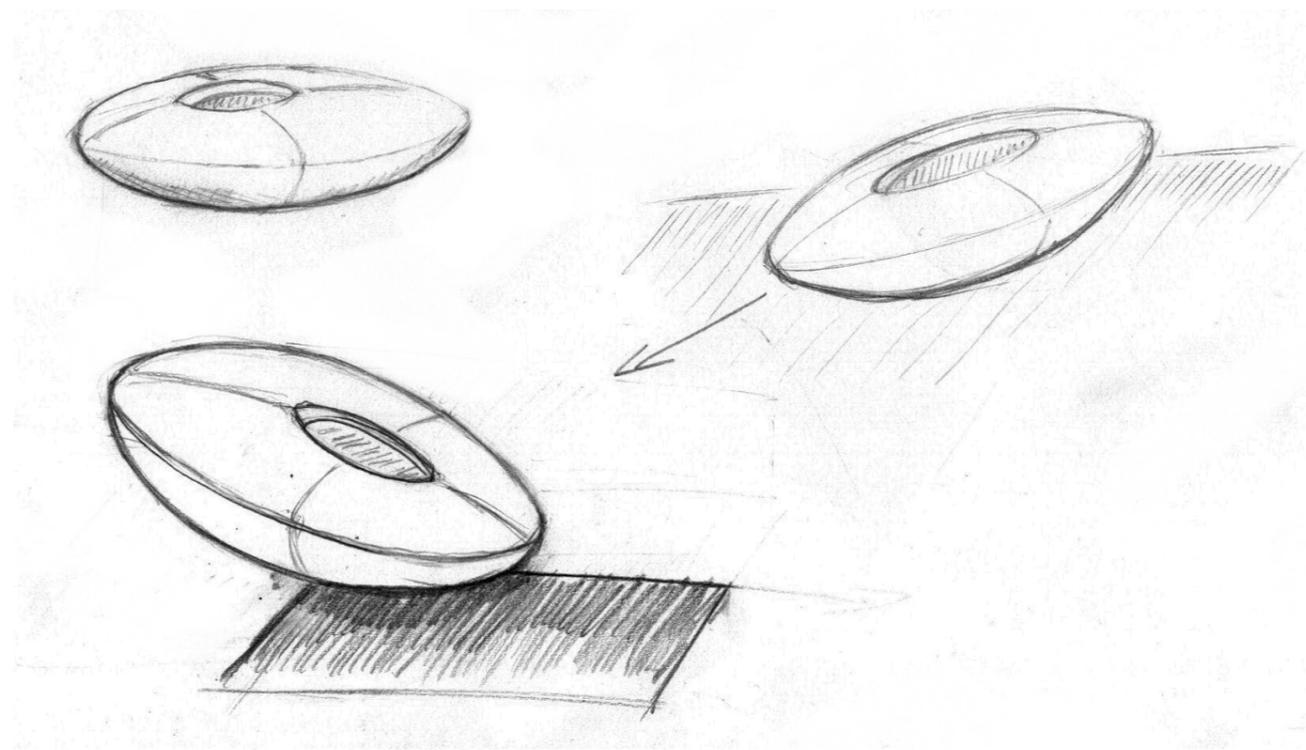
Grip. Because every incision into the shape of the RVC had such a drastic effect it took some effort to get the side grips right.



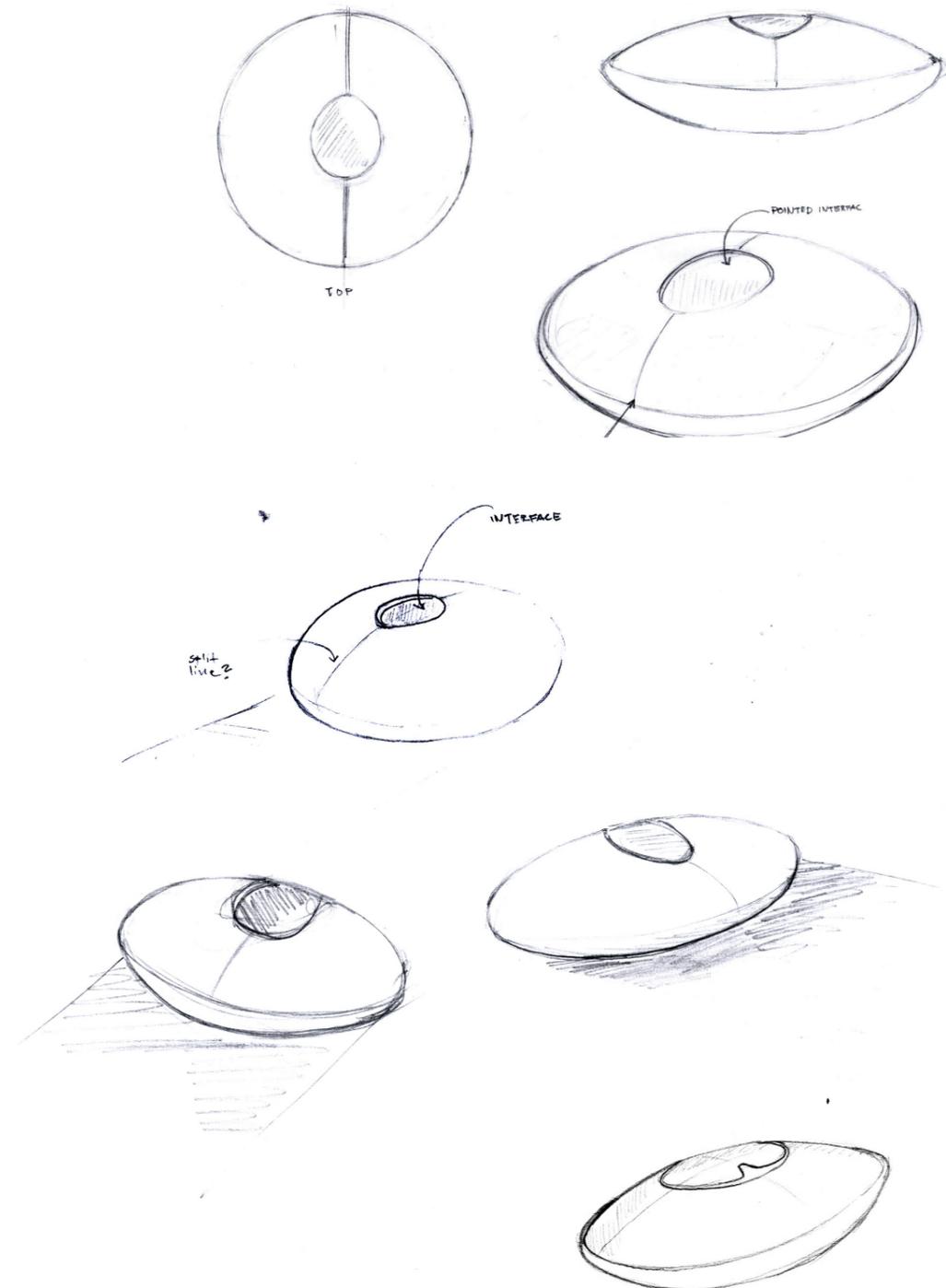
After observing some people lift the sketch model, I realised that the grip was actually needed at lower height for the fingers to fit. After this the grip was revised, see next spread.

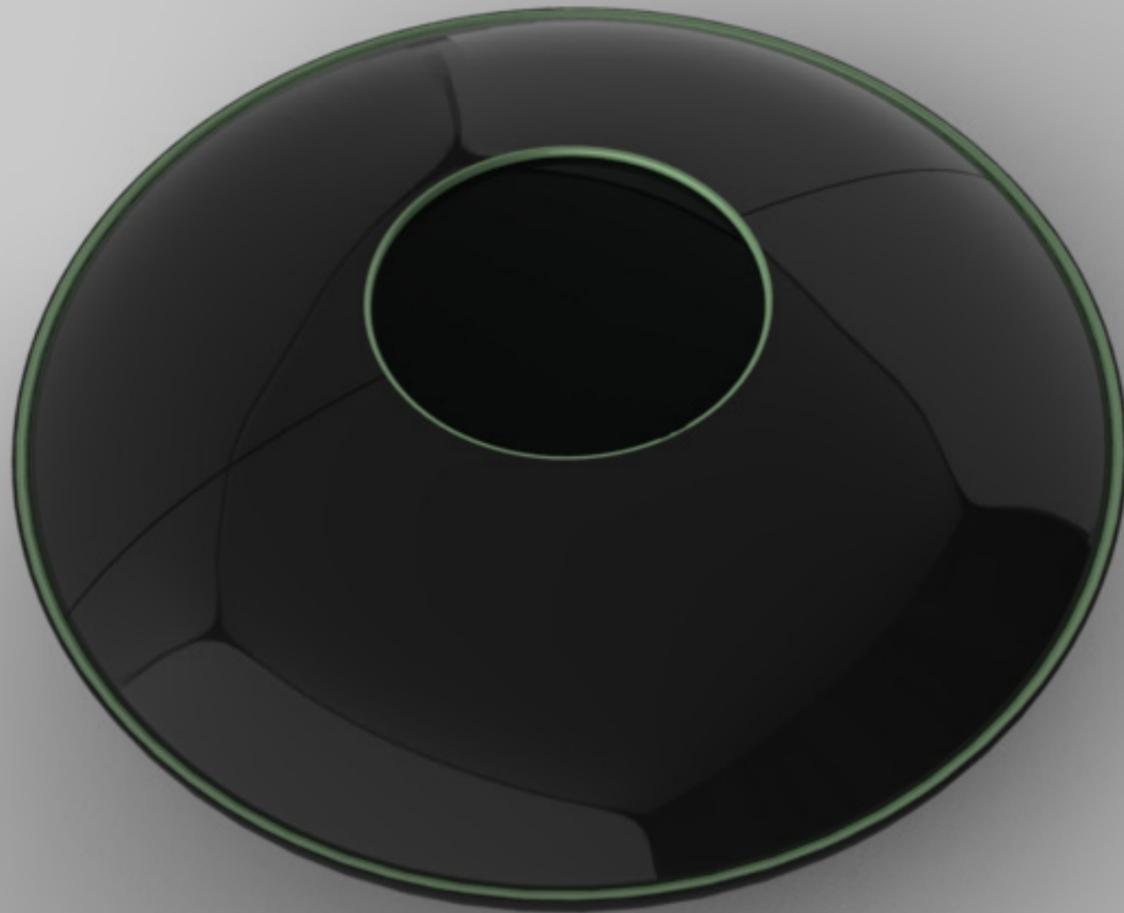


Revised grip. A circular indent (shown in orange) will hint the correct holding position to the user.

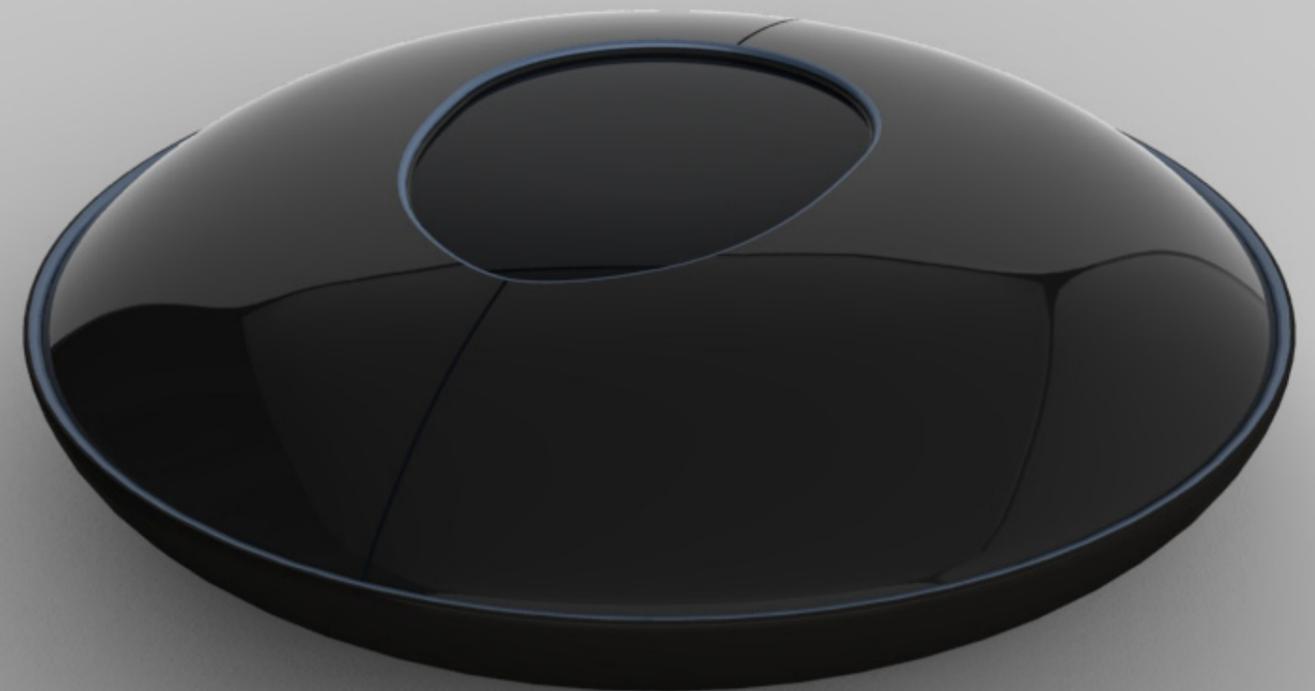


Interface redrawn. The directional interface was deemed too prominent and overshadowed the shape of the RVC. Concept seen above was the initial idea for a semi-circular interface placed at the top of the product. Later refined into the rounded shape seen to the right.





3D-CAD of the circular interface concept.

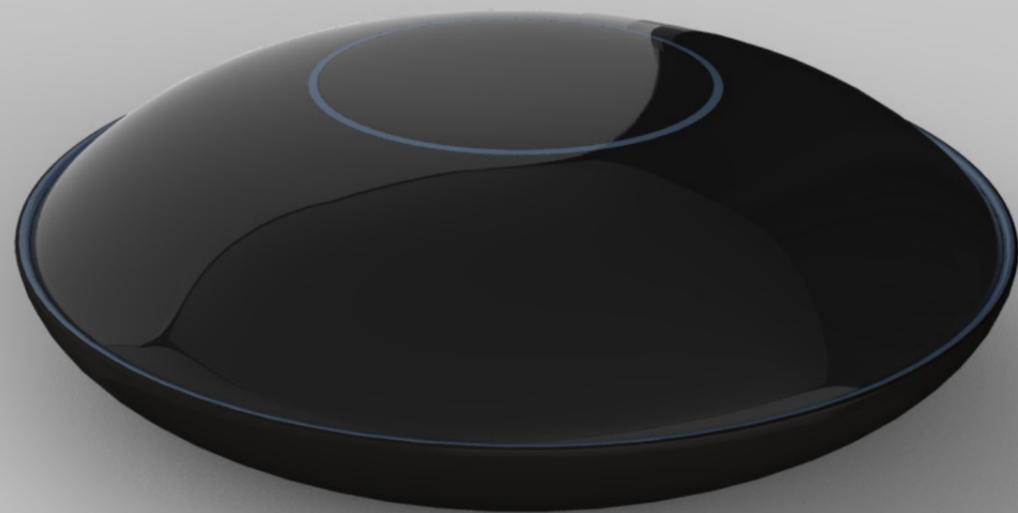


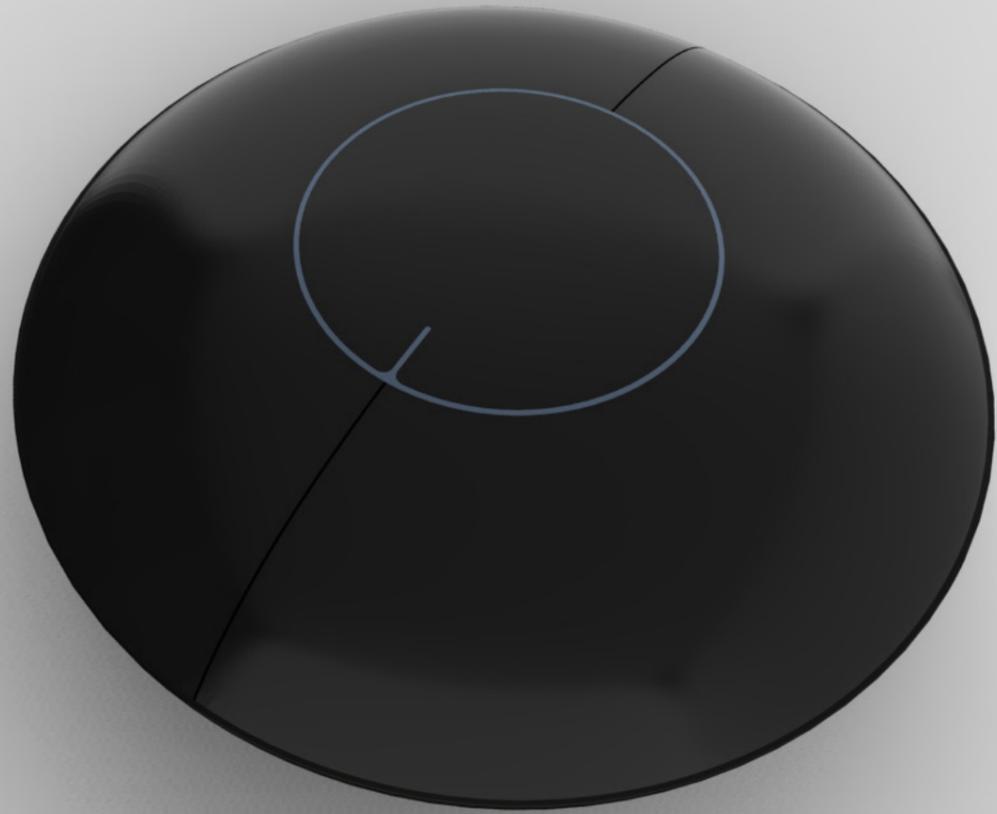
A pointed interface to communicate direction was also considered, but decided to be unnecessary.



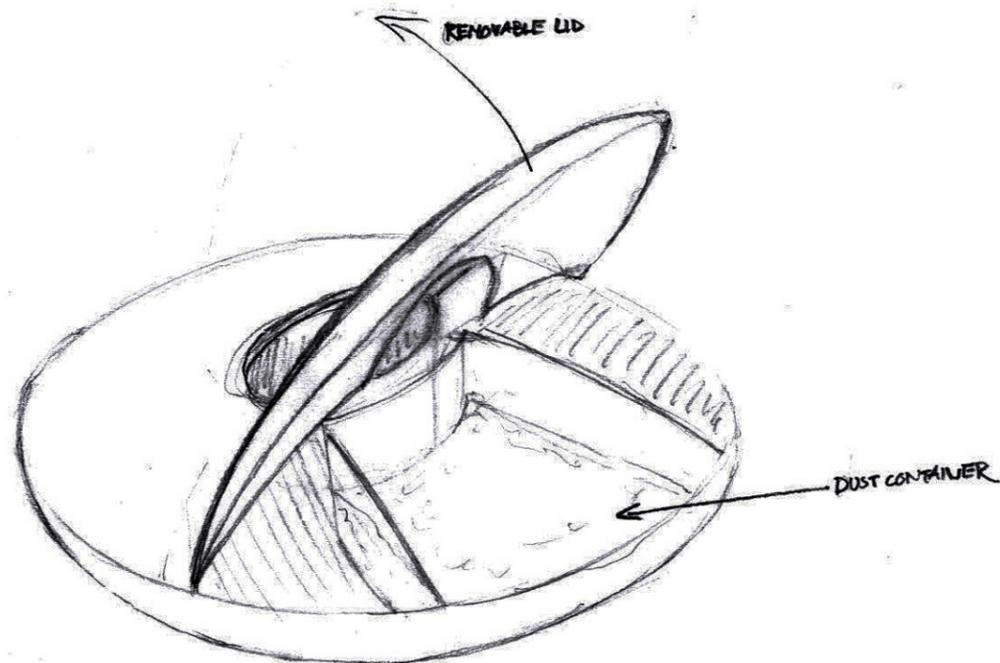
The interface made flush with the rest of the shape. To highlight the interface and show the user where to interact with the RVC the interface is slightly concave in the upper left rendering and surrounded with a colour ring in the bottom left.

The induction stove above can be seen as inspiration for highlighting a flushed surface.

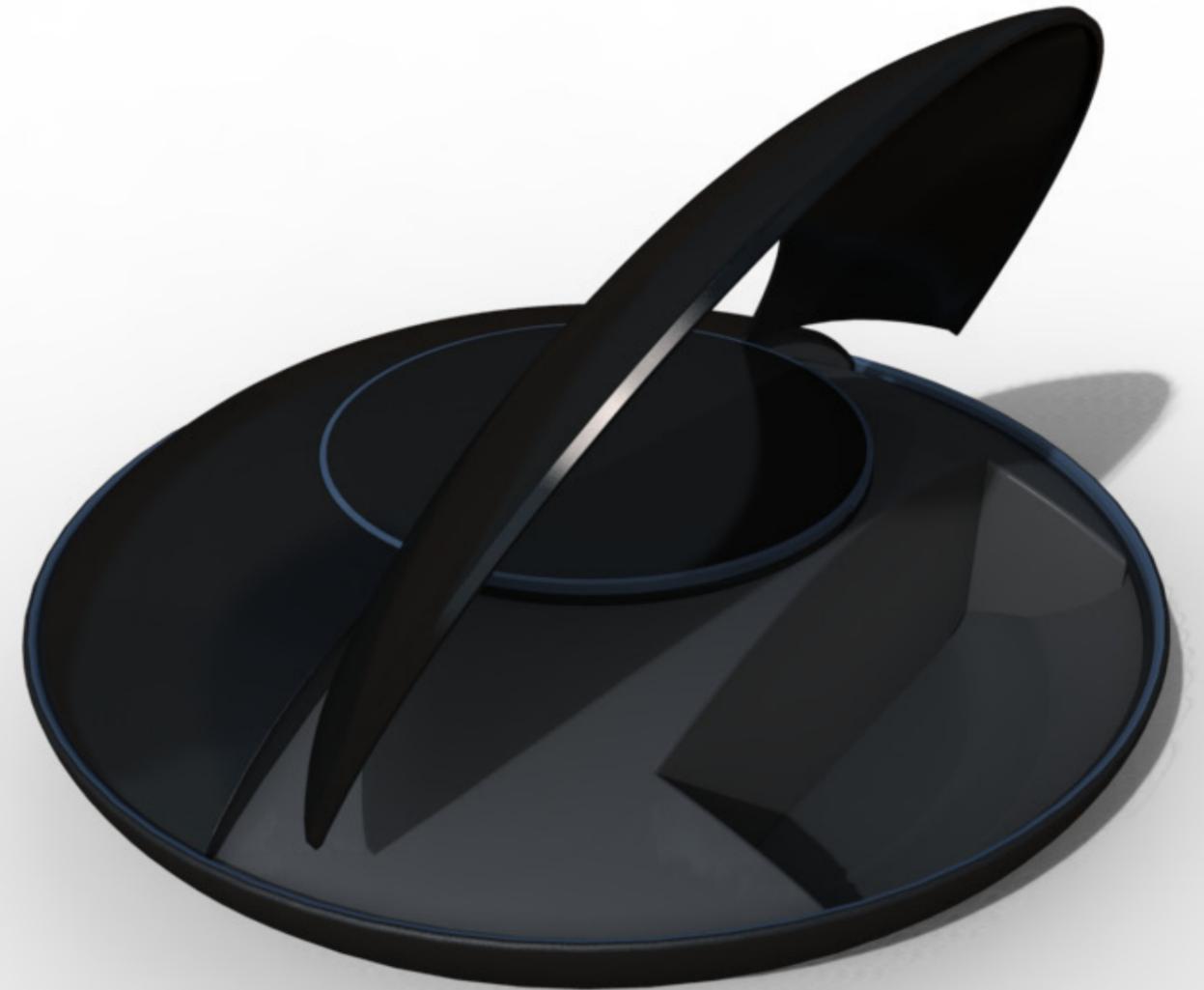


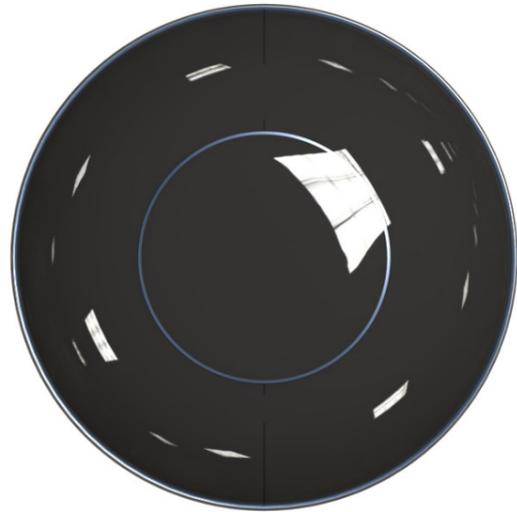


Directional indication. Different solutions for communicating direction was considered. Adding some kind of graphic or logo, as in rendering above, was decided to be enough to establish a direction.



Concept for removal of dust container. Pushing on the back half of the RVC makes the shell pop up, after which it can be lifted up and the dust container removed.





Colorization. The interface needs contrast to display properly which requires a dark colour to be applied to the RVC. To lighten the heavy expression, a lighter colour was chosen for the details. The final colorization can be seen above, where a matter finish was chosen as to not overly reveal scratches and dirt.



Interface concept. When the RVC is given an “attention” command it stops and turns to the user and communicates the command has been received. This is shown by an expanding digital ring (as seen above), similar to the way an eye opens up. The RVC is then ready to be given whichever command the user wishes.



Digital representation. Additionally, the interface can show digital icons representing the battery running low and the dustbin being full. In this case the RVC will automatically be returning to its charging station and most commands will be ignored. This way the user will know why the RVC is returning to charging station instead of vacuuming.

PART 5: FINALIZATION

RESULT

The following pages depict the resulting design concept of this project; a full-scale model of the design as well as digital visualisations of the concept.







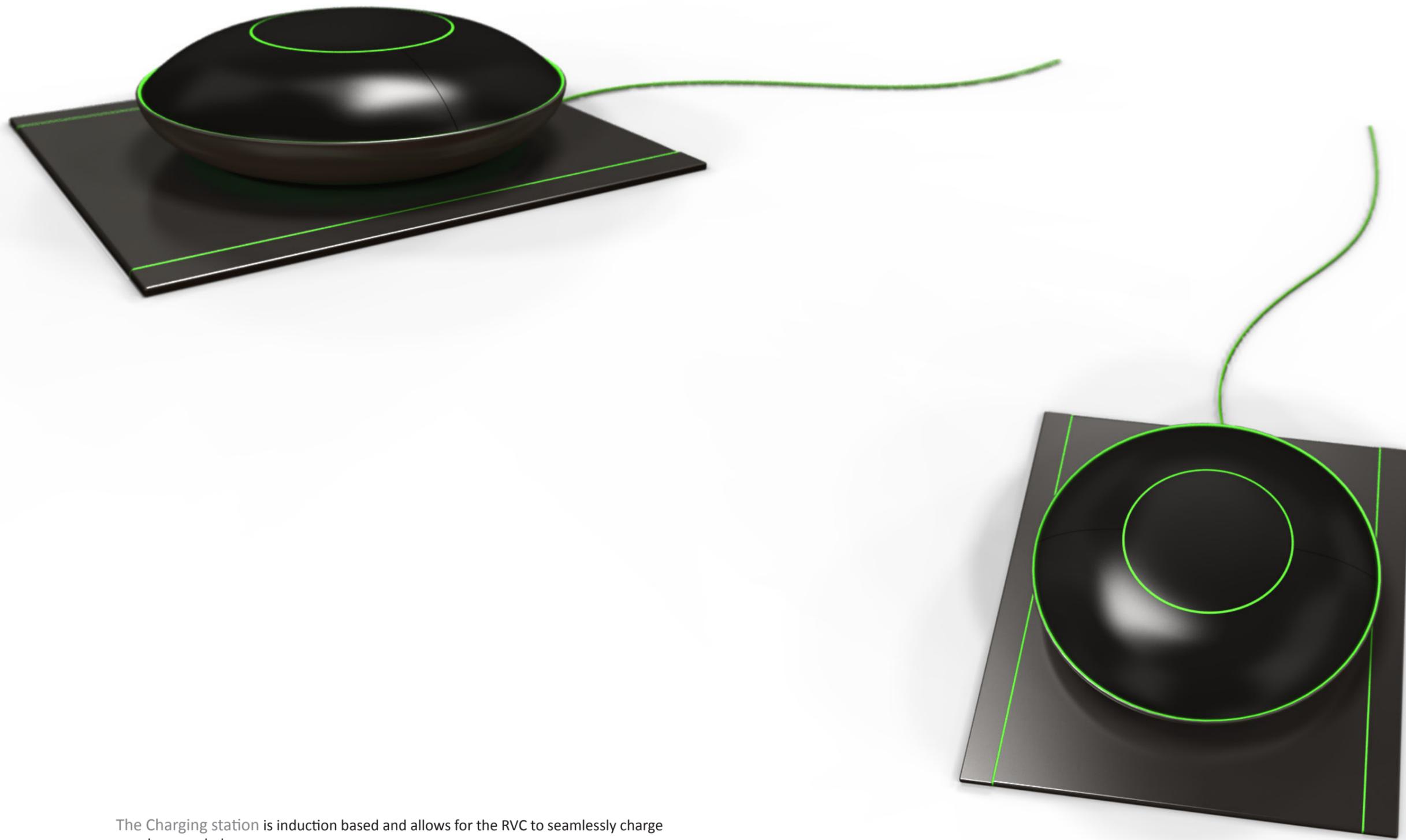
The RVC being given the attention command.



Top view.



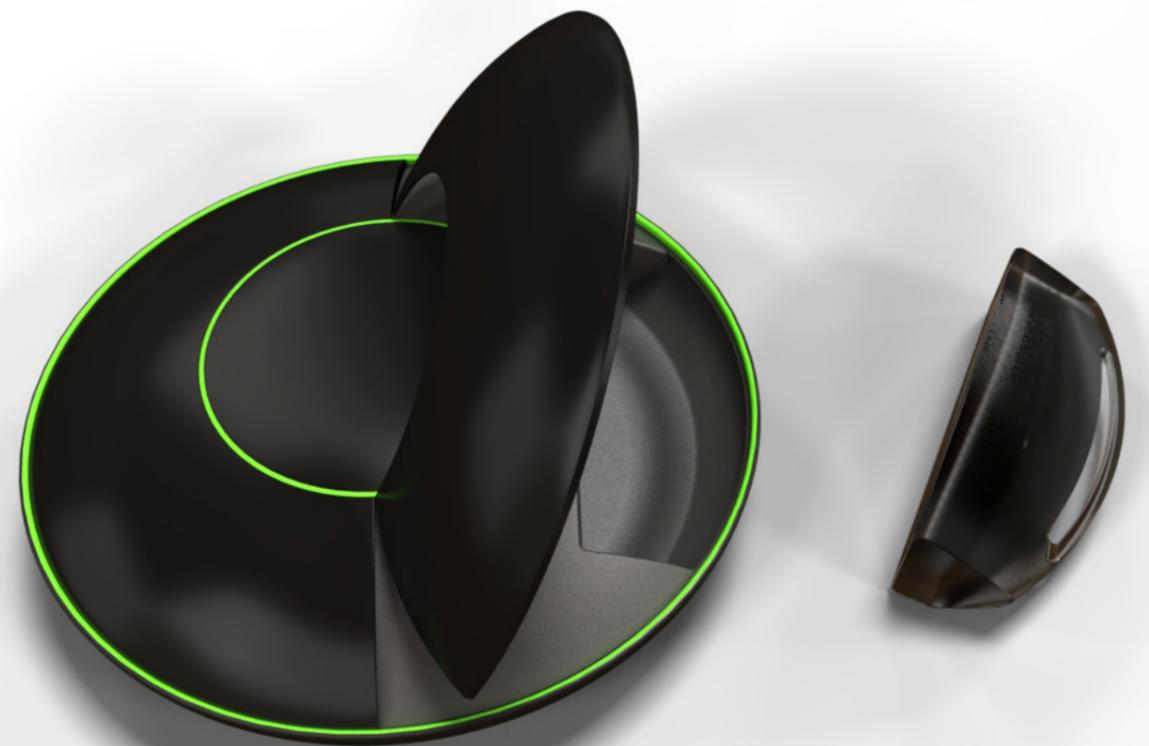
The brush, seen here, allows for more accessibility.



The Charging station is induction based and allows for the RVC to seamlessly charge up when needed.



The dust container is removed and emptied by first pressing down on the back half of the RVC which makes the lid pop up.



The user can then lift up the lid, which is fastened by hinges, and remove the dust container by the handle.



Close-up of the meeting between the lower and upper shapes.

View of the RVC placed upsidedown. The slightly indented green ring is the grip and the brush can be glimpsed in the background.





Back view detailing the two air-exhaust on either side of the RVC.

15. ACKNOWLEDGEMENTS

I would like to extend my gratitude to:

First and foremost my family, girlfriend and friends for their support.

All the helpful interview participants that kindly let me into their homes to share their experiences. Special thanks to Henrik Thorvinger, Mia Bancke, Kicki Alsén and Anna Aalto.

Koray Özsoy for sharing with me his inspirational and insightful thesis report.

My supervisor Charlotte Sjödel for at times pushing me in the right direction.

Jasjit Singh for going beyond his role as examiner.

The School of Industrial Design at Lunds University and Claus Eckhardt for supporting me in realizing the model.

Finally, the dog Ted for enduring some confusing moments for the sake of my research.

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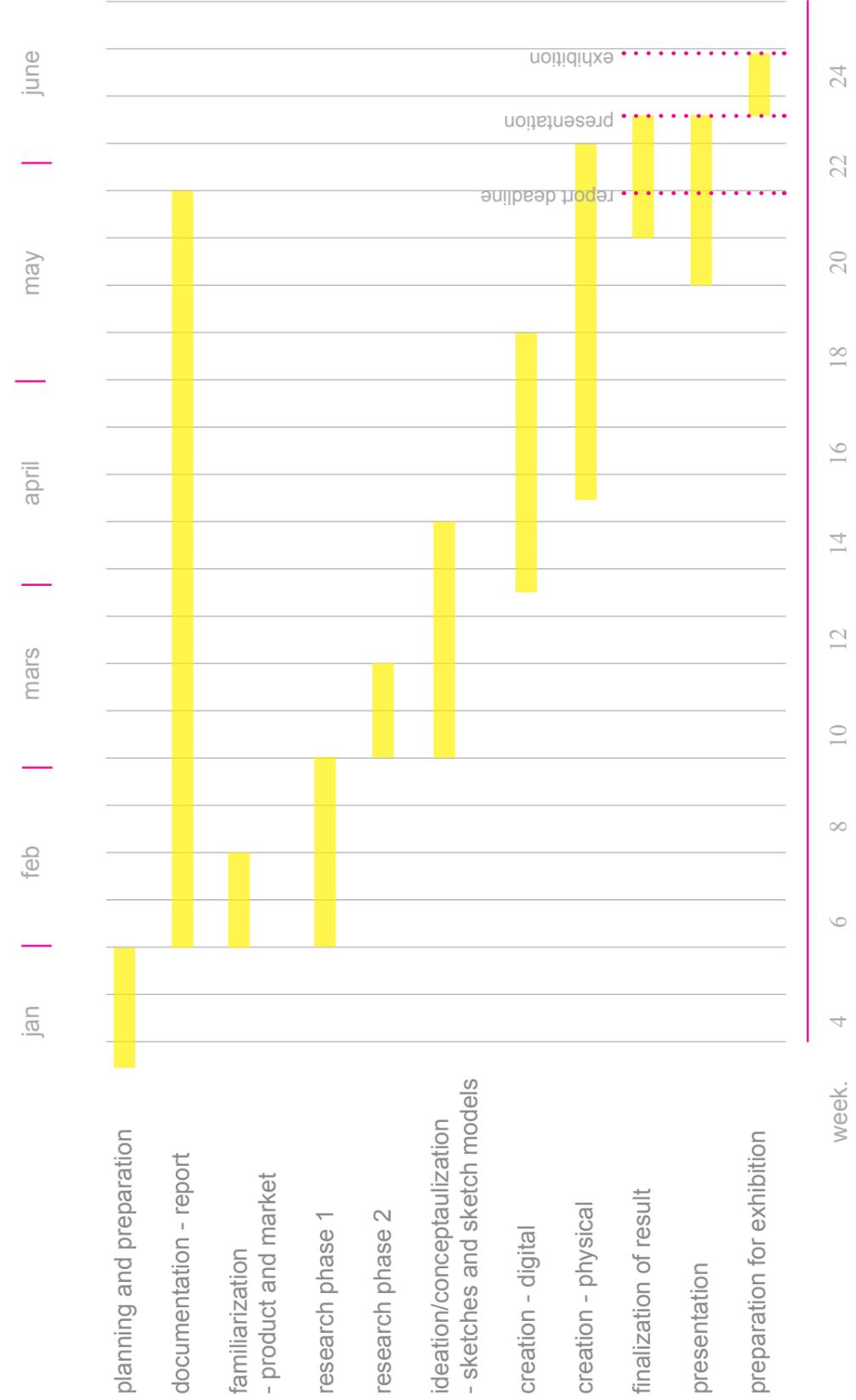
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APPENDIX

Dmitrij Juzoviński
Lund University
2011-01-21

Project time plan - robotic vacuum cleaner

Appendix A - Project time plan



Cleaning Robot Market Leaders
iRobot
Matsutek
Roboking
Metapo Cleanmate
Electrolux
Karcher
LG

Cleaning Robot Market Participants
Aquaproducts
Bandai
Coroware
Electrolux
Hanool Robotics
iRobot
Karcher
KumoTek
Kyosho
LG
Microbric
MSI
Neato Robotics
NEC
Parallax
Samsung
Surveyor
Yujin
Zodiac Pool Systems

INTERVIEWS, MANUFACTURERS

Interview 2011-02-09. Sales staff, Kärcher, Göteborg, Sweden. Telephone interview.

What does your range of robot vacuuming cleaners look like?

We only carry one model of autonomous vacuums.

What is your main target group?

Our RVC is meant for personal usage and mainly house-owners. We are active in Sweden and Denmark.

What is the price range?

Our model costs about 15000SEK.

Do you feel there is a pull from the market for RVCs?

Not particularly. I think the technology is too expensive as it is, maybe in the future. The same goes for robot lawn mowers.

What is your sale volume of RVCs?

We sold about 25 last year (2009)

Do you perform any marketing specifically for RVCs?

No.

INTERVIEWS, RESELLERS

Interview 2011-02-11. Sales clerk, ElGiganten, Nova Lund, Lund, Sweden.

What RVC models do you carry?

I think we have two models of RVC's, both from Samsung. They costs somewhere between 3800-5000SEK depending on model. We do not have them in the store, but I can order one for you, or you can go to our website and order one.

(Follow up) What is the difference between the two models besides price?

I am not entirely sure; I think the more expensive one has more programs.

(Follow up) Why don't you have them in the store?

We had a show copy before; I don't know why we got rid of it. They are just not so popular.

Which model sells the best?

I believe the less expensive one is more popular.

How many RVC's do you sell in comparison to traditional vacuums? (Every 100/1000?)

That's hard to estimate! Maybe 500 regular ones for one RVC.

(follow up) Why do you think that is?

I think the people who come in and buy them already know what they are looking for; they've seen it somewhere and are curious. But most don't know of RVC's at all.

When people come in and are looking for a regular vacuum cleaner I have a hard time recommending them a RVC as an alternative. A robotic vacuum doesn't really offer the same kind of suction and cleanliness. I say the same thing to customers looking for a small hand vacuum, it's more of a complement. Neither would I recommend it for people allergic to dust or mites as they (RVC's) do not have enough suction to handle that properly.

Maybe it is discouraging for some to buy a complement that is relatively expensive.

Do customers frequently come back with complaints on the purchased RVC?

That I do not know, you will have to ask the complaints department.

Do you have any other comments?

We actually use a Samsung Navibot RVC here in the store to keep it tidy. It works pretty well for day to day use.

Comments on interview;

It is surprising that a store of that size do not have any RVC's in-store. The sales clerk was not overly optimistic about RVC's and the sales are astoundingly low. Customers actually purchasing a RVC are ones already set on buying one, so no real sales pitch is made in the store. These factors combined of course mean a low sale volume.

It is also interesting that the employees use a RVC themselves for vacuuming the store, and the sales clerk mentions it works well, which in a way contrasts some of the things she said about RVC's up to that point.

Interview 2011-02-11. Sales clerk, Media Markt, Nova Lund, Lund, Sweden.

What RVC models do you carry? What do they cost?

We have a couple of different models of the iRobot brand, more specifically the Roomba 500 series. The cheapest one we have is 4600SEK and the most expensive one is 6500SEK.

(Follow up) Do you have them in stock?

No, they are order only. We have one copy of Roomba 520 in the store here that is ready to buy.

(Follow up) What is the difference between the two models besides price?

I am not really too familiar with this. My best tip would be to go directly to the manufactures website to compare the models.

(Follow up) Do you have the information on your own website?

No.

Which model sells the best?

The ones in the lower price range are also the ones which sell the best. This is true for most household appliances though.

How many RVC's do you sell in comparison to traditional vacuums? (Every 100/1000?)

I would say maybe one to a thousand. I've sold maybe an average of 1 a month since I started working here.

If you generalize, who is a typical buyer.

Well, if I have to say something it would be bachelors or families with a couple of children. They have often read up on the internet before they come here and somewhat know what they want.

What do you think would have to be improved with the RVC for it to become more

popular at your store?

They would have to be a bit cheaper. Another thing people often mention is that it's tedious to empty the dust bag frequently and they have to do it pretty often. So bigger dust containers would be good.

(Follow up) Aren't there models that have self emptying dust bags?

Yes, but those are the expensive ones.

Any additional comments?

You know, we had a demonstrational Roomba set up in the store awhile back, it went around vacuuming in a small area. People got curious and I do recall sales going up. But sales space is limited, so we had to make room for other things.

INTERVIEWS, OWNERS

Interview 2011-02-03, Henrik Thorvinger, age 29, owner of an iRobot Roomba 534, telephone interview

Was the choice between a regular and automatic vacuum?

No, I was looking for an RVC, because I wanted to try it out. Thought it was a cool idea, as I hate cleaning and therefore put it on my Christmas gift-list.

How long have you had your RVC?

For about 2 years.

Did you have to use both a regular vacuum and RVC to clean?

Yes, but I used the RVC more regularly maybe once a week or so. I used the regular vacuum when doing a more thorough cleaning about once a month.

Did you have to prepare the cleaning area before starting the robot vacuum cleaner?

Yes, I put some chairs up and tried to rid the floor of things like clothes and shoes. ...this did not take more than 3-5 minutes though; I did not find it very cumbersome.

What were some of the problems you encountered when using the RVC?

If someone in your household has long hair it tends to get stuck underneath the robot, I had to remove those hairs manually myself.

The robot sometimes got stuck on higher thresholds, so I had to lift it over. But it could

handle most thresholds. I also had to lift it between different floors because of stairs. But it quickly learned the layout of a new area.

Did the RVC have trouble getting under your furniture?

Actually not too much trouble. There were one or two things it couldn't get under; I had to vacuum there myself.

Was the sound level high?

No, it was quieter than my regular vacuum cleaner.

Was it complicated to understand the RVC and get it started? Did you feel in control of the process?

It was not complicated. I basically just plugged it in and pressed the start button. Although I would like to say that I usually do not have any trouble with technical things like this.

Where did you store your robot vacuum? Out in the open/ in a cleaning closet?

In the open, because it had a pretty big charging station that it had to return to. But I tried to hide it a little behind a piece of furniture, so it was not overly visible.

(Follow up question) Did you show it to house guests?

No, it is not something I usually showed off.

Comments from interview object:

Henriks brother, who was present and also had some experience with the Roomba 534, told a interesting story on the topic. The robot was cleaning when their mother had visited them one Christmas, and upon seeing this she exclaimed: "Poor robot, it has to clean on Christmas while we sit around enjoying ourselves."

Comments on the interview;

Through the whole interview Henrik was very positive about his experiences. He is obviously a person who likes to try new things, and is very receptive to new technology. The interview shows that minor faults do not bother him as much as they maybe would other, less enthusiastic, people.

The story about their mothers' reaction, which was entirely unprompted, might show a clear distinction in attitude between generations. While Henrik seems to see the automated vacuum as an exciting innovation, his mother seemingly relates to it as one might a personal butler or pet – projecting feelings onto the product. Of course some of her statement is probably of a humorous nature, but must have stemmed from a spontaneous thought.

Interview 2011-02-03, Mia Bencke, age 27, owner of an Infinuvo CleanMate QQ-2L, house visit. Household = 60 square meters, two room apartment. Two people, mother and daughter.

How long have you had your RVC? Where did you purchase it?

About 6 months. I bought it used from the United States for about 2000SEK

Do you have to use both a regular vacuum and RVC to clean?

Yes I often use both when cleaning. I use the RVC maybe 3 times a week, and complement with the traditional vacuum cleaner when needed.

How long does it take for your RVC to vacuum your living space?

I think it takes something like 30 minutes. Sometimes it takes longer but I do not know why.

Do you have to prepare the cleaning area before starting the robot vacuum cleaner?

Yes a little bit here and there. For example: if I want it to vacuum under the bed I have to remove some storage boxes from under there. Often what happens when I don't do any preparation is I have to watch after it so it doesn't get stuck or something. I end up lifting it up sometimes and putting it on the spot I want it to clean on.

What are some of the problems you encounter when using the RVC (like cables, battery life and such)?

It gets stuck on the shoe rack and on some carpets. The dust bag is also filled up and I don't know how to empty it!

Does the RVC have trouble getting under your furniture and other hard to access places?

I don't know, not really. It does get under the bed as I said. It does not get under the sofas on the other hand.

Is the sound level high?

Well...of course it makes some noise but about as much as my regular vacuum.

(Follow up) Can you have it on when your home?

Yes, I usually turn it on when I'm home.

Was it complicated to understand the RVC and get it started?

Yes, it was a little tricky. The instructions were in English (as opposed to native Swedish, writers note).

Do you feel in control of the RVC when it is vacuuming?

Yes, I think you could say that!

Where do you store your robot vacuum? Out in the open/ in a cleaning closet?

It is in my living room, pretty much out in the open.

Do you show house guest the RVC when they visit (i.e. is it a topic for conversation?)

Yes, people usually ask a lot of questions, but there is not much to say. Although, sometimes I think I am going to start talking to the robot!

Do you try to keep children/pets away from the RVC?

Not really. I think my small children more or less get excited when it is vacuuming which tends to end up with them jumping around in the sofa.

What do you think of the cleaning experience with your RVC? On a scale from 1-10, where 1=horrible 5=Ok and 10=Very enjoyable.

7.

Interview 2011-02-04, Josefine Granding Larsson, age 30, owner of an iRobot Roomba unknown series, mail interview. Household = 90 square meters, two floor apartment, two people.

When you purchased your vacuum cleaner, was the choice between a regular and robotic vacuum cleaner?

No, I had a traditional one and wanted an RVC as well.

How long have you had your RVC?

Since 23d of September 2010. (a couple of months, writers note.)

Do you have to use both a regular vacuum and RVC to clean?

Yes, some of our rooms are tiled. The tiled floor is too rough for the RVC to be effective.

How long does it take for your RVC to vacuum your living space?

We vacuum one room at a time, so I don't know how long the whole living area takes.

Do you have to prepare the cleaning area before starting the robot vacuum cleaner?

Depends on which room. Usually we do not have to prepare at all. In one of the rooms we have to fold up a carpet that the RVC has trouble vacuuming.

What are some of the problems you encounter when using the RVC (like cables, battery life and such)?

We have not encountered any problems at all. We already knew removing carpets and thing like that would have to be done before we bought, in other words no problem at all.

Does the RVC have trouble getting under your furniture and other hard to access plac-

es?

Yes, if the furniture is too low it does. But it can get under our bed, which our traditional vacuum cannot.
Is the sound level high?

No.

Was it complicated to understand the RVC and get it started?

No.

Do you feel in control of the RVC when it is vacuuming?

Not at all! But that is fun. We see the RVC as a pet.

Where do you store your robot vacuum? Out in the open/ in a cleaning closet?

It is placed in a corner and is not easy to see, if you are not standing right next to it.

Do you show house guest the RVC when they visit (i.e. is it a topic for conversation?)
Absolutely.

What do you think of the cleaning experience with your RVC? On a scale from 1-10, where 1=horrible 5=Ok and 10=Very enjoyable.
10, we love our Roomba!

Interview 2011-02-07, Kristoffer Larsson, owner of an iRobot Roomba 581, mail interview.

When you purchased your vacuum cleaner, was the choice between a regular and robotic vacuum cleaner (hereafter shortened to RVC)?

No, we had a traditional vacuum cleaner and wanted to test an RVC.

How long have you had your RVC?
About six months, maybe a little less.

Do you have to use both a regular vacuum and RVC to clean?

We more or less only use the Roomba. We use it twice a week to cover the whole apartment. We very rarely have to use the traditional vacuum cleaner.

How long does it take for your RVC to vacuum your living space?
It is hard to say, as it cleans when we are at work. Maybe 3 to 4 hours.
Do you have to prepare the cleaning area before starting the robot vacuum cleaner?
We try to pick up loose items from the floor, including kitchen chairs which we put up on the kitchen table. But that doesn't take more than a couple of minutes per time

What are some of the problems you encounter when using the RVC (like cables, battery life and such)?

No problems, really. But you have to remember to empty the dust bag after each time, and clean the brushes every two times.

Does the RVC have trouble getting under your furniture and other hard to access places?

No, not at all.

Is the sound level high?

It is relatively loud. But as I said, we are rarely home when it vacuums, so it doesn't matter much.

Was it complicated to understand the RVC and get it started?

No, not at all. But then again I usually have an easy time with technical things like this, and I work as an IT-consultant.

Do you feel in control of the RVC when it is vacuuming?
We have towers that limit it to a specific room/area until it's done, and it then continues to the next room. So I think we're in control.

Where do you store your robot vacuum? Out in the open/ in a cleaning closet?

At the docking station in the study.

Do you show house guest the RVC when they visit (ie. is it a topic for conversation?)

Yes!

What do you think of the whole experience with your RVC? On a scale from 1-10, where 1=horrible 5=ok and 10=Very enjoyable.

10.

Please also add any comment you feel you want to make.

It is very nice to have the Roomba. It is not perfect, but "good enough". You never need to have "cleaning weekends" anymore.

Interview 2011-02-08, Web questioner at www.vof.se (Forum för vetenskap och folkbildning), username: Grape. Owner of an iRobot Roomba, 560.

When you purchased your vacuum cleaner, was the choice between a regular and robotic vacuum cleaner (hereafter shortened to RVC)?

No, I already have a fully functioning regular vacuum cleaner.

How long have you had your RVC?

About three years now.

Do you have to use both a regular vacuum and RVC to clean?

Not for regular cleaning, the traditional vacuum is only used sporadically to vacuum on special occasion.

How long does it take for your RVC to vacuum your living space?

If I guess; about one hour or so. The RVC vacuums when I am not at home so I have a bad perception of how long it takes.

Do you have to prepare the cleaning area before starting the robot vacuum cleaner?

I do a visual check and eventually pick up stuff from the floor before I leave for work in the morning.

What are some of the problems you encounter when using the RVC (like cables, battery life and such)?

The Roomba (manufacturer brand, writers note) has some design flaws that mean that you have to clean its brushes regularly, as not to affect the life expectancy of the machine. I have changed a gear box on warranty, because I did not know of that problem at first. Otherwise I have nothing no other remarks.

Does the RVC have trouble getting under your furniture and other hard to access places?

No, a decimeter is about all it needs to vacuum. That is enough for it to reach under sofas, beds and the likes.

Is the sound level high?

Probably not louder than an ordinary, cheap vacuum. But the sound could be perceived as disturbing when you are at home, if you are not actively participating in the vacuuming when the RVC is on.

How often do you have to empty the dust bag?

Once a week or so, which means every third run with the RVC. The brushes should be cleaned every time because otherwise dirt can be drawn in to the gear box and cause damage.

Was it complicated to understand the RVC and get it started?

Nope, unpack it, press start and it gets going.

Do you feel in control of the RVC when it is vacuuming?

Control? Well, as I said I am usually not at home when it vacuums, so I would not exactly say I am in control of the process. I would say I am happy with the vacuuming

though!

Where do you store your robot vacuum? Out in the open/ in a cleaning closet?

The charging station is located in a corner of the living room so it can stop and start without interruption.

Do you show house guest the RVC when they visit (ie. is it a topic for conversation?)

As I said it is placed right in the open which often leads to a discussion and a quick demonstration if I have guests that have not seen one before.

13. What do you think of the experience of vacuuming with your RVC? On a scale from 1-10, where 1=horrible 5=Ok and 10=Very enjoyable.

8.

Please also add any comment you feel you want to make.

In my case the Roomba meant that I ran an automatic vacuum three times a week. This can be put in relation to the fact that I, as a sloppy bachelor, vacuumed maybe once every two weeks before I got the RVC.

Interview 2011-02-08, Web questioner at www.vof.se (Forum för vetenskap och folkbildning), username: anilov. Owner of a borrowed iRobot Roomba, unknown series.

When you purchased your vacuum cleaner, was the choice between a regular and robotic vacuum cleaner (hereafter shortened to RVC)?

No

How long have you had your RVC?

1,5 years.

Do you have to use both a regular vacuum and RVC to clean?

Yup.

How long does it take for your RVC to vacuum your living space?

It takes forever. If I work from home I notice it takes at least half an hour for it just to vacuum the living room, it then usually runs out of batteries and begs for charging to be able to complete the job.

Do you have to prepare the cleaning area before starting the robot vacuum cleaner?

Yes, a lot. I have kids and therefore Lego.

What are some of the problems you encounter when using the RVC (like cables, battery life and such)?

I think the battery is getting bad. The charging-station is a dust collector in itself; additionally it is in the way in the only place we can place it. The instructions say that the RVC should always be charging when it is not in use, but that boulder of a charging station is something you do not want to have standing anywhere visible. The dirt container is hard to empty without spilling the dirt back on the floor, also the brushes have to be cleaned regularly.

Does the RVC have trouble getting under your furniture and other hard to access places?

It gets under the sofa, is not able to get under the kitchen closets in the kitchen. It always get stuck on the legs of the recliner.

Is the sound level high?

Insanely high. I have had to apologize to the neighbors at times when I used it late in the evening. It is impossible to work at home with the RVC on.

How often do you have to empty the dust bag?

Depends on how dirty it is at home, so that is almost impossible to give an answer to.

Was it complicated to understand the RVC and get it started?

No.

Do you feel in control of the RVC when it is vacuuming?

I do not really understand the question.

Where do you store your robot vacuum? Out in the open/ in a cleaning closet?

Under the bed.

Do you show house guest the RVC when they visit (i.e. is it a topic for conversation?)

No, the kids have showed it to their friends a couple of times, but they mostly tried to play floor ball with it, so nowadays I try to hide when friends are visiting.

What do you think of the experience of vacuuming with your RVC? On a scale from 1-10, where 1=horrible 5=Ok and 10=Very enjoyable.

1.

Please also add any comment you feel you want to make.

Those who constructed the Roomba apparently do not have 65 cm long hair. Then they would have discovered that the hair twists itself into the wheels and the small brush so they can hardly turn, and that makes the battery run out very quickly. Furthermore, it is almost hopeless to get rid of the hairs, not even with the small knife that you get with the product does it work. I can possibly recommend a robot vacuum cleaner to

short-haired people without small children, with open planned living areas and very little furniture and carpets. If you fill those criteria, it is most certainly wonderful. If you do not, it feels slightly frustrating to spend more time maintaining the machine, lift away things so that it can move, and sweep up everything that falls outside trash bag when you empty the tank, than it would have taken to lift the real vacuum cleaner, vacuum, and set it back again.

Interview 2011-02-09, Web questioner at www.vof.se (Forum för vetenskap och folkbildning), username: nähädu. Owner of a Electrolux Trilobite.

When you purchased your vacuum cleaner, was the choice between a regular and robotic vacuum cleaner (hereafter shortened to RVC)?

No

How long have you had your RVC?

About six years.

Do you have to use both a regular vacuum and RVC to clean?

Yes.

How long does it take for your RVC to vacuum your living space?

Hard to say. It vacuums a 20 square meter living room in about half an hour; in which case it gets really clean.

Do you have to prepare the cleaning area before starting the robot vacuum cleaner?

Yes, you have to brush dirt and dust from the edges of the room into the center.

What are some of the problems you encounter when using the RVC (like cables, battery life and such)?

Bad battery life, small dust container.

Does the RVC have trouble getting under your furniture and other hard to access places?

Yes.

Is the sound level high?

No, more quiet than a regular vacuum cleaner.

How often do you have to empty the dust bag?

After about 4-5 vacuums.

Was it complicated to understand the RVC and get it started?

No.

Do you feel in control of the RVC when it is vacuuming?

Yes, if you have been careful to enclose it in the room.

Where do you store your robot vacuum? Out in the open/ in a cleaning closet?

In the open.

Do you show house guest the RVC when they visit (i.e. is it a topic for conversation?)

Absolutely. It often makes appearances at after parties.

13. What do you think of the experience of vacuuming with your RVC? On a scale from 1-10, where 1=horrible 5=Ok and 10=Very enjoyable.

8.

INTERVIEWS, NON-OWNERS

Interview 2011-02-04, Marika Williams, 25, student. No experience with robotic vacuum cleaners.

How often do you vacuum?

Once a week or so.

How long does it take you?

I have a very, very small room in a dorm, so it only takes me about 10 minutes. Sometimes when I feel it needs to be done thoroughly it takes 20 minutes, which only happens about once a month.

Do you prepare the room before vacuuming?

Not really. Well, if I think about it, sometimes I have to pick up bags and shoes and stuff. Although it is very boring - it never takes more than probably five minutes.

Are there places that are inaccessible to you when vacuuming?

Yes, a couple. Behind the toilet for example. I have a cupboard that I have never moved and so on.

Describe your feelings on vacuuming on a scale from 1-10, where 1= Horrible, 5= Ok, 10= Very enjoyable.

2 or 3.

Have you had any experience with an RVC?

No, not really.

Have you ever considered purchasing an RVC?

No. Vacuuming is not really a priority for me.

(follow up) Why not?

As I said, I have a small room and it is not something I think I really need.

(follow up) Even though you have limited knowledge of RVC's, please try to explain your reasoning for discarding the idea of a purchase.

Even though I do not know for sure, I believe that a good RVC is very expensive, and if there are cheap ones they are probably nothing more than gadgets. I also think you do a better job when vacuuming manually than a robot would. ...I do not really know how they work. But now that you mention it, it would be interesting to see one.

Comments from interview object;

After the interview Marika did recall that she knew someone who had a pool cleaning robot and that they have had some problems with it. She mentioned that it would not reach everywhere and would get tangled in its own tubing.

Interview 2011-02-04, Selma Öström, 25, student. No experience with robotic vacuum cleaners.

How often do you vacuum?

Once every week. I do some more serious vacuuming once every two months.

How long does it take you?

Maybe 10 minutes.

Do you prepare the room before vacuuming?

Yes a little bit. I pick up some stuff; small carpets, put up some chairs and hang up my guitar, that's about it.

Are there places that are inaccessible to you when vacuuming?

Yes, some corners and such. But if I remove the shaft I can pretty much vacuum everywhere.

Where do you store your vacuum cleaner?

In a cleaning cupboard, it is basically never out in the open besides when it is in use.

What problems do you experience with when vacuuming?

Unplugging and plugging it is somewhat of a pain. I wish the cord would be a little longer. I have to re-plug a couple times when vacuuming it, and sometimes it is only a matter of a couple of decimetres. The automatic cord reel is also something that bothers me, it does not always work and at times feels dangerous.

Describe your feelings on vacuuming on a scale from 1-10, where 1= Horrible, 5= Ok, 10= Very enjoyable.

6. I actually like my vacuum cleaner, it is pretty good.

Have you had any experience with an RVC?

No I don't think I've ever seen one. Electrolux makes them right?

Have you ever considered purchasing an RVC?

No I have not. The idea kind of makes me paranoid. I feel it could accidentally pick up small valuable things that you forgot on the floor. And I don't really know how well it would be able to handle my apartment.

(Follow up) What other potential problems do you think an RVC would have?

It would probably bump into table- and chair legs, I would worry it would leave marks. Would it be able to get under sofas and beds? Also I don't think it can get over thresholds.

(Follow up) What would you want from an RVC for it to be a consideration?

It should be able to sense when it is on a carpet and change the vacuuming accordingly. I would also have to be as flexible as a regular vacuum can be, but I don't think that is doable.

I would not want it to take much time to vacuum because I don't think I would be able to relax while it was going around the apartment. I think I would follow it around to see that nothing bad happens, or maybe position myself on a piece of furniture as to not ruin anything in its programming.

And I would definitely have to test it thoroughly a couple of times before trusting it to vacuum my home. Honestly, for me, I think it would be more energy efficient to just vacuum manually.

Comments on interview; Selma clearly states that is it not very fond of the idea of a automatic device working in her house, and the question is if she would ever be susceptible to it.

Interview 2011-02-22, Maria, 34. Household: house, 116 square meters. Two person family.

How often do you vacuum?
Two times a week.

How long does it take you?

10 to 15 minutes if I do a regular clean. It takes forever if I am meticulous!

Do you prepare the room before vacuuming?

I might have to pick up clothes or newspapers. Does not take too long.

Are there places that are inaccessible to you when vacuuming?

Yes, amongst others the storage room, I have not been able to vacuum there forever.

Do you have pets?

Yes, a cat. Two dogs.

What problems do you experience with when vacuuming?

The vacuum gets stuck everywhere, like corners of furnishings, cupboards. The cord is not long enough, so I have to switch.

Describe your feelings on vacuuming on a scale from 1-10, where 1=Horrible, 5= Ok, 10= Very enjoyable?

I would say 5. It is a necessary evil.

Have you had any experience with an RVC?

No, not at all.

Have you ever considered purchasing an RVC?

No, never. There would not be a lot left of it after my pets were done with it, I would presume. I have never thought of it.

(Follow up) What potential problems do you think an RVC would have?

I don't know. Maybe it would work well in open spaces but would have problems otherwise?

(Follow up) What would you want from an RVC for it to be a consideration?

It would have to be small and flexible. And you should not have to vacuum even if you have one of these things.

Interview 2011-02-22, Ylva, 54. Household: 6 room house. Two person family.

How often do you vacuum?

Once a week. I have a dog and have to vacuum pretty regularly.

How long does it take you?

30-40 minutes, but it depends. Sometimes a longer vacuuming is needed.

Do you prepare the room before vacuuming?

I have to mop beneath the sofa, the vacuum cleaner does not fit under it.

Are there places that are inaccessible to you when vacuuming?

Yes, the sofa as I said. That was a miss I should really have thought of that when buying the vacuum.

What problems do you experience with when vacuuming?

Can not think of anything really. Maybe when I get water on the floor spilled from my dogs water bowl.

Describe your feelings on vacuuming on a scale from 1-10, where 1=Horrible, 5= Ok, 10= Very enjoyable?

6. It is not too bad.

Have you had any experience with an RVC?

None.

Have you ever considered purchasing an RVC?

Nope, It has never really been a possibility and have never thought of it.

(Follow up) What potential problems do you think an RVC would have?

That it is very loud. The price is probably an issue. I wonder if it leaves marks on chairs and such.

(Follow up)What would you want from an RVC for it to be a consideration?

It would have to be able to pick up the dog hairs after my dog, probably be able to handle gravel as well.

Interview 2011-02-22, Kicki, 61. Household: 67 square meter apartment. Single living.

How often do you vacuum?

Once a month.

How long does it take you?

15 minutes if it is only a routine clean, otherwise 30 minutes.

Do you prepare the room before vacuuming?

I have to move some things around.

Are there places that are inaccessible to you when vacuuming?

No. Well, maybe behind the bookcases, they are too heavy to move.

What problems do you experience with when vacuuming?

Basically it is boring, but rewarding once done. I have a long pile rug and have to vacuum it individually without the vacuum shaft, which is bothersome.

Describe your feelings on vacuuming on a scale from 1-10, where 1=Horrible, 5= Ok, 10= Very enjoyable?

3

Have you had any experience with an RVC?

No, none.

Have you ever considered purchasing an RVC?

No I have never seen one, do not know how they work.

(Follow up) What potential problems do you think an RVC would have?

Is it able to handle carpets? What about thresholds? It would probably be able to cope with my low thresholds however. Does it work in a systematic way? I have a very open planned apartment, would it only clean a little here and there if it could not be contained in one room? I believe it would get stuck at places in my house.

(Follow up)What would you want from an RVC for it to be a consideration?

It would obviously have to be able to do most of the things I said. How do I know if it really makes the floor cleans?

Interview 2011-02-22, Kristel, 44. Household: 110 square meter house. 3 person family.

How often do you vacuum?

3 times a week. I get my son to do it.

How long does it take you?

I think it takes me 30 minutes for the whole house. It takes my son no more than 10, so I guess it is all about how thorough you are.

Do you prepare the room before vacuuming?

No.

Are there places that are inaccessible to you when vacuuming?

No, well...possibly behind the couch.

What problems do you experience with when vacuuming?

It is not the most fun thing to do. And it is pretty noisy, I usually turn the music up a lot.

Describe your feelings on vacuuming on a scale from 1-10, where 1=Horrible, 5= Ok, 10= Very enjoyable?

4

Have you had any experience with an RVC?

None whatsoever.

Have you ever considered purchasing an RVC?

No never.

(Follow up) What potential problems do you think an RVC would have?

It would probably bump into a chair leg or something, then turn in the other direction and bump into the other leg so it gets stuck. I do not think it would work in our house. You would probably step on it a lot too. And does it vacuum corners?

(Follow up)What would you want from an RVC for it to be a consideration?

I would have to see one before I can answer that.