STATE OF FLUX.
THESIS BOOK.

MICHAEL MEIER | ED-20 CONNECTED DRIVE | DEC 2015

Pratt








STATE OF FLUX
Physical display of information in cars

by

Michael W. Meier

A thesis
submitted in partial fulfillment
of the requirements for
the degree of Master of Industrial Design
School of Design
Pratt Institute

February 2016

STATE OF FLUX
Physical display of information in cars

by

Michael W. Meier

Received and approved:

______________________ Date 2015/12/15
BMW Group - ED-20, Thesis Advisor - Dr. Michael Herrler

______________________ Date 2015/12/15
BMW Group - ED-20, Head of Department - Georg Friedrich

______________________ Date 2015/12/15
Pratt Institute, Thesis Advisor - HyukJae Henry Yoo

______________________ Date 2016/1/11
Pratt Institute, Department Chair - Constantin Boym

STATE OF FLUX
Physical display of information in cars

by

Michael W. Meier

CONFIDENTIALITY CLAUSE

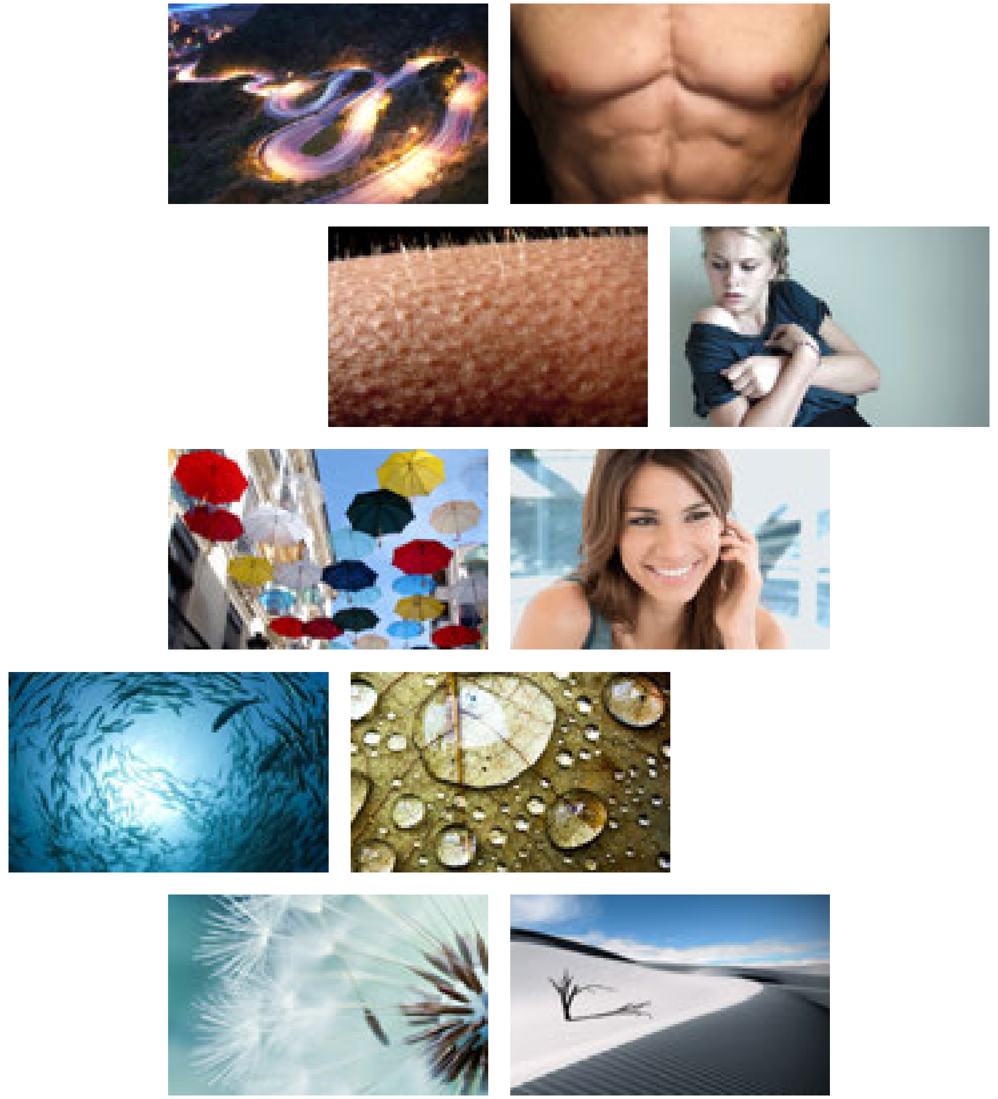
THANK YOU.

WORDS ARE NOT ENOUGH.

At first, it sounded like a really wacky dream. A master's degree in New York City. But it turned out to become probably the most amazing experience of my lifetime. Some things I have seen there made me laugh and cry. People gave me food for thought and inspired new ideas. Foreign cultures and religions made me reflect on who I am. It did something to me I truly treasure and I believe this work is proof of that. That is the reason why I am so grateful for the past three years.

I would especially like to say thank you to my thesis advisor Henry. He has always been a great support with fresh input and an open ear. The same applies to all colleagues at BMW Group, particularly Dr. Michael Herrler for his guidance through the natural ups and downs of an explorative design process. My family and friends have always been very important to me. Their recent backing and stability was key in making this dream come true. Thanks everyone, I appreciate it.

TABLE OF CONTENTS



Mood Board, Appendix I

BRIEFING.

FUTURE VISION.

When I started working on this thesis, I had this vision of a novel, emotionally charged interface and interior design that blurred the line between the digital and physical world. Driving situations should create the impression of the vehicle behaving and reacting more like a “life-form” with emotional intelligence and unique character identity. Utilizing natural human gestures, feelings, and body language, the automobile needed to be reinterpreted as a living object (“in a state of flux”).

Form and function are an interplaying unit of choreographed motions to offer tailored information. They are metaphors of physical change as well as progress, ultimately culminating in “sheer driving pleasure”. This user experience was kept in mind while the thesis statement was formulated: *Physical motion and choreography of alternating car interior geometries can be used to display context-based information and serve as enhancement for the driving experience.*

Lukas Pobuda, 123rf.com

TANGIBLE.

PHYSICAL REALITY.

Since humans have become aware of their environment and began to create tools to alter it, we have lived in a so-called "state of flux". The term itself is a common American idiom and goes back to the idea that everything and everyone changes constantly. This enduring change has been and will always be bound to our tangible, physical reality. However, mankind's possibly greatest and most powerful invention, the internet, has an intangible nature. Intangible, that is until recently.

This chapter evaluates the magnitude of what ever-recurring change could possibly mean for us, the environment, and also in particular the automobile industry in the coming years. For this purpose, several different subjects and elements amenable to change will get analyzed and brought one step further. The ultimate goal is to obtain a clearer picture of what the words "premium driving experience" are going to mean in the not too distant future, within the context of privately owned cars.

Eurographics.de

NATURE

Earth's rotated axis and orbit around the sun causes various seasons and powerful weather phenomena. Yet some of them are a known result of human influence. Global warming has already led to "observed changes in the global water cycle, reductions in snow and ice, global mean sea level rise and temperature extremes" (UN Climate Change Secretariat 6). Cars should not contribute to this effect, instead protect from those adversities and embrace nature's health by offering sensual delight.

Nobeastsofierce, shutterstock.com

HUMANS

Man came into being throughout millions of years of evolution and subsequent physical mutation. The assumption that our body measurements are very different from each other is absolutely right, but from an anthropomorphic point of view, the vast majority of vehicle engineers simply choose to pick the 95th percentile of a male US population sample. Its "geometry can be used to set up the interior systems" (Macey 88), which is crucial for designing an automobile's interface and interaction concept.

Vladimir Zakharov, gettyimages.de

CITIES

About 66 percent of "the world's population is projected to be urban" (UN Population Division 1) by the year 2050. Consequently, living space will be rare and expensive. Commuting traffic will increase as many neighborhoods are being gentrified. Public transportation systems and car sharing ventures are also growing stronger. It is only logical that privately owned cars will be smaller and more agile than today. Even affluent people who enjoy driving are going to attach importance to highly variable space concepts.

Guliveris, istockphoto.com

INTERNET

The exponentially growing computing power demanded by the Web's infrastructure is basically intangible. It is probably mankind's fist invention we have lost the full comprehension for regarding its extent. Kurzweil predicts, that we are heading into a "singularity". This means that artificial intelligence will outrace our mental capabilities. Yet, thanks to the Internet of Things, we are going to be surrounded by super smart objects, cleaning out our apartments. Let us hope they will stay satisfied with it though.

PERSONAL EXPERIENCE

When I think about my personal experience regarding change, it clearly means to be at different locations. That is what I want contributing to this thesis. My course of education demanded frequent traveling. Originating from a rural area, cars have always been crucial for me to participate in various activities or simply commute to work. During my apprenticeship as a banker, I have learned about stock markets, credit businesses, accounting, and project management. Although it was an interesting time, I felt an urge to pursue a more visually driven job. After my bachelor's degree in Design & Product Management in Salzburg, Austria, I decided to learn more about aesthetics and the international scope of design at Pratt Institute in Brooklyn, New York. Their approach to high quality, hand-crafted prototypes and competence in creating beautifully arranged objects in three-dimensional space is unparalleled and even taken one step further with regard to the new "Global Innovation Design (GID)" program.

Raiffeisenbank Floß eG / FH Salzburg GmbH / Pratt Institute

Hiyoshi Campus

KEIO UNIVERSITY

GID understands design as a cultural matter of world-wide responsibility and looks at it from three different angles, namely aesthetics, technologies, and engineering. At Keio Media Design, interacting with and creating virtual reality applications are just as common as game design, storytelling classes and business model development. One explores the essence of concepts and recombines their elements unexpectedly to ultimately achieve real innovation.

Kensington Campus

ROYAL COLLEGE OF ART

RCA / Imperial College imparts knowledge about engineering, mechanics, and basic electronic toolkits like the Arduino platform or Processing programming language. This enables students to quickly build working prototypes and test out ideas in conjunction with the target group. Holistic support and tutoring from industry professionals as well as collaborative projects with globally operating companies rounds off the demanding curriculum.

CHANGING COMPETITION

In the future, automobile manufacturers and their suppliers will have to face new competitors from outside the industry. Apple or Google are pushing hard to widely distribute their systems. CarPlay lures with access and integration of the mobile app ecosystem and Google's services offer location-based intelligence. Due to those companies' heritage, the importance of data will rise and ultimately cause and accelerate a profound socio-economic shift.

Apple Inc.

Google Inc.

SELF-DRIVING CARS

Research regarding fully autonomously driving cars has already existed for a while now. Google has performed well on the technological intricacies and challenges since 2008. Bertoncello and Wee's article, *Ten Ways Autonomous Driving Could Redefine the Automotive World,* illustrates that consumers will begin to adopt self-driving cars by 2030 and they will eventually "become the primary means of transport" by 2050. In the meantime, established automakers need to refresh and revamp their premium brands.

Apple Inc., Google Inc., Tesla Motors Inc., Uber.com

One approach to justify the surcharge is to "add more value" in regard to "green mobility" (Mohr 16). Thus, marketers make sure that their brands communicate coolness, clean electrified power, and emotionally charged mobility. Tesla, for example, does just that. Offering new on-demand services such as car sharing, could actually be an alternative to privately owned vehicles. Ventures like DriveNow, car2go, and Uber are increasingly successful, as particularly younger generations seem to have shifted consumer preferences, as McKinsey & Company explain in an online press release. This target group is used to the possibilities of digital connectivity. Today's benchmark is set by smartphones and this generation demand the same from cars whilst on the road. The importance of connected automobiles grows, as "the number of networked cars will rise 30 percent a year for the next several years" (Mohr 14). It is more than unlikely that the complexity of this matter, especially regarding software, content, and technical infrastructure can be handled by a single company. Strategic alliances are the logical next step.

FUTURE PREMIUM

The streets will be filled with both manually controlled and computerized vehicles, until highly automated cars become status quo. Consumers are going to adopt the most comfortable solutions in regard to their everyday life and capabilities of integration. This will shift the definition of premium, as this new breed supports distinguished sets of activities. Mobility will not mean the fun of driving per se, but significantly improved traveling safety.

Daimler AG

commons.wikimedia.org

MANUAL DRIVING

Driving means being exposed to certain risks, as humans are not infallible. Yet, automated vehicles could be "reducing accidents by up to 90 percent" (Bertoncello and Wee). This is going to cause gradual adjustments of legal and statutory requirements, until limitations for human-controlled cars transform into restrictions or even prohibitions. Consequently, those old-fashioned vehicles are going to develop a particular form of nostalgic appeal, as they could be perceived as rebellious, daring, or bluntly "bad ass".

Denisenko, shutterstock.com

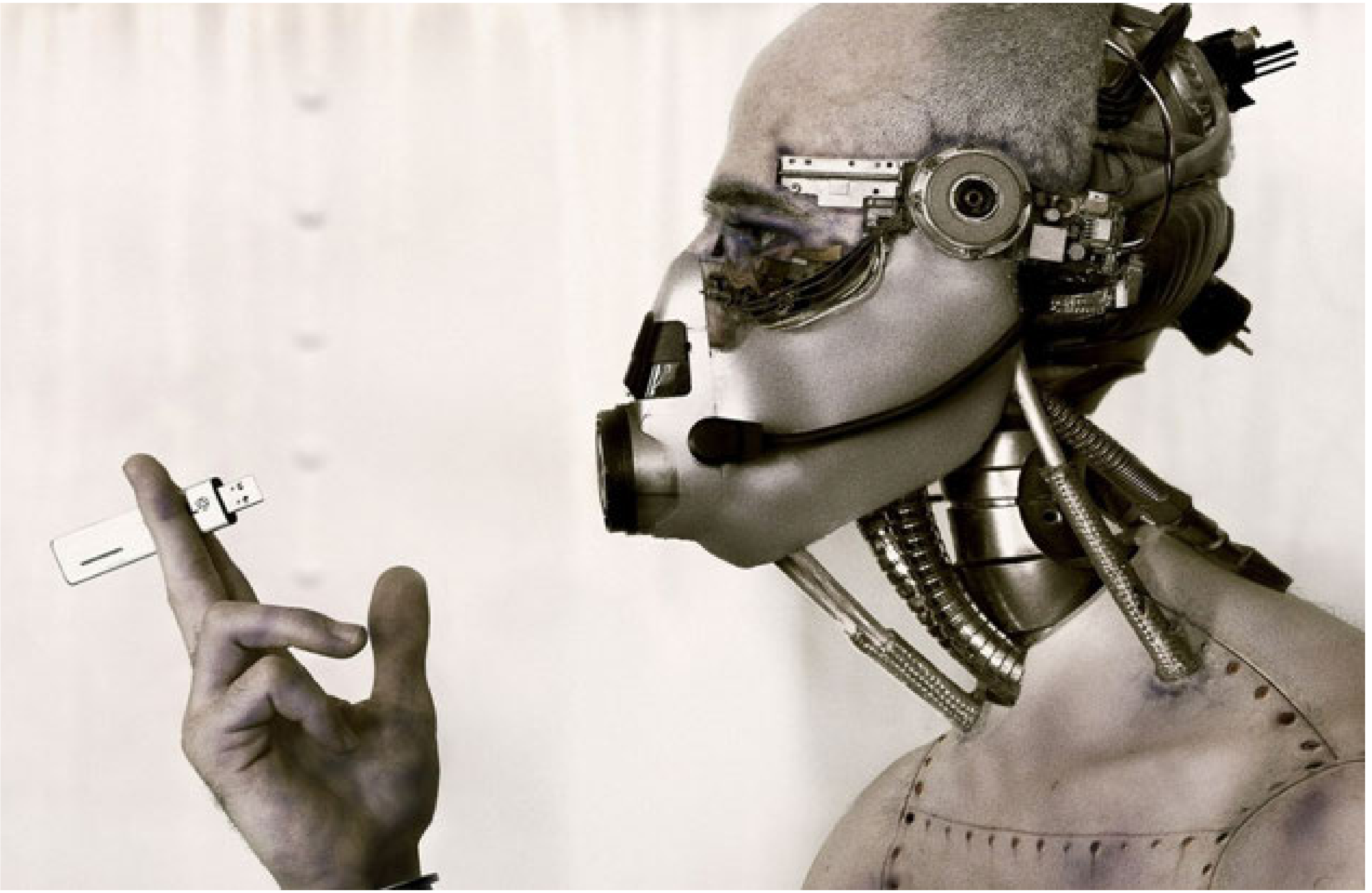
INSURANCES

An additional impact of currently developing trends in the automotive sector concerns insurance companies. Delineated briefly, they are going to face profound changes to their present business models. Instead of insuring individual drivers and human errors, a shift to corporate customers and their car sharing fleets seems imminent. Due to this fact and dangers of manual driving, custom insurances are increasingly difficult to afford. Hence, the exclusivity of cars, as we know them today, will gain gradually.

Manualdrivingschool.com.au

EXPERIENCE

Drivers are striving for emotional experiences, rather then trivial mobility. Gobé argues that "sensory elements" could be "key factors" for differentiation (68). Being close to nature looks like a sustainable way of fostering joy and ultimately a premium driving experience. One simply enjoys the warming sun or cooling wind just as a glass of good wine. Every product "should elicit the user to engage with them through their physicality" (Overbeeke et al. 9). Driving vehicles consciously will become an immersive event.



Wallpaperscraft.com

INTERACTION.

ALMOST NATURALLY.

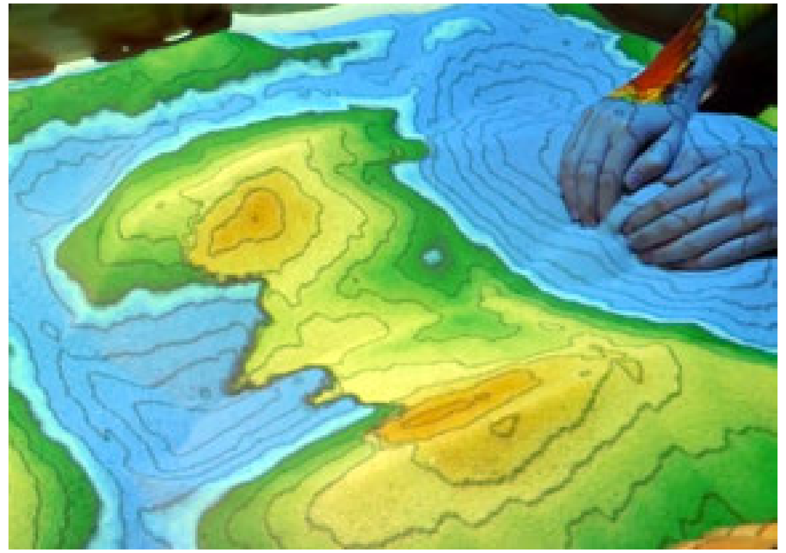
The digital world is just as subjected to the state of flux as the physical. Hence, its intangible properties transforming profoundly very soon. The Internet of Things, with all its possibilities of cross-linking smart objects, paves the way for tangible interactions in the near future, as visualizations of digital data on two-dimensional displays have little somatic value. From an evolutionary point of view, adding the third and fourth dimension to objects' interfaces represents inevitable yet logical progress.

The latest research projects, illustrating the attempts of the digital breaking into and interacting with our tangible reality, will be presented. The goal is to obtain a seamlessly physical, as well as immediate and undelayed, interplay between in- and output of data. Moreover, the chapter examines how humans articulate and express diverse mindsets by means of body language, posture, as well as ("gesture"). Ultimately, the relevant findings will be related back to driving environments and contextual situations.

MakerBot Industries

MAKERBOT / 3D PRINTING

Three-dimensional printing has existed for a while now, but the MakerBot is the first serious attempt to make the technology readily available in retail stores. Introduced as a technique for model building, the idea of obtaining fast and precise copies of digital geometeries quickly spread into the “maker scene” and will contribute to the democratization of design. Despite the complexity of creating printable geometries, new possibilities for distributing goods e.g. clothes, inspire designers and marketers alike.



Oliver Kreylos

AUGMENTED SANDBOX

The Augmented Reality Sandbox harnesses real world topography created by users interacting with the system. It was developed to simulate the behavior of flowing water and teach Geology to kids in science museums. The somatic innovation consists in the actual human-machine interaction and happens in a partially three-dimensional way, as physical input modifies the scanned topography data and subsequently outputs digitally augmented projections in real-time onto the boxed sand grains.

Pega Design & Engineering

TECH TAP / MUSIC

Interacting with this music listening device is just as simple as refilling a bottle of milk. The “liquid” or respectively the light represents a timer, which show the “amount” of music filled into the bottle by opening the tap. The jar can be carried around at will and acts as a regular speaker. This design already comprises three and a half dimensions of physical interaction. Nonetheless, it is a nice metaphor, but the fourth dimension would count in full, if the device had somatic properties during the output phase as well.

MIT Media Lab

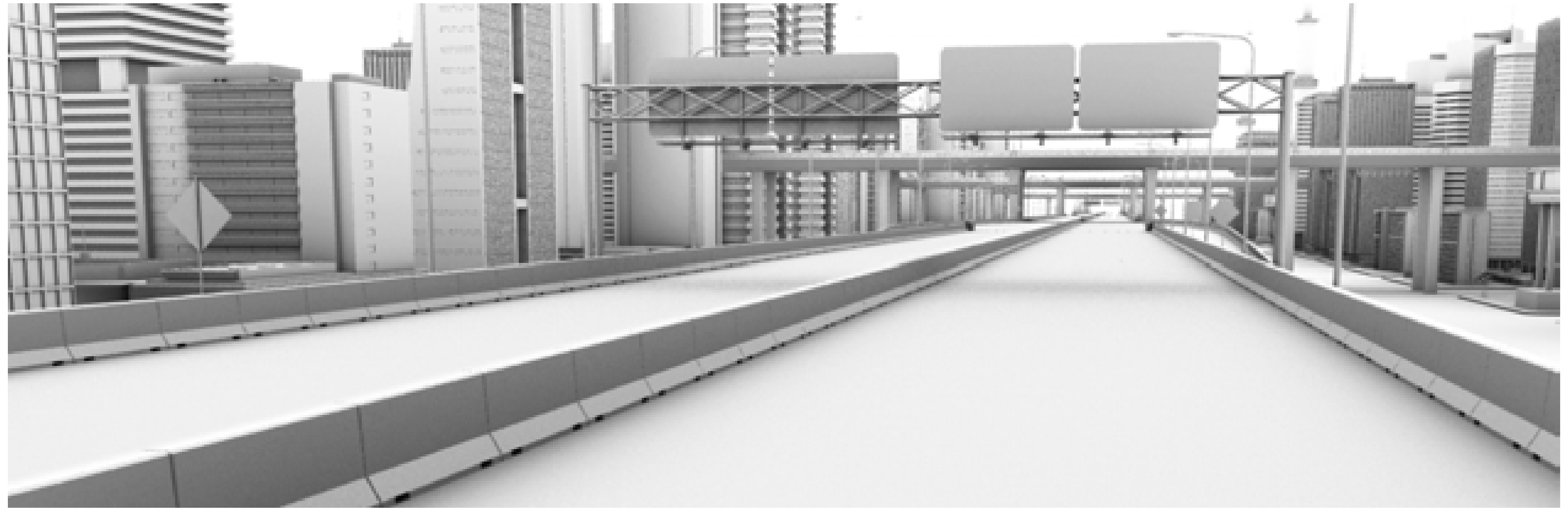
INFORM SHAPE DISPLAY

Almost naturally, the device enables users to communicate and interact remotely with one another. For this intent, gestures are translated into physical up- and downward motions of linear actuators, built into a table. One could say, it works like a kinetic telephone. Therefore, it is not only human-machine, but human-machine-human interaction. This novel technique for displaying data incorporates all four dimensions to their full extent, as in- and output happens on a direct, immediate, and tangible basis.

DETERMINED (FOCUS ON GOALS)

Generally, there are three ways of dealing with change. Being reserved, indifferent, or open to it, depends on and expresses inner mindsets. One reason to be "closed" to change is a certain anxiety about possibly negative consequences, as humans have a basic need for safety and stability. We express this need physically by crossing our arms in front of the chest. The gesture looks like as if we would wrap and hold ourselves for soothing purposes. At the same time, it communicates a persistent point of view, as it is "an attempt to put a barrier between the person and someone or something they don't like" (Pease 93). An interpretation in regard to the topic of this thesis could be that this barrier exists in ones mind, as well as in somatic terms on the street itself. Our bodies become the mirror of a traffic situation expressing the urge to reach a destination fast, safe, and without any frequent or bothering deviations.

Ollyy, shutterstock.com



Michael W. Meier

FOCUS DRIVING (HIGHWAY)

Due to its meaning and underlying mindset, the discussed gesture of crossed-arms in front of ones chest can be fitted well to a highway driving situation. High speeds and the resulting need for protection ultimately means to pursue and focus on personal goals. There is no going left or right. Straight thinking patterns and hard-lined acting propels within this almost hostile, rushed and stressful environment. Therefore, the automobile has to assist the driver in perceiving and shielding from suddenly occurring objects or the misbehaving of other road users. Daily commuters do regularly expose themselves to traffic jams and boredom, but the perceived ordinariness indicates a deeper wish for real experiences. The resulting mentally rejected situation calls for an act of defiance. Yet, it is almost impossible to verbally articulate oneself as "being in a car renders us mostly mute" and restricts users to "basic signals" (Vanderbilt 21). In this situation, some vent their spleen with an unambiguous finger gesture.

INDIFFERENCE (ENJOY THE MOMENT)

Another mindset that needs to be discussed for the scope of this thesis is being indifferent. One could argue that a variety of reasons exist for this specific way of thinking. Nonetheless, an application of a personal system and order of priorities seems very likely. Certain things are more important to some people than others. For example, some prefer to pursue a professional career over starting a family. The depicted physical gesture on the photo below illustrates this mindset. It looks like the person is weighing and considering arguments for and against something with openly demonstrated palms. Matt Levi's video, produced by the Stanford Graduate School of Business, shows this offering gesture in action. Further it is observable, that the height of the hands varies while the options are being offered. Navarro speaks of "gravity related arm movements", virtually lifting someones individual priorities (110).

Asier Romero, shutterstock.com

Michael W. Meier

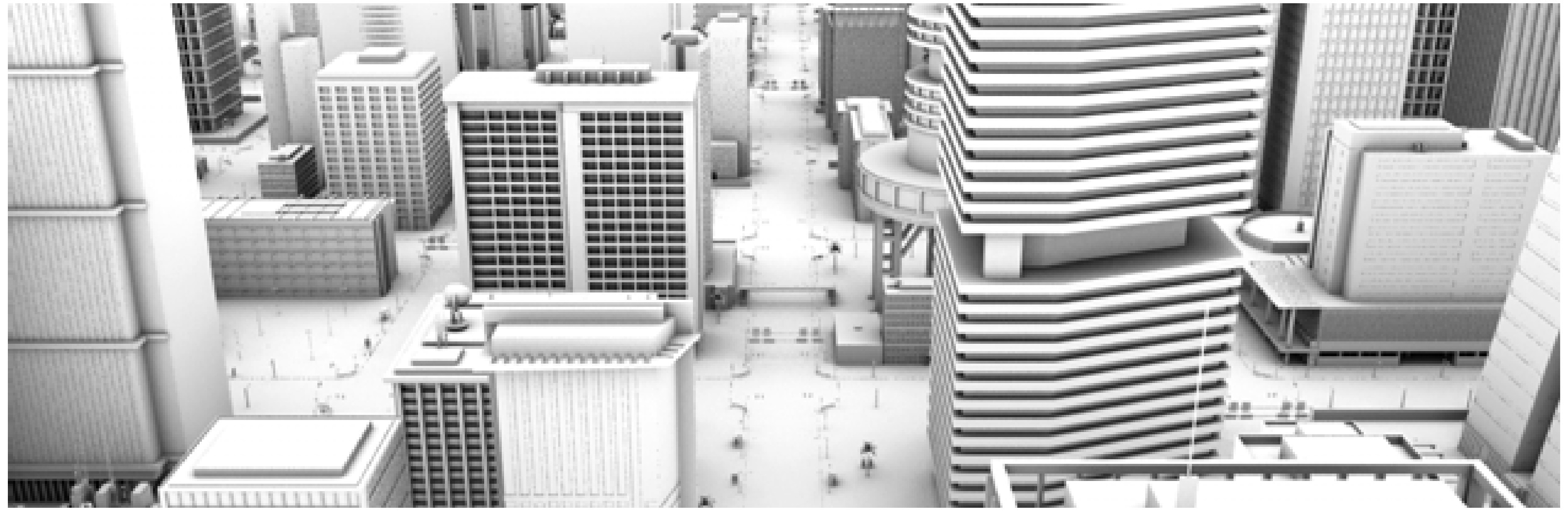
CRUISING MODE (CURVY / RURAL)

The weighing gesture expresses a deeper mindset of indifference and fits a curvy road in a rural environment. Lower speeds, joyful bends of the course of the street, and detours are the opposite of driving on a busy highway. Instead, it stands for relaxation, fun, and enjoyment. Our vehicles should proactively support this positive experience of being close to nature and celebrate the conscious perception of ones environment, as people generally seem to enjoy driving their cars. Vanderbilt argues that "the driving people didn't want to do was, in fact, the driving they needed to do" (140). Thereafter, the longing popular dream of undertaking a joyride down the legendary Route 66 makes perfect sense. In the field of cars, BMW successfully built a brand around the joy of driving. Hartson and Pyla note that the company has "elevated the user experience to new heights in the industry" (23). An interpretation of the brands core statement is to set and enjoy ones own priorities. Maybe even whilst in rush hour traffic.

ACCEPTION (NEW DISCOVERIES)

The third relevant mindset for this thesis is being open to change and understanding it as a chance for progress. Many reasons for this way of thinking might exist, yet having a fundamentally positive attitude towards life seems to be the most important one. People open to change are striving to discover something new and develop themselves further. This either could be a deeper philosophical urge, or simply the pursue of hobbies. In any case, this search for experiences is driven by desire for self-fulfillment. Culshaw argues, that it represents the ultimate need proposed by the psychologist Abraham Maslow in the 1960s (510-511). Below, the photograph shows the posture with arms wide open, welcoming and enjoying the things to come. Allan and Barbara Pease claim that this gesture can be observed during conversations, as soon as we “begin to feel comfortable with each other” (217).

Andresr, shutterstock.com



Michael W. Meier

EXPLORATION MODE (URBAN / CITY)

The welcoming gesture presents the chest in an open manner and expresses an open mind and flexibility. No harm is expected, as the performer embraces the chance for change. This gesture fits well to the urban city environment. More people will live in cities in the future and their titulation as melting pots or centers for culture and innovation already illustrates the latent opportunities today. Future automobiles are going to assist us within the so-called “concrete jungle”. Interesting locations and events will be highlighted whilst driving by or looked up on demand. The core of the idea is to consciously discover and perceive new input in its otherness. The surprise of the unexpected is accompanied by a realistic attitude of mind. An awareness for the problems and drawbacks of cities, yet the deep and unconditional love for imperfection. Humans are born discoverers and never stop trying to make the best of situations. Vanderbilt also proves this point by quoting scientist and philosopher Blaise Pascal (7-8).

Universal Studios Inc.

MISSION.

DESIGN TARGET.

This chapter summarizes the relevant ideas and findings from the previous ones. Moreover, it puts the design goals of the thesis project in words and produces a clearer picture for the subsequent ideation work. The joy of driving and user experience are important core values of the BMW brand. They will be kept in mind whilst the goals are being written down. More complex relationships in the discussed fields of research will be broken up into coherent units of statements, sentences, or bullet point lists.

For the sake of brevity, the content within this chapter is deliberately condensed. It will serve as a reference for the following design explorations. Thus, interpretations and meanings can easily be matched to the predefined objectives. This project can be considered a success, if the designed vehicle embodies a positive user experience as well as joyful driving and expresses context-based information via physical motion and alternating geometries instead of common, two-dimensional touchscreen displays.

CLIMATE & ENVIRONMENT

Man made structures, such as streets, are generally at the mercy of nature. Thus, changing climatic conditions could mean unexpected dangers for drivers. Sustainability plays an important role for the premium perception of a brand. The creation of a joyful experience will depend on the right balance between a delightful openness to nature and the protection from its extremes. Hence, the concept of a convertible car seems to be a good starting point. Further environmental aspects, regarding driver and vehicle assistance systems, are briefly listed below.

ASSISTANCE

- **Street Conditions**
- **Temperature**
- **Rain / Ice**
- **Fog / Wind**
- **Dazzling Light**
- **Night Vision**

Jules_Kitano, shutterstock.com

SPACE & LOCATION

Populations in cities grow. This means that the availability of personal space in the future will be inversely proportional to its importance. Thus, cars pose a chance to offer intelligent space and possibilities for personal fulfillment by adaptively reacting to individual needs, changed parameters, or environmental conditions. Vehicles are going to offer optimized, service-based routing, as well as notifications regarding traffic or obstacles. They will be just as smart as cab drivers in New York City, avoiding certain streets at certain times of the day.

ADAPTION

- **Obstacles (Radar)**
- **Maps / Navigation**
- **Traffic Jams**
- **Positions (Cars)**
- **Destinations**
- **Redirections**

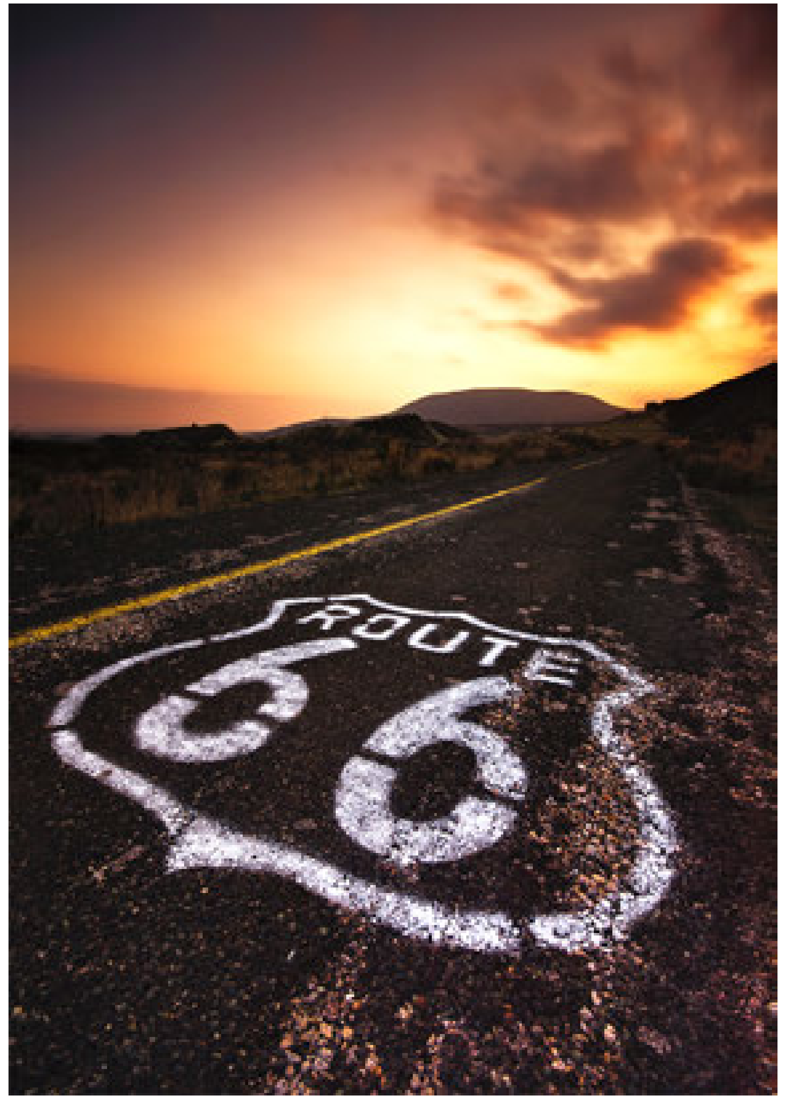
stokemyfire.com

MOBILITY & TRAFFIC

Our future experiences of riding cars will be physical. It is human nature to communicate via body language and gestures. Hence, we are in pursuit of somatic and delightful pleasures. Displays are going to show data via physical motion and choreographies, providing entertainment, emotions, and ultimately an enhanced driving experience utilizing immersive, event-like properties. Manually controlled cars, with their dangerous and adventurous image, will be the epitome of joyful driving. Relevant aspects in regard to the evaluation of experiences are listed below.

EXPERIENCE

- **Mindset**
- **Gestures**
- **Heart Rate**
- **Brain Waves**
- **Blood Sugar**
- **Eye Tracking**



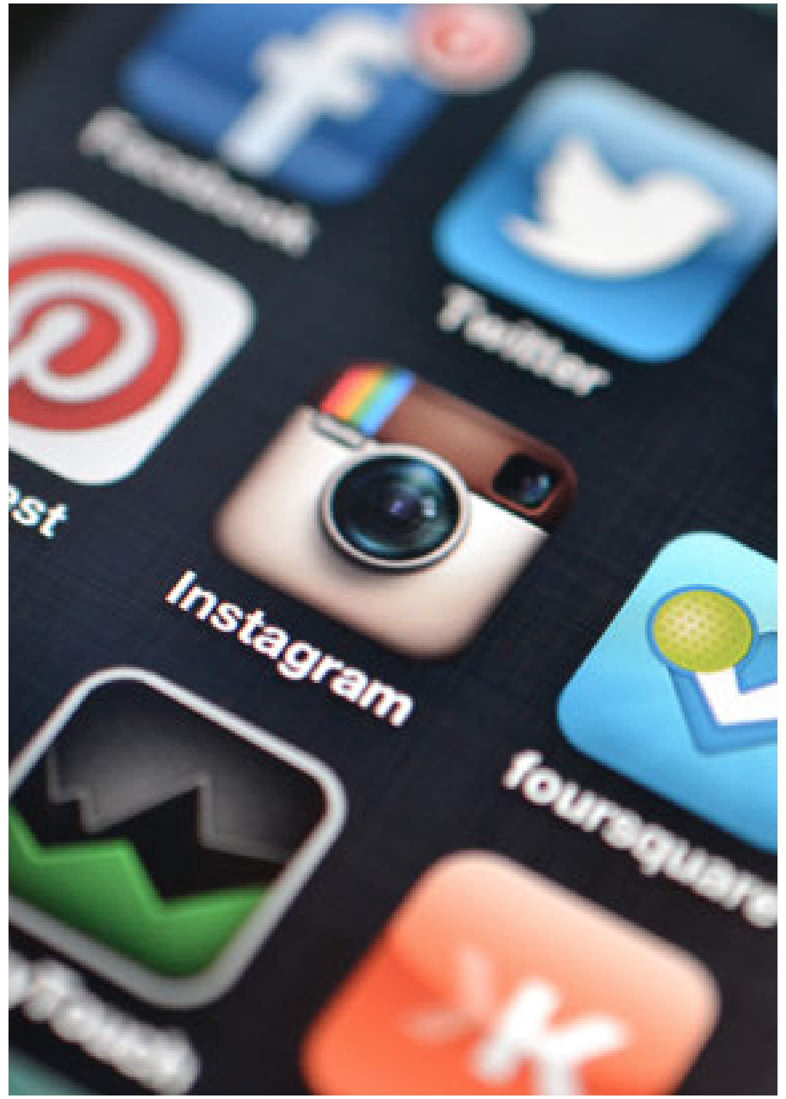
Paco Giménez, flickr.com

CONTENT & INFORMATION

The previous examples of interaction and interface design show, that in- and output of data, as well as connectivity in general, increasingly happens in somatic manner. Yet, cars have not reached the same interlinking level as cell phones or tablets. Safety aspects are one reason for this fact. Thus, information and content needs to be optimized, filtered, as well as appropriately presented within an automotive environment. Just as cloud-based content, individual interests and preferences should be taken into account to personalize the experience.

FILTERING

- **Cloud Data**
- **Appointments**
- **Locations**
- **Notifications**
- **Phone / E-Mail**
- **Social Media**

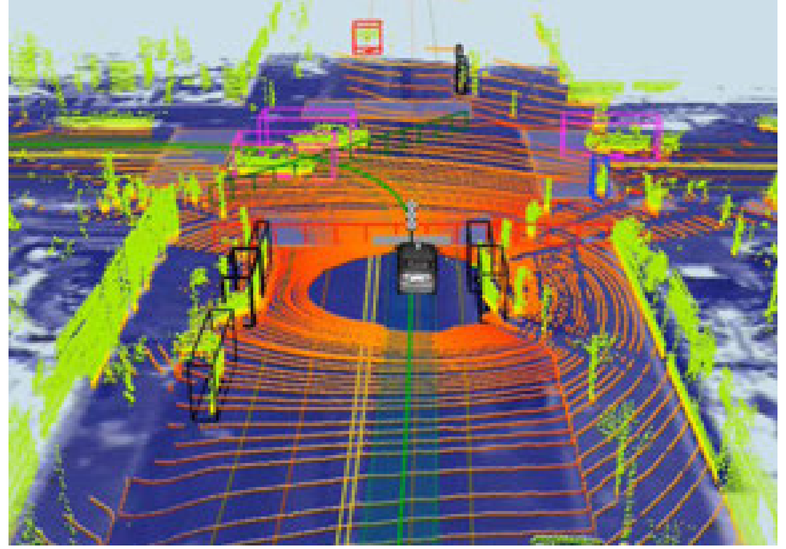


Jason Howie, flickr.com

TODAY & TOMORROW

To summarize the current situation, one can say that the changing climate with its consequent danger of extreme weather could pose inconvenient situations, just as the little developed connectivity of cars in general. Urban drivers are wasting too much time in traffic jams instead of enjoying smartly routed journeys, as no intelligently adapting personal space with abilities to focus on oneself is being offered. The increasing flood of digital information contributes to a certain carelessness as a driver or pedestrian and can lead to dangerous situations.

An ideal scenario of the future combines the connectivity and experience of the Internet of Things with the pleasures of manually driving automobiles. The car represents intelligently acting yet personal space, that offers sensual delight and interaction via somatic gestures. Moreover, future premium brands are going to sell adventurous and environmentally friendly values with focus on needs for individual mobility. Well filtered and appropriately presented contents and services offered inside the car, will be tailor-made mirrors of online identities and create immersive and sensual experiences for the drivers.



Bill Gross, idealab.com

1GB DATA PER SECOND

To provide the experience mentioned in the previous paragraph, the car needs to learn how humans perceive and interpret their environment. Thanks to the gathered data, it will subsequently be able to express itself via naturally looking gestures. The image above shows captured data from a Google car, used internally for path planning (Rayej). Further data needs to be collected from cloud-services in real-time, to meet up with future users' expectations of connectivity and premium driving experiences.

Michael W. Meier

Maglara, shutterstock.com

BLANK CANVAS.

STARTING FROM SCRATCH.

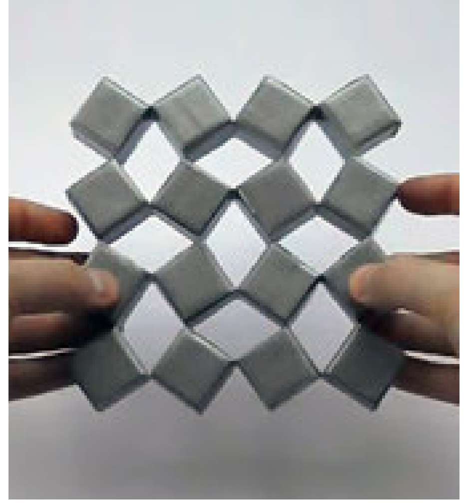
This chapter illustrates the individual steps as well as aspects of the project's design process. There were no restrictions given. Thus, it could be developed from the ground up to explore the concept of choreography to depict feelings and information. Further, the chapter discusses possible directions and metaphors for the concept in regard to their meaning for human-machine interactions. The goal of the process is to find an aesthetically pleasing "body" for the ideas of this thesis work.

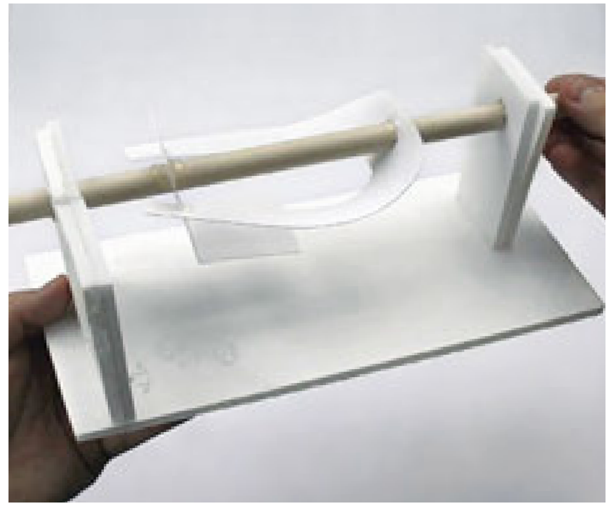
At first, it will be determined which motions actually make sense regarding an automotive environment and which meanings are associated with, or can be assigned to them. The next step is to investigate today's technological options to artificially make objects move and behave as if they were alive. Further, metaphors will be determined and sketches created. Finally, the concept will be reviewed and verified. Quick mockups and clay models will help to refine the vehicle's proportions.

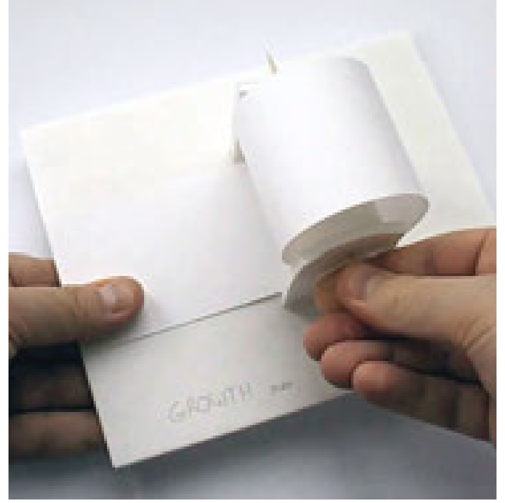
KINETIC STUDIES

Following Blom and Chaplin's advice, the two-page spread shows the exploration of kinetic models. According to them, one can only learn to choreograph by "experimenting" (30). The mockups depict parts or aspects of motions in regard to a greater choreography. One could say, they form the vocabulary of the language, the car is possibly going to speak. Designing meaningful sequences of motions for physical parts the vehicle is how the term ("choreography") is understood for this work.

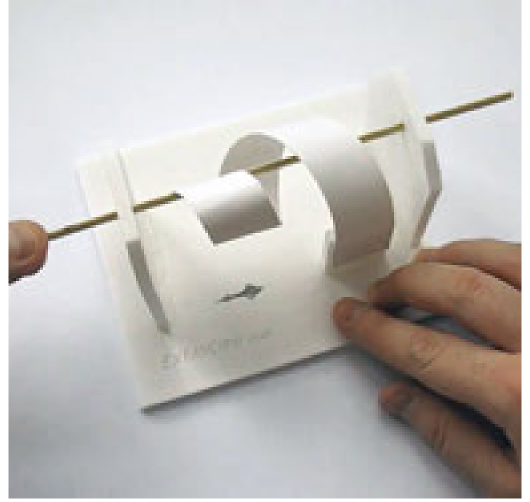
The models are "choreographic phrases" in regard to the theme of rotation (Blom and Chaplin 76). On the lower left, the "Yoshimoto Cubes" stand for the idea of context-based enlargement or growth of operating elements inside the automobile. Instead, the "Rotary Cockpit" model plays with the concept of tilting or leaning the whole vehicle to the left and right. "Growth" could be the basis of a converging UI element, reaching into space, where "the dancer creates a dynamic image" (Blom and Chaplin 78).

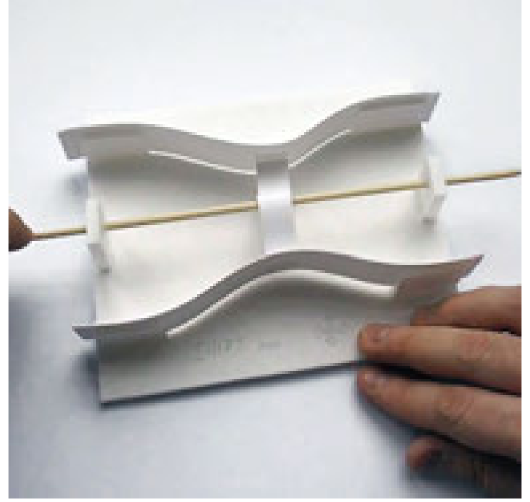






Yoshimoto Cubes / Rotary Cockpit / Growth





Leaning / Expansion / Shift

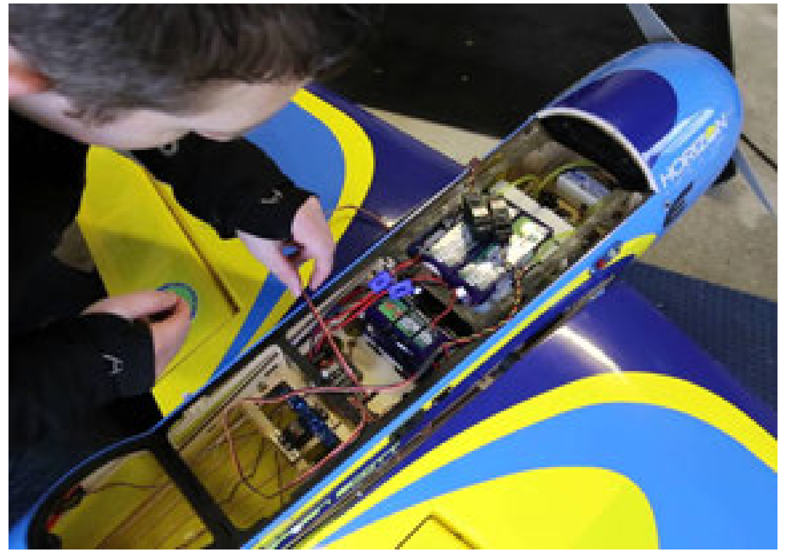
The model titled "Leaning" embodies the idea of rotation, combined with a strong sense for direction. Its paper material and off-center pivot point tilts the object in a flexible manner. Rotation, direction, as well as dynamic growth in space over time is shown from "Expansion". The mockup on the upper right is called "Shift" and illustrates the influence of the airstream. Faster speeds streamline the vehicle and shape a tighter appearance. One could say, the car "snuggles" around the driver and conveys a feeling of safety. Moreover, thanks to steering motions, the geometry leans into curves.

Its dynamics are "the manifestation of time and force produced by the body as it moves" (Blom and Chaplin 160). To create a summarizing choreography, the model's phrases need yet to be combined. This happens by the use of so-called "transitions". Blom and Chaplin call this "sense of natural evolvement from one thing to the next" an "earmark of organic form" (178). Nonetheless, the overall choreographic style needs to fit the BMW brand values. Attributes such as joyful dynamism and innovation have to be recognizable in "an identifiable manner or mode of physical expression" (Blom and Chaplin 267).

MUSCLES / ARTIFICIAL MOTION

This chapter's section shows and compares the technological options to actually make parts move. Most of them are readily available and root in robotics, whereas they are called artificial muscles. The research in this unique field recently makes interesting progress. For example, woven fishing wire bears unexpected strengths to lift up weight when exposed to heat. Shaer and Hornecker would speak of so-called "reality-based interactions" (19), in case some of the properties of artificial muscles could be applied to "tangible user interfaces" (48).

The individual methods for artificial motion were compared with each other. The table on the opposite page shows the range of utilized criteria to subsequently evaluate and score their properties for the sake of this thesis. Most important was the ability to animate and control the mechanism. Distinctive sets of motions should be shown, while exerting real-time influence with some sort of remote control. Context-based information and feelings need to be visualized in front of a live audience, to leave the impressive sensation of a reacting "life-form", interacting with its environment as well as the driver.

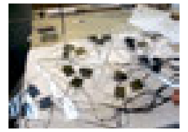


Stephen Scott, youtube.com

R / C AIRPLANES

The use of servo motors from the field of R / C model-building seemed logical. They scored the highest value in the right-hand table and are available in a wide range of dimensions regarding size, speed, torque, as well as power consumption. Their proven technology is reliable and precisely controllable. Standardized electronic components mean a high availability at model making shops, and programmable angles via microcontrollers such as the Arduino Uno, are further justifying arguments.

MECHANICS

LINKS

Responsive Kinematics
https://www.youtube.com/watch?v=lecR-fSRnL8

Animatronic Tail
https://www.youtube.com/watch?v=IA55Ad9BY5Q

PROS

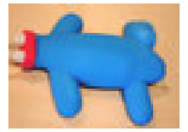
- Fast Motions (Servos)
- Buildability, Deployability (DIY Level)
- Versatility (Adaptable Mechanics)
- Motion Control (Arduino, Joystick)
- Feasibility (Reliable, Mature Technology)

CONS

- Complexity (More Parts)
- Installation Space
- Noisy (Servos)

SCORE	25/35
Ability to Animate	●●●●●
Motion Control	●●●●●
Feasibility	●●●●○
Complexity	●●●○○
Installation Space	●●●○○
Durability	●●●○○
Audibility	●●○○○

PNEUMATICS

LINKS

Festo Bionic Learning Network
https://www.youtube.com/watch?v=NNNfn7ac-rY

Glaucus Soft Robot
https://www.youtube.com/watch?v=RCEzuPKgK6c

PROS

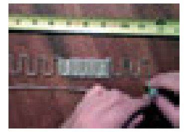
- Fast Motions (Pro Level)
- Life-Like Possibilities
- Installation Space

CONS

- Complexity (Many Parts)
- Engineering (Difinition, Vetting)
- Noisy (Valves)
- Slow Motions (DIY Level)
- Motion Control (Arduino, Joystick)

SCORE	23/35
Ability to Animate	●●●●●
Motion Control	●●●●○
Feasibility	●●●●○
Complexity	●○○○○
Installation Space	●●●●○
Durability	●●●●○
Audibility	●○○○○

MAGNETISM

LINKS

Linear Magnetic Motion
https://www.youtube.com/watch?v=Thg2bqDbjB8

ZeroN Magnetic Interface
https://www.youtube.com/watch?v=-i2kJMJz7Wg

PROS

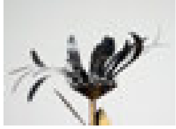
- Fast Motions (No Friction)
- Show Effect (Magnet Magic)
- Simple Mechanics (Less Parts)

CONS

- Complexity (Engineering)
- Stabilization (Sideways)
- Relatively Slow (Ability to Animate)
- Motion Control (Arduino, Joystick)
- Strong Magnets = Health Risks

SCORE	21/35
Ability to Animate	●●○○○
Motion Control	●●○○○
Feasibility	●●●○○
Complexity	●●○○○
Installation Space	●●○○○
Durability	●●●●●
Audibility	●●●●●

THERMAL

LINKS

Fishing Line Artificial Muscle
https://www.youtube.com/watch?v=fNS0pxnQfdY

Shape Memory Alloy Demonstration
https://www.youtube.com/watch?v=bvw7_a2gU24

PROS

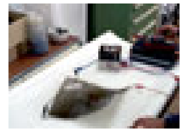
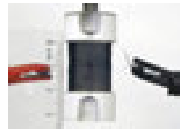
- Strong Fishing Line (Heavy Weights)
- Fabric Properties (Weaving)
- Simple Mechanics (Less Parts)

CONS

- Heat Reactive (Real Car Feasibility)
- Relatively Slow (Ability to Animate)
- Complexity (DIY Weaving)
- Durability (Thin Nitinol Wires)
- Motion Control (Arduino, Joystick)

SCORE	21/35
Ability to Animate	●●○○○
Motion Control	●●○○○
Feasibility	●●●○○
Complexity	●●○○○
Installation Space	●●●●●
Durability	●●○○○
Audibility	●●●●●

ELECTRICITY

LINKS

ShapeShift - Electroactive Polymers
https://www.youtube.com/watch?v=4XGVMXCxBNA

Contractive EAP Actuator
https://www.youtube.com/watch?v=4ergyPGm5u4

PROS

- Shapeability (Surfaces)
- Organic Motions
- Relatively Easy to Build

CONS

- 4000 Volts (Feasibility, Dangerous)
- Low Lifespan (Real Car Feasibility)
- Heat Reactive (Real Car Feasibility)
- Relatively Slow (Ability to Animate)
- Motion Control (Arduino, Joystick)

SCORE	18/35
Ability to Animate	●●○○○
Motion Control	●●○○○
Feasibility	●○○○○
Complexity	●●○○○
Installation Space	●●●●●
Durability	●○○○○
Audibility	●●●●●

DIRECTIONS / MOVING PARTS

There was a decision to make regarding the amount of moveable parts, as they are influencing the general design direction of the project. The one calling for less or integrated parts had convincing arguments and ultimately won the competition. A mechanical system containing many parts usually means higher risks of defects and subsequently shorter service intervals. Yet, the possibilities of the futuristic Internet of Things could mean intelligent sensors for "condition-based maintenance routines that are far more cost-effective" (Manyika et al. 82).

Utilizing reduced amounts of parts could potentially mean a fusion of interior and exterior components, ultimately resulting in a both-way communication of the vehicle. On the other hand, more parts possibly hold opportunities for physical interactions and individualization. However, they also mean a higher complexity in regard to production and later assembly. But the recent advancements in the field of nanotechnology and swarm intelligence make one dream of generative production methods and self-induced, real-time adaption of geometries, just as building a morphing sandcastle on the beach.

Luigi Colani

LESS / INTEGRATED

This direction calls for the use of the typical BMW design language to "represent the simplest complete solution" (Cooper et al. 154). A meaningful fusion or reduction of parts could result in shared tasks and holistic operations. Their physical change due to motions would effect the visual appearance, and the function of the whole vehicle. The futuristic looking and streamlined properties are well suited for later model building purposes, as connected parts without many joints are easier to paint and assemble.

Joachim Sauter

MORE / MODULAR

This direction's core idea is to arrange equal parts to a greater something. It bears lots of potential within assigning information or other dynamic data, represented by individual, interconnected, as well as intelligent modules. They could be elements of the car's interface, designed for somatic interaction and individual adaption according to the driver's physical and mental needs. In the far future, larger structures will be made up of such modules. However, today's technology for artificial intelligence is still not there.

Kawka, redbubble.com

MILLIONS...

The Beetle is metaphorically represented by grains of sand, consisting of uncountable amounts of miniaturized, interconnected nano modules. This concept harnesses the main idea of the Internet of Things and takes it to new and maybe unexpected extremes. Shaer and Hornecker point out the great scientific research of Hiroshi Ishii and his students, to "make bits directly accessible and manipulable" (8). The implications of this freely definable matter are just as frightening as impossible to realize today.

STYLING / VISUAL METAPHORS

An important goal is to obtain a holistic car concept, charged with the metaphors on the right. This applies to their visuals as well as behavioral elements. They generate interesting storytelling aspects and subsequently the desired narrative depth. The gestalt of the car has to represent the designed interactions. Hallnäs explains the inner logic of forms and functions: “In respect of driving a car, the form of car driving relates to the ways in which we drive a car, that is, to the logic of driving inherent in the way in which the car is designed” (76).

The depicted objects as well as represented metaphors were analyzed in regard to their visual characteristics and habitual interactions within their natural environments. They are objects in an enduring state of flux and contain well-suited combinations of features concerning the goals of this thesis project. Moreover, they pose valuable assets in respect of marketing strategies and brand communication. Qualities such as sustainability and dynamic mobility are latently present within the selected metaphors and will be explained in detail by the following paragraphs on the right hand side.

Jinbon Lau

WASP

Wasps or bees are just as endangered today, as manually controlled cars will be in the future. Their values have to be recognized, utilized, and protected in order to prevent a great loss. The insect metaphor includes interesting possibilities regarding shapes, forms, and functions. For example, a combination of wings, slim waistline, and jointed extremities, could result in an interesting propulsion system. Other qualities worth mentioning are color contrast, small size, and the purpose-bound existence of the drones.

Mercedes-AMG GmbH

SPEEDBOAT

This metaphor suits the concept of constant change, as the surrounding water represents the flow of time and an ocean of possibilities. Being the driver, one floats above everything and follows their own path. The streamlined appearance of the boat inspires fast and longish vehicles, without the application of wheels. Due to their form, they feel more like frictionless gliding than common driving. Also, it implies the presence of clean water. Thus, environmentally friendly powertrain technology as well as sustainability is communicated.

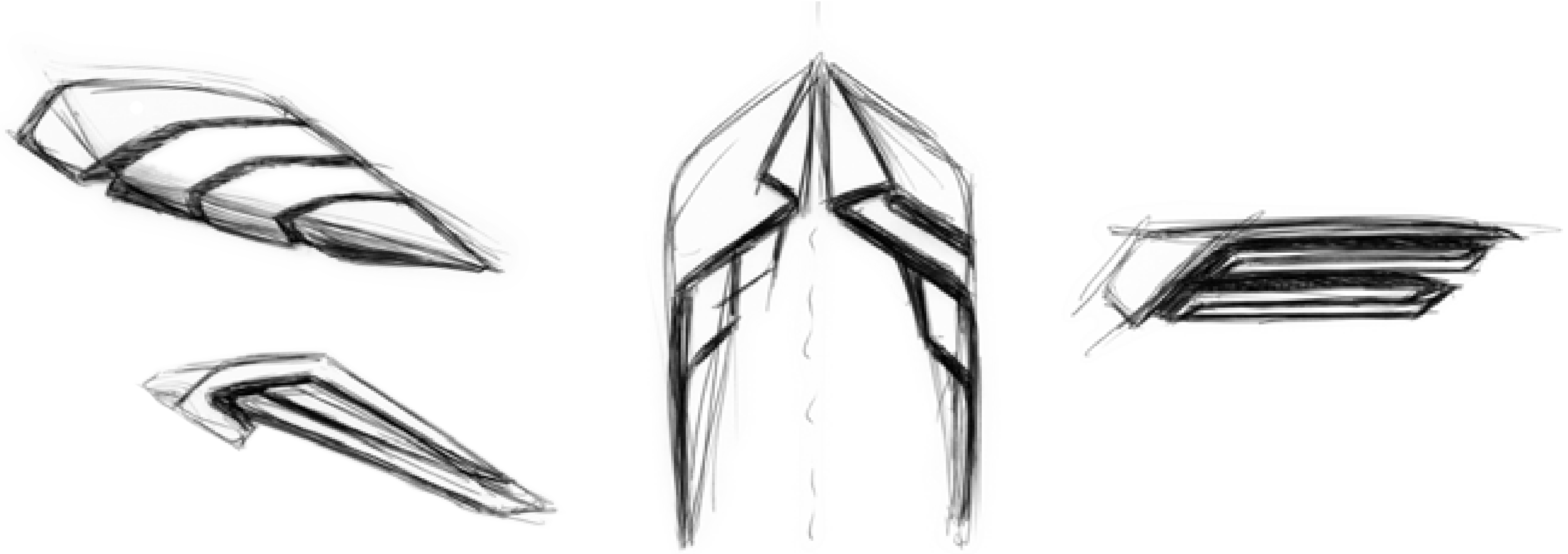
German Aerospace Center (DLR)

FLOW

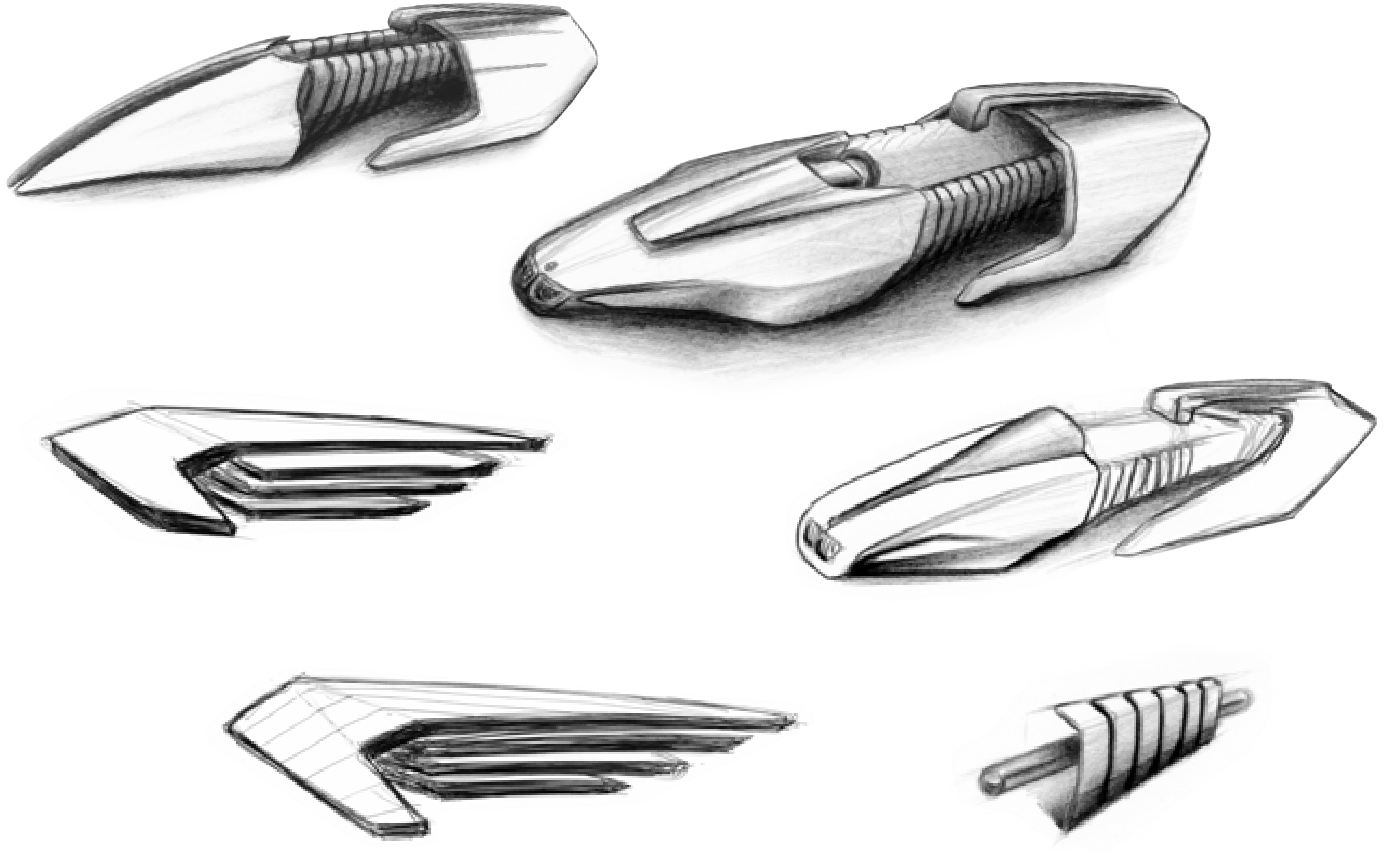
An airstream or flow of water is visualized by this metaphor. The surroundings pass us by while driving and express change. It can be interpreted as the natural course of things within the state of flux. The smoothness of the flow means great qualities regarding aerodynamic properties. They should be applied to reduce the consumed amounts of fuel or electric energy. The metaphor offers the ideal framework to convey BMW brand values, such as dynamism, sportiness, as well as premium mobility.

SKETCHES / FORM FINDING

The sketches printed on this two-page spread illustrate some of the steps of finding shapes and forms for the metaphors on the previous pages. They transfer the ideas for interactions into clues regarding interior and exterior parts of the vehicle. This search is about finding general forms, as well as detailed solutions and combinations of geometries by the means of visual exploration. It is not a straight process, but an act of mutual influence of sketches and the concept ideas on pages 43-44. The ideation results deliberately leave a certain amount of space for independence, as they are intended to shape the narrative element of “interpretive information design” (Katz 75). Below, the sketches depict the cockpit in combination with the wings metaphor and kinetic pulse generators. On the right, exterior sketches illustrate an idea for a bendable car, that widens or shortens itself depending on contextual conditions.



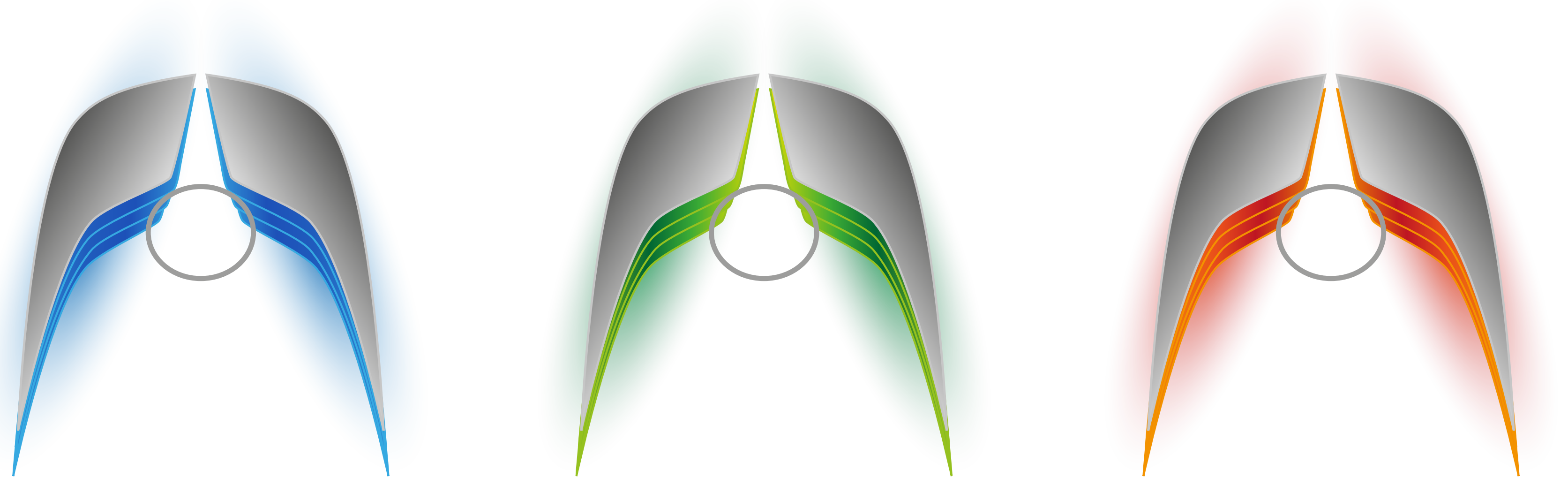
Michael W. Meier



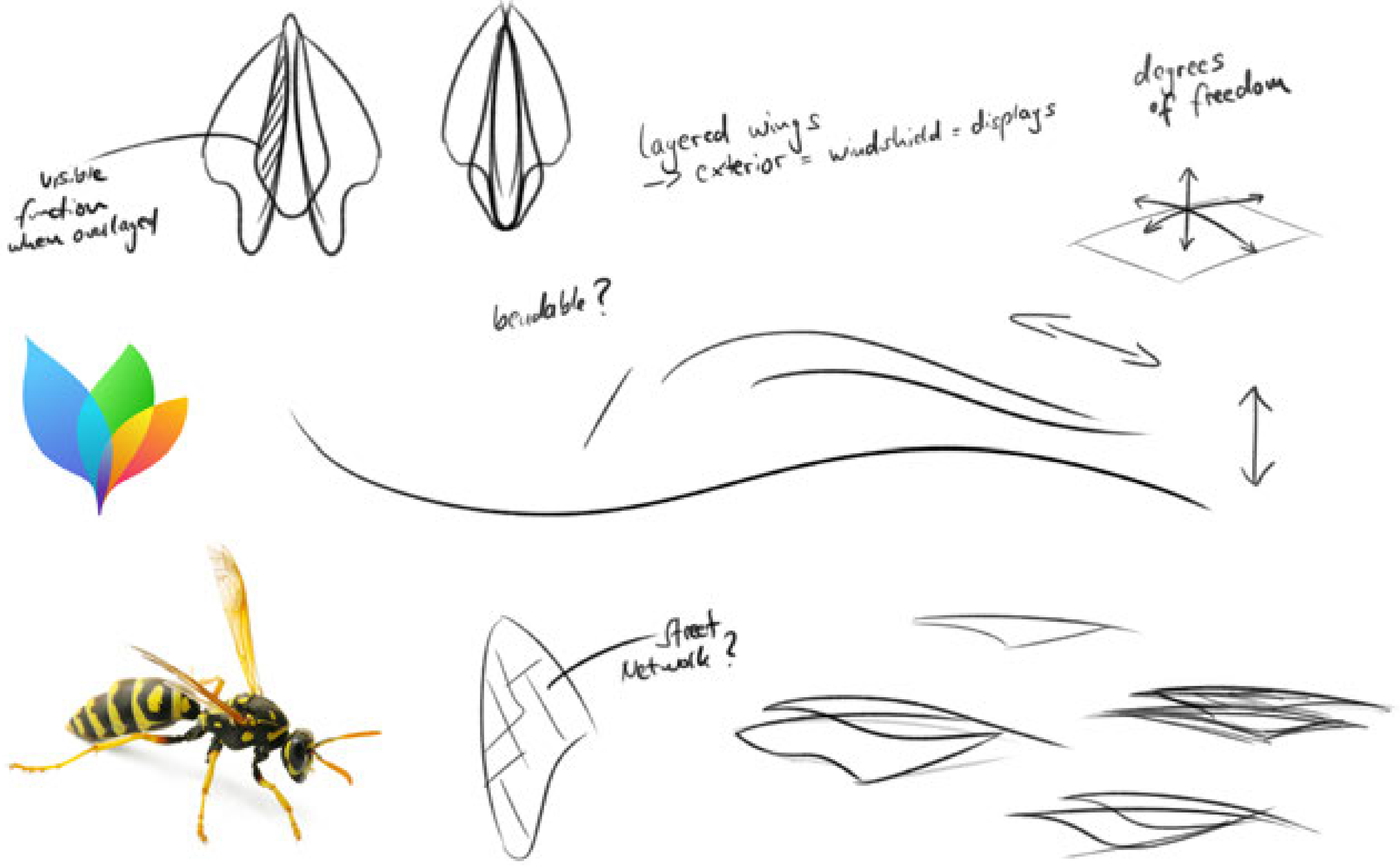
Michael W. Meier

CONCEPT / ILLUSTRATION

The idea below deals with the question of how digital information could be presented within an automobile's interior. Data sources could either be the cloud or the immediate driving environment itself. Choreographed motions applied to certain parts of the cockpit make sure, that the digital life of the driver does not end at the driver's door. Yet, according to a study by Gellatly et al., this is exactly what happens. The researchers found that even the latest cars "did not do a very good job of supporting devices and data flow into and out of the vehicle" (159). The concept below applies color coded data sources to a protruding "stack" geometry within the cockpit. More recent bits of information get "stored" on top of each other, until the driver decides to "read" them. The opposite page shows an ideation about overlapping screens. Their motions would mimic wings and unveil information in certain positions.



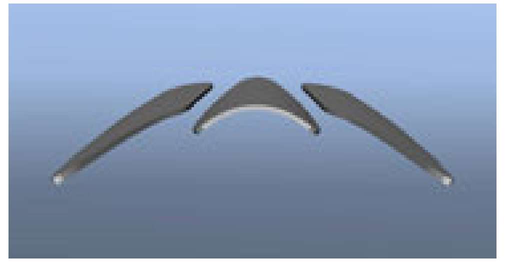
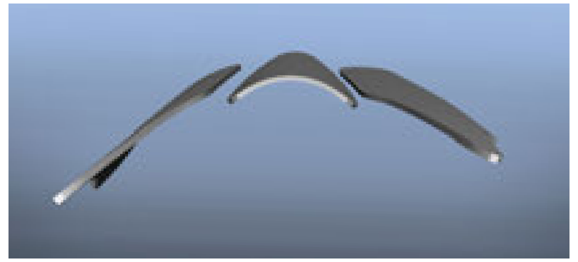
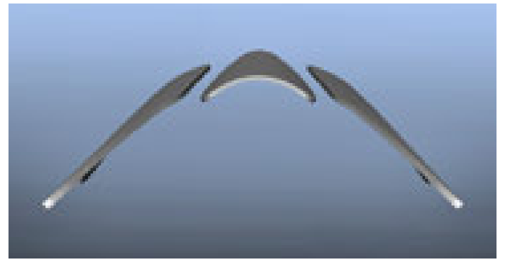
Michael W. Meier



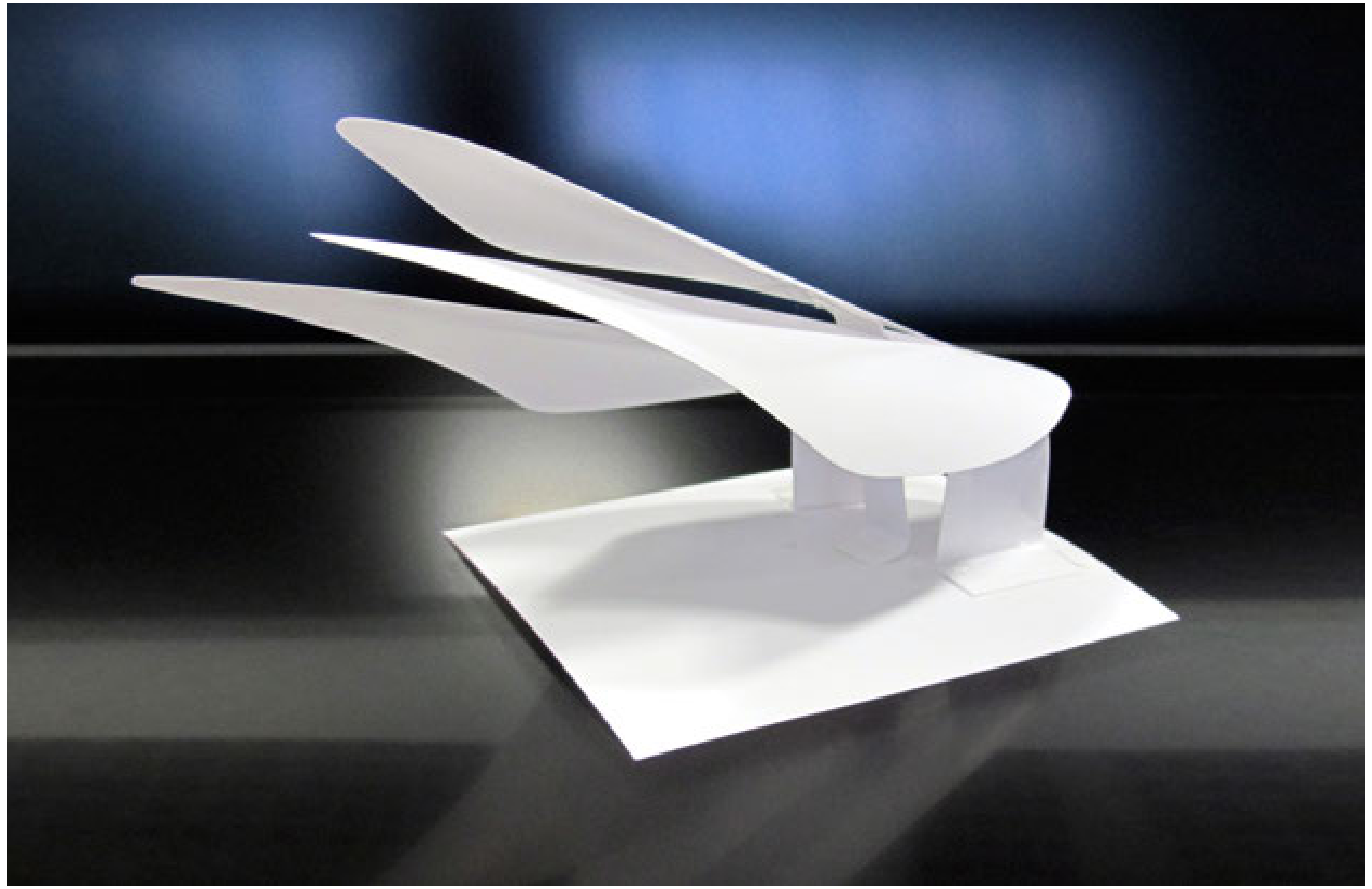
Leaves: IdeasOnCanvas GmbH / Wasp: Alekss, canstockphoto.com

MOCKUPS / PAPER & MAYA

Different positions of the shown wings were simulated in Autodesk Maya to get a better feeling and impression of them within the three-dimensional space. Moreover, paper models were built. The photo on the right shows how the wings would move within a thought airstream. They convey a certain feeling of lightness and agility that interactive system should express in its final form. Standard ISO 9241-210 defines such systems as a "combination of hardware, software and / or services that receives input from, and communicates output to, users" (2). Although, as Shaer and Hornecker argue, even complex data structures could be associated with physical objects (51-52), the driving experience should remain the focus of this thesis. Sengers puts it this way: "Think of meaning, not information. Computers care about information. Humans care less about raw data than they do about what information means to them" (27). Pursuant to the definition of "user interface", drivers should be able to "accomplish specific tasks with the interactive system" (ISO 9241-210 3). In the scope of this work, this means the car is acting as a medium for the driver's mindset and style of driving. The car's wings mirror this mindset, or the other way around. One could speak of sympathy between the driver and the reacting automobile. This directed feedback will be recognized subconsciously by the driver and influences the "user experience" in a positive manner. According to ISO 9241-210, it is a "consequence of the presentation, functionality, system performance, interactive behavior, and assistive capabilities of an interactive system, both hardware and software" (7).

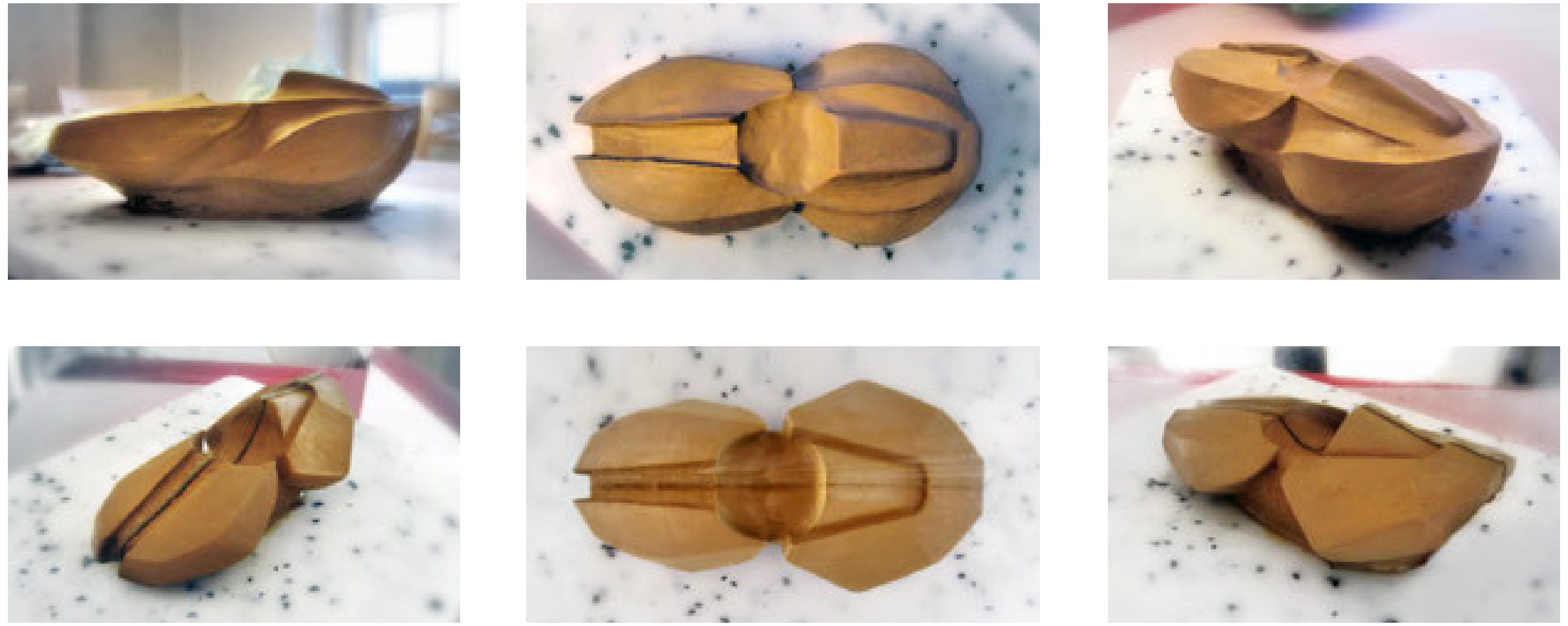
Focus Driving / Cruising Mode / Exploration Mode



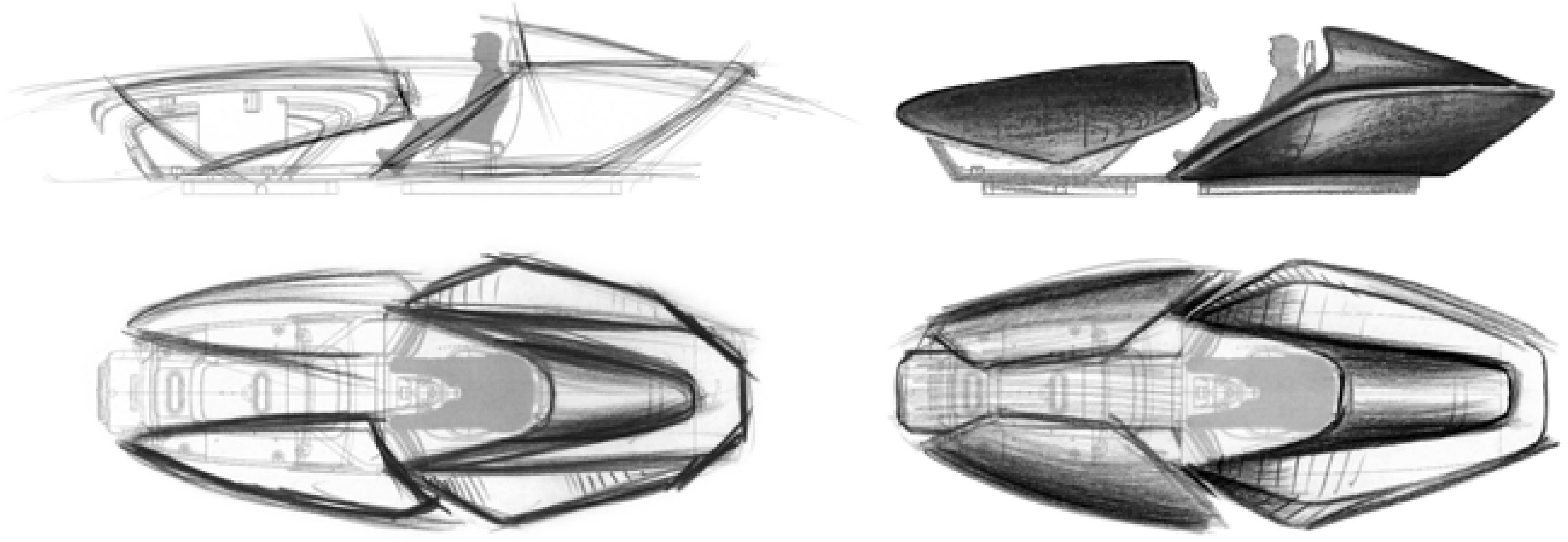
Phenotype: Lightweight Wings Flowing in the Airstream

PROPORTIONS / REFINEMENT

The photos below show two different sets of clay models. Sketches and metaphors, depicted on the pages 39-46, served as templates for the basic proportions. The wasp's slim waistline, "missing" wheels, as well as the longish streamlined shape of the speedboat are already recognizable. Interior and exterior form an inextricably linked unit. If one of them changes its position, the other does too. Therefore, a changed interior alters the exterior appearance of the car. The one-seated car focuses on the driver. He is surrounded by a "digital entity", which reacts physically to given driving commands.



Clay Modelling



Keysketch

The "problem" with the wings, as movable parts of the interior / exterior, was that they changed the vehicle in a way that seemed too dramatic. A design had to be found, which prevents the discontinuation of visual lines on the car despite its moving parts. Thanks to the clay models, this circumstance could be solved rather quickly. The sketches above show the development as well as refinement of the new version. This keysketch uses an underlying package of the BMW i8. It directly affects the driver's sitting position, view, as well as the length and height of the vehicle. The car is made up from four major parts: center wing, left / right wing, and back. As the center wing slides back or forth, the interior feeling changes. The left and right wings lean to the sides, whereas the back holds the driver seat, air-intake, and propulsion system. The scanned version of the upper right-hand sketch was imported into Autodesk Alias to design the NURBS surfaces of the following model. The process will be discussed in more detail.

Autodesk VRED Rendering

FINAL MODEL.

LET'S GET PHYSICAL.

The final concept car does not drive, it hovers. On the model, this is simulated by the blue glowing socket. The hover technology, as well as the overall concept, will be explained in depth from page 65 on. For the final presentation, a real model in the scale of 1:6 was built. A digital one, as depicted on the left, has its charms too, yet is not as comprehensible. More VRED renderings can be seen in the next chapter from page 68 on. The model can actually move its wings by remotely controlled servo motors.

The gestures can be demonstrated in real-time during the final presentation. Therefore, the audience will be able to play with the vehicle and experience the concept in person. The reference and experience-based model was built in the BMW workshops, with the help of large rapid prototyping machines and lots of manual sanding. Real car paint was used for all layers, such as the primer or glossy finish. All electronics, as well as the LED controllers are built into the podium, which is also a shipping box.

SCALE MODEL 1:6

The model was built to take it apart right in the center. This helps to get a better view into the interior and cockpit. Moreover, the installation of the LED strips could be done easier this way. Yet, the main reason for the separation was the logistical aspect, as the two parts were intended to be placed inside the podium for shipping. The transparent tag next to it is made of laser cut and engraved Plexiglas.

Normal Position

Exploration Mode

The view on the left-hand side shows the vehicle while in closed, normal position. It can be opened to depict the so-called “Exploration Mode”. This enables the driver to go on a voyage of discovery. The movements itself are controlled by an off-shelf Nintendo Wii Nunchuk controller. Details about the underlying technology are explained from page 57 on. The model is consistent with the project’s internal logic of interaction. The physical input from the joystick will be digitally interpreted by an Arduino microcontroller, subsequently sent to the servos, and finally somatically displayed by the vehicle’s wings.

Normal Position

For a better illustration of the motions, this thesis book contains a DVD with video files. It can be found at the end on page xxxvii. The possibility to demonstrate the positions live during presentations offers many advantages. First of all, moving models are still the exception and provide a certain kind of "coolness" and show effect. Moreover, due to the precise control over the wing's positions, intended expressions can be discussed with greater ease. Another point is that the audience has the ability to play with the scale model and gets closer to the real user experience than it would by looking at renderings.

The motions are performed in a smooth as well as appropriate way. They fit the overall design and feel as if the car would shift its balance. This transfer of weight serves steering purposes and directs the vehicle to the left or right side. The wings can be controlled individually or in combination with each other. Therefore, it is possible to demonstrate and observe various patterns of choreographed motions. The operator of the model will not be able to make any mistake, as there are failsafe positions programmed into the servo motors. Hence, there is no need to worry about bumping or scratching parts.

Exploration Mode

COCKPIT DETAILS

The 3D printed driver inside the car is a scan of the author of this thesis. In front of him, there is the steering wheel with large, touch-reactive surfaces to control a possible later GUI within the helmet of the driver. The BMW logo on the steering wheel is glued on. There is a transparent display on top, showing speed and power output of the car. Further, the dashboard contains orange colored, kinetic layers.

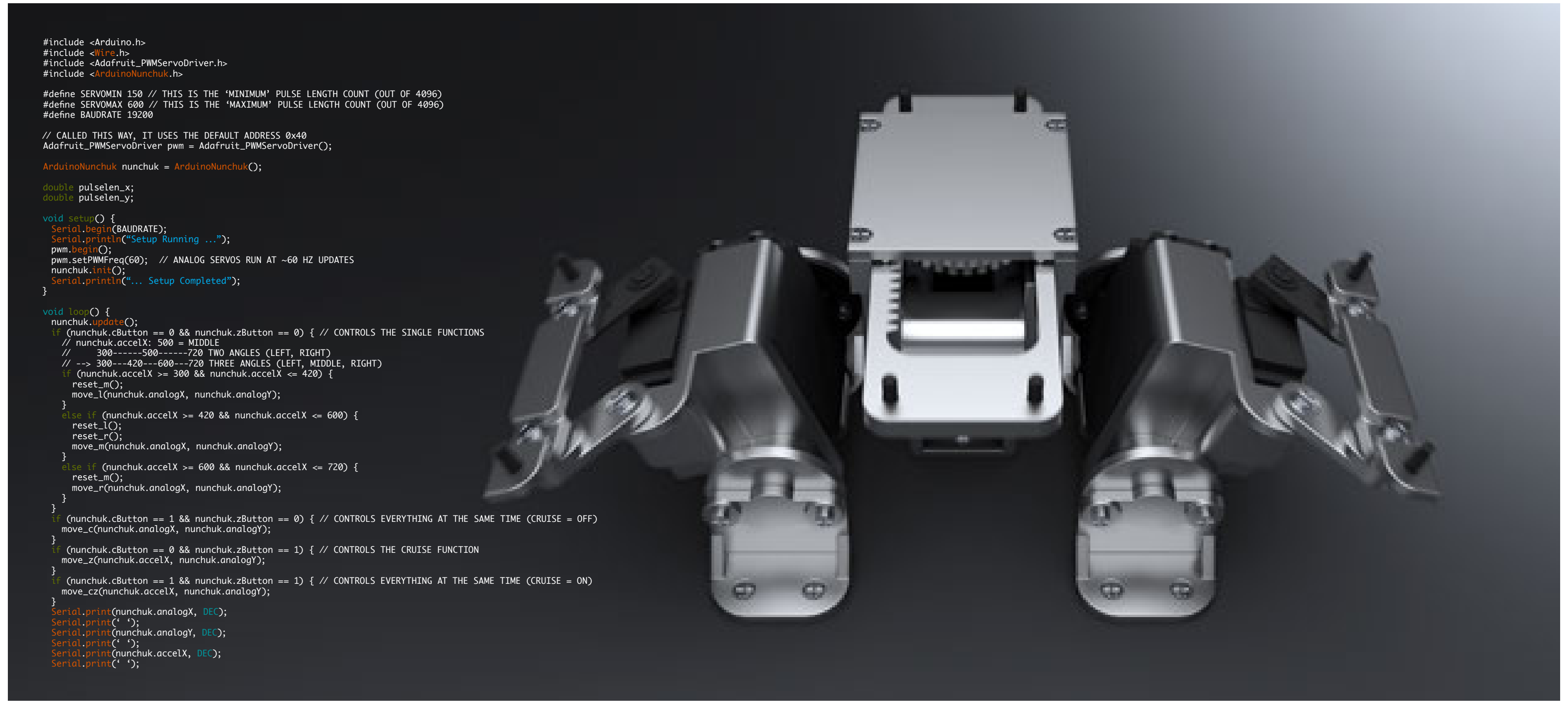
Steering Wheel & Dashboard

3D Printed Driver & Air-Intake

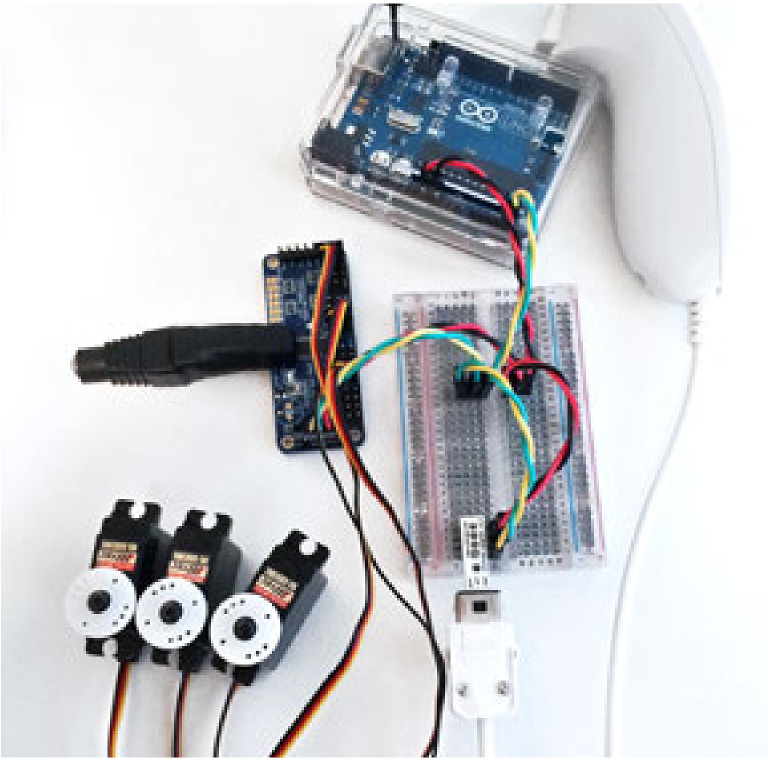
Those layers are able to slide back as well as forth and light up if necessary. Basically, they visualize proximity and direction regarding objects or notifications. The closer they get to the driver, the smaller the distance to an object on the street. The lights indicate directions such as left or right. Moreover, they display gradients from top to bottom and the other way around. One could say, that they visualize time and space with the help of nonverbal signals. The grid behind the driver's seat constitutes an air-intake. It will be compressed inside the back and serves as cooling for the propulsion system.

MECHANICS / ARDUINO CIRCUITRY

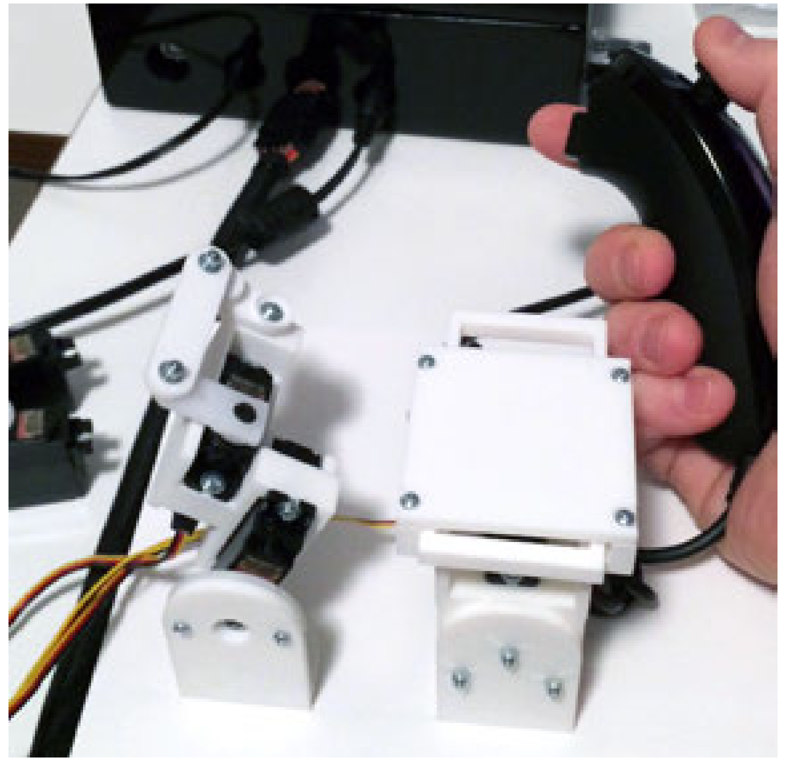
The rendering below depicts the mechanical armature of the wings. On the left an excerpt of the Arduino Uno programming code is shown. The full version of it can be found on the DVD. The center wing uses a “rack and pinion” mechanism to slide back and forth (Sclater 11). It converts the rotary motion of a gear to a linear one. The lateral wings use rotation as well as “four-bar linkages” (Sclater 90).



Rendering of Mechanical Armature



Controller, Breadboard, Servos



Right & Center Wing, Wii-Nunchuk

Altogether, five servo motors are controlled by a Nintendo Wii Nunchuk controller. Its thumb-operated joystick sends positional data to an Arduino Uno microcontroller. The image above shows the prototype implementation of the wiring, utilizing a breadboard. A pulse width modulation board (PWM driver) sends varying signals to the motors and controls their angles. The photo above shows the first 3D printed prototype of the armature. It still uses the smaller and less powerful servos. All in all, the armature did not change much. Most revisions concerned stabilization as well as precise execution.

SOLIDWORKS EVOLUTION

The actual NURBS surfaces of the car were created with the help of Autodesk Alias. It provides precise control over surface behavior, continuity, and curvature. Subsequently, the parts were imported into SolidWorks. This program allows virtual assemblies and evaluations. Further, it enables the adaption of parts to one another and the simulation of mechanical processes. Out of those reasons, it was used to create the armatures for the servo motors, as they should move in a smooth and approachable way. Rehder and Hentschel speak of an intimate feeling (14), machines are going to convey. The renderings below illustrate the evolution of the lateral wings' armature. The first version holds small servos, intended for rotating the structure. Yet, the weight of the wing would result in instability and wobbling. Hence, a stabilization was added in the revision. The third and final version uses stronger servo motors as well as optimized details.

Version 1: Early Mockup / Version 2: Added X-Axis Fixture / Version 3: Stronger X-Axis Servo

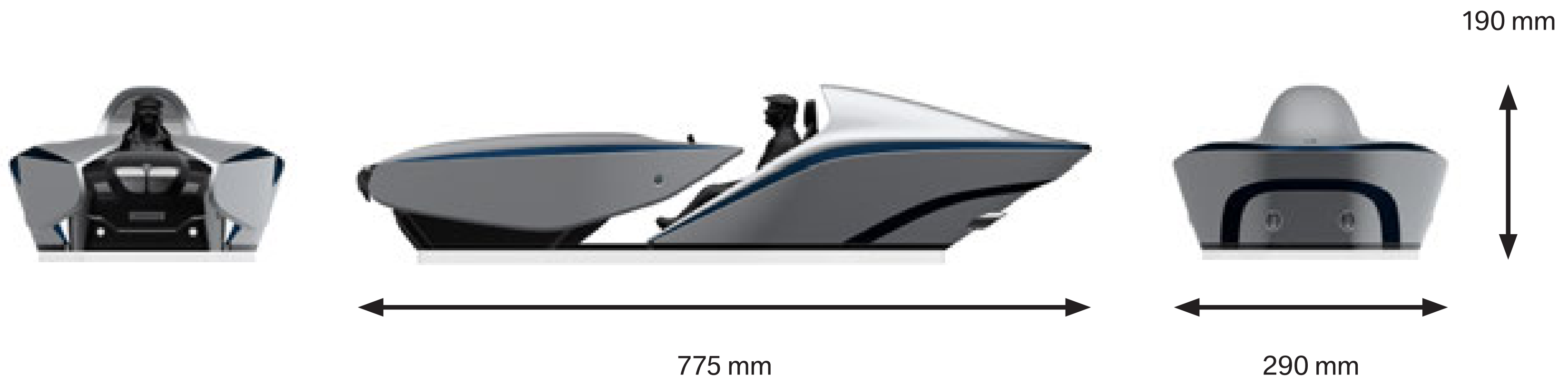
The motors and mechanical parts should be visible as little as possible. The goal was to obtain an impression of magical movements with invisible functionality. Some kind of bowl or shell was created for an early version of the housing. It had cutouts for the lateral wings and the top could be removed to access the mechanical parts on the inside. Yet, the design was discarded, as the overall visual style did not match the vehicle's targeted expression. For the second version, the massive socket was subject to change as well. It became much thinner and its outline now follows the servo housing in an integrated way.

The most recent version of the servo housing consists of four parts: front, back, left, and right. A top cover does not exist anymore, but the parts are now curved and held by screws in the socket. They can be removed quickly to service the mechanical innards. The rendering in the center shows the left side panel removed. One can find larger versions of the depictions within the Appendix, starting on page xxi. Later versions of the virtual assembly contain a revised version of the seat, to fit the 3D scanned data of the driver. The last rendering on this page shows the mounted back of the vehicle. It is one large, hollow piece but with reinforcing ribs inside.

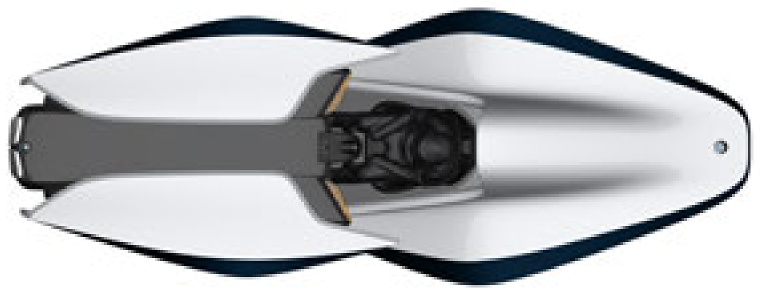
Servo Housings, Appendix II - IV

DIMENSIONS / POSITIONS OF WINGS

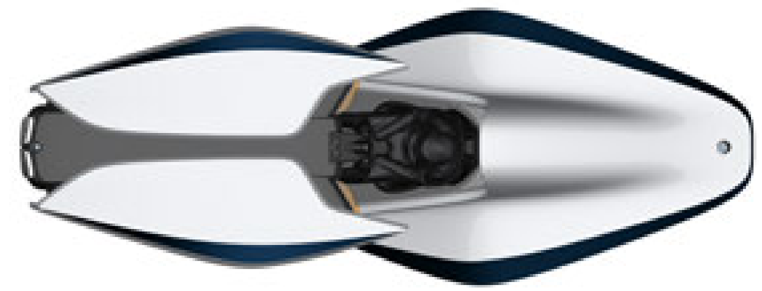
The dimensions of the physical model are depicted below. Its scale 1:6 is a little smaller than other models within the automotive sector. They are usually built at about 1:4. A couple of reasons lead to this decision. On the one hand, the model was intended to be shipped to the Pratt Institute in Brooklyn, New York. Therefore, an eye on the weight was important. Moreover, the 3D printed wings were about to become too heavy for the servos. The motors had enough torque, yet the vehicle's wings started to wobble slightly. Now, the thickness of the rapid prototyping material varies from 3 to 5 millimeters, meaning a certain torsional rigidity. Larger parts demand even stronger walls or lighter materials. This would have lead to alternative manufacturing methods, such as milled foams or complex GFK fabrications. Nonetheless, the targeted goal was to keep the motions just as smooth, characteristic, and aesthetically pleasing as possible. Kliën supports this intention and argues that choreography is "a way of seeing the world, perceiving patterns, relations and proportionalities" (148-149). To put these aspirations into the practice of this thesis, one could speak of choreography as an "aesthetics of change" (Kliën 7). The renderings on the right show the vehicle's changing expressions.



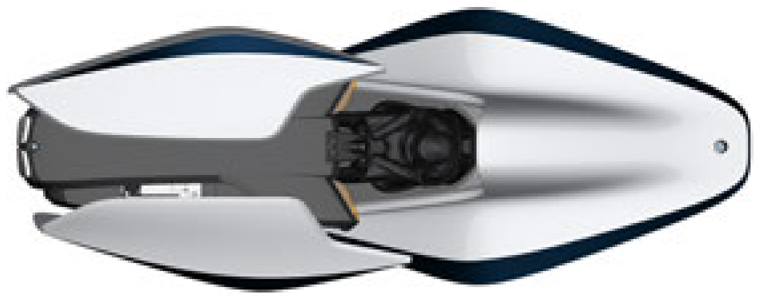
Scale 1:6



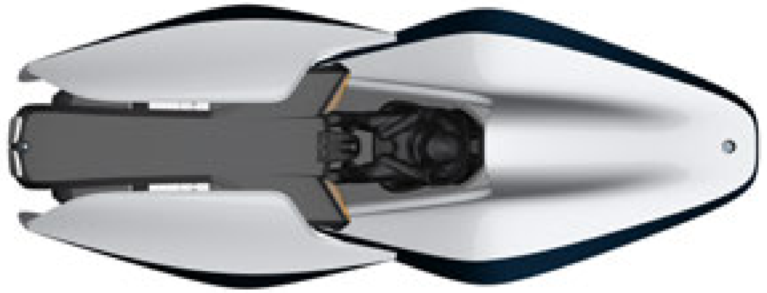
Normal



Focus



Cruising



Exploration

The normal position represents the posture after the vehicle awakens from parking mode. It constitutes a neutral driving behavior. While being on the highway, the car goes into focus mode. As the automobile becomes tighter and more streamlined, the driver feels safer. Within cruising mode, the car leans into curves as if the driver would enjoy a day off skiing. The exploration mode opens and widens the car to offer more space and a better view to the driver. Now, he feels comfortable and is ready to discover something new. The positions of the wings are based on locations, yet they can be selected on demand.

COLOR OPTIONS

Many colors variants were tested out virtually to achieve the best support for the overall statement of the vehicle. The whole BMW car paint palette was available, including glossy and frozen finishes. The decision was made in favor of three areas: exterior (primary), interior / servo housing (secondary), and flux-lines (highlight). The finally chosen car paints are called Mineral White, Mineral Grey, and Cosmic Blue.





Schemes and Statements



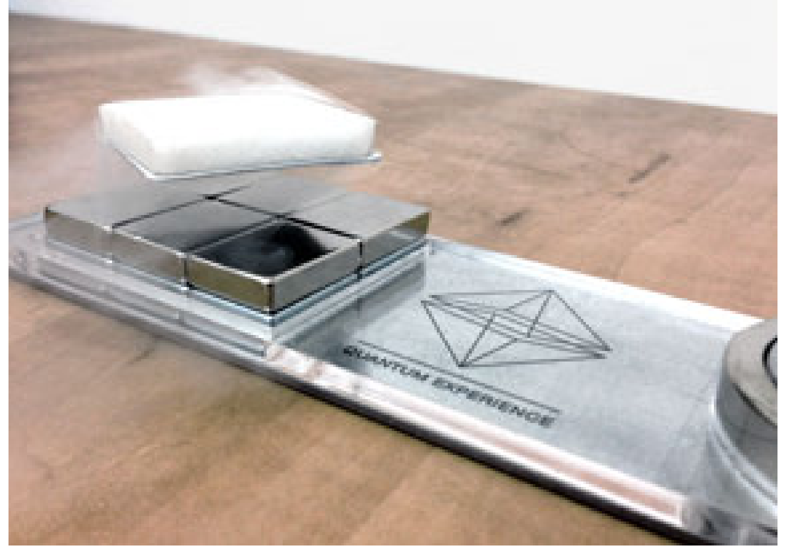
BMW Group

The picked combination is the result of the colors within the BMW Yachtsport and Sailing Cup world. Metaphors such as “water” and “boat” fit the concept very well, as already discussed from page 40 on. Moreover, it adds the targeted event as well as competition character. One can find the three colors above. The warm-white colored boats create a high contrast to the water. It forms the background of the scenes and looks greyish-green. A deep and dark blue on the sails functions as the highlight color and offers a strong contrast to the white fabric. The BMW logo works as a variation of the depicted range.

HOVER TECHNOLOGY

The research suggests that there are at least two promising technologies to make objects hover. The first is called quantum levitation or flux pinning. It utilizes liquid nitrogen as well as strong rare earth magnets to lock a cooled superconductor in space. The technology works quite well and has an almost “magical” effect to it, but does not solve the problem of propulsion. The superconductor is simply locked in space, but does not move in any direction, unless the magnets do. Another auspicious hover technology from Hendo makes use of rotating, repelling magnets.

It appears to be more seminal than quantum levitation, as it could solve the propulsion problem. For this purpose, electromagnets are mounted on rotating discs. The magnets are turned on and off by a controller in varying frequencies and create a repulsive force. One could think of it as a canoe. As there are four of those rotating discs, the hover board is able to push itself into different directions. The future might bring intelligent streets, carrying a current of electrical energy or data streams. If they had magnetic properties too, maybe some similar kind of technology could become reality one day.



Quantum Experience Ltd.

QUANTUM LEVITATION

Although this technology looks very complex and scientific, it is just a couple of rare earth magnets mounted on a tray, with a cooled superconductor on top of it. The superconducting material has ceramic properties and is cooled with liquid nitrogen to about -180° Celsius. Thereby, atomic processes within the material are slowed down. This enables the magnets to lock the superconductor in the space above them. One can change it’s position, but the cooled material will retain its pivot even at an angle or upside down.

Toyota Motor Corporation

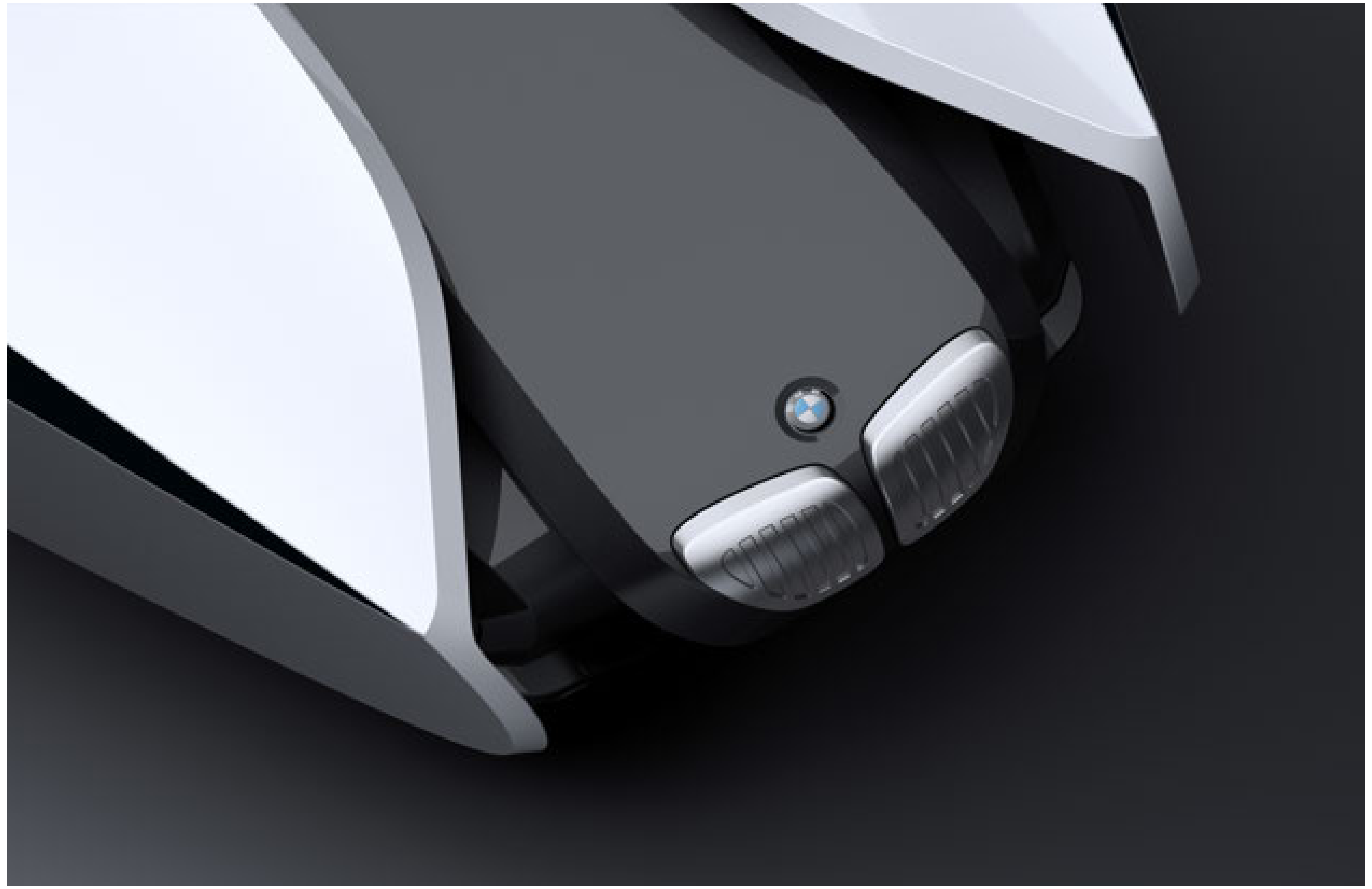
LEXUS HOVERBOARD

This hover board utilizes quantum levitation technology, as introduced in the last paragraph. The concept was intended for a marketing campaign and received lots of attention on the internet and social media. The board shows that the technology, pushed with enough efforts, has the potential for a degree of maturity. Yet, it is still not suited for public streets, as it always depends on liquid nitrogen and magnetic tracks. Therefore, Lexus built a whole skate park with predefined magnetic pathways, to make it work.

Arx Pax, LLC

HENDO HOVER

The crowd funded company focuses on the development of hover technology. It still makes use of magnets, but does not need liquid nitrogen for cooling a superconductor. The board is able to float above thin diamagnetic or paramagnetic materials such as copper or aluminum. Maglev trains work in a similar way. Due to the nonexistent friction, they pose a very efficient form of mobility. Although the technology looks very futuristic, it could actually be ready for larger production volumes in some years.



Front / Sliding Nose

VIRTUAL.

DIGITAL REALITY.

The following chapter illustrates the concept with the help of still renderings, created in Autodesk VRED Pro. They show the exterior, interior, as well as scenes from a simulated driving context. The images depict the vehicle with the associated wing positions on the highway, a rural mountain road, and within an urban city environment. A description of the cockpit animation and its creation will follow subsequently. The required footage of road sections and situations are sourced from a common car racing video game.

The NURBS surfaces of the 3D model were created and edited with Autodesk Alias Automotive. Thereafter, the data set was imported into VRED Pro as combined shells via the FBX format and structured into assembly groups. Hence, they could be rigged and textured for the following animation work. Especially the ego perspective of the driver should be illustrated in this context to simulate the overall user experience of the vehicle. The final video can be found on the DVD at the end of this book.

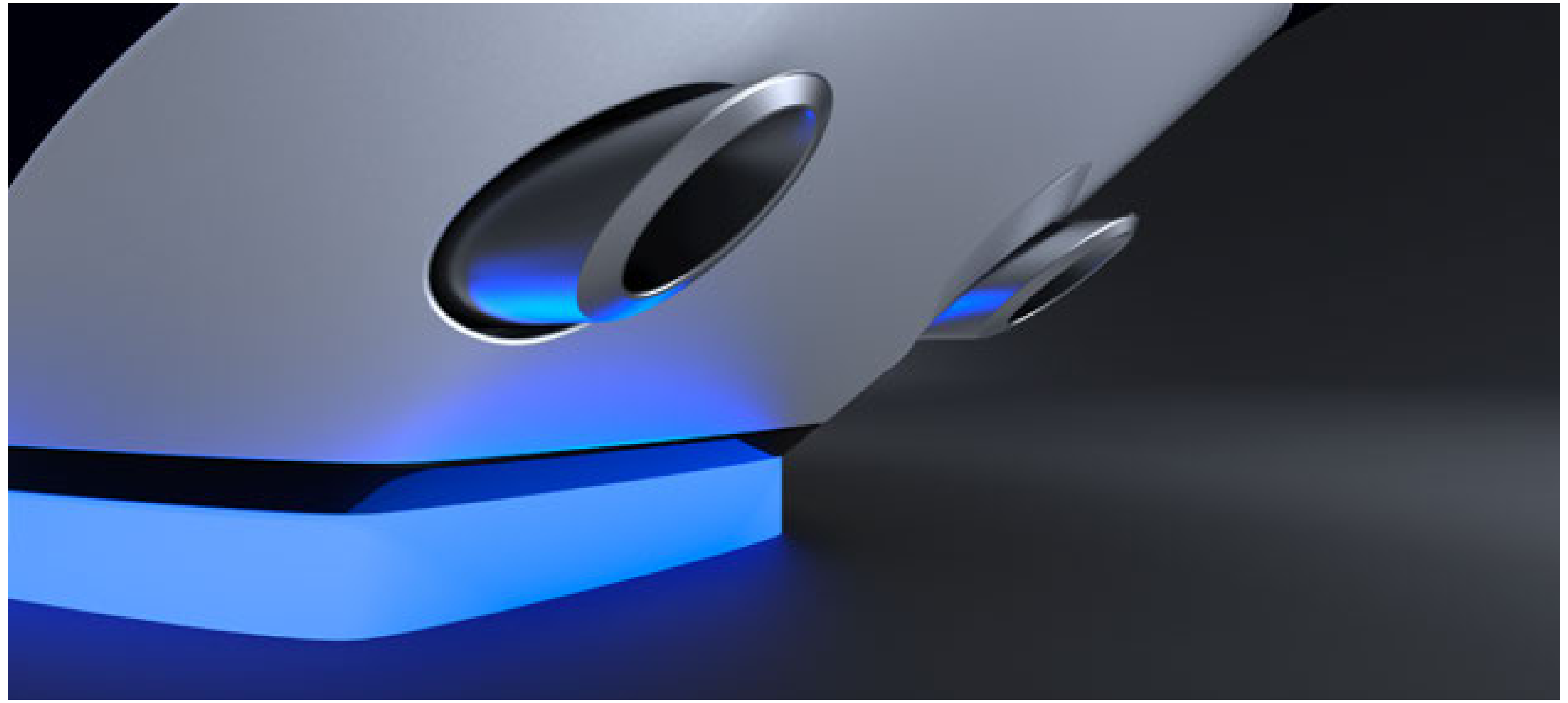
VISUALIZATION

The whole 3D model of the vehicle consists of so-called “NURBS” surfaces, organized in several assembly groups. This allows the rigging and texturing of the individual parts. The driver instead, is a highly detailed polygon model. The scanned 3D data of the upper body was cleaned and edited with Sculptris to make him ready for SLA printing. Arms and legs were added manually. The cap covers the fine hairs.

Cockpit, Appendix V

Driver, Appendix VI

The virtual 3D model does not only serve the purpose of illustrating the concept. It is also a template for the creation of the physical model and exists as a supplement in case of a later publication or presentation without the real one. Delicate details such as the speedometer are laser-engraved on 3 mm strong Plexiglas and glued onto the steering wheel assembly. For the video of the cockpit, the speedometer needle and indicators were technically rebuilt for animation purposes. Hence, they are able to portray driving situations correctly and operate in conjunction with the kinetic layers on the dashboard.



Rear Side, Appendix VII

The virtual studio environment above shows the rear of the model with its exhaust pipes. They are intended to vent compressed air to generate the required propulsion of the car. The pipes could be omitted as soon as the Hendo Hover technology makes further progress, as discussed on the pages 65-66. For the following action renderings, the blue socket of the model was removed and replaced with a futuristic-looking underbody illumination to create the impression of a hovering vehicle. Of course, the color could be changed for individualization purposes or even removed in case of a later serial production.

The rendering below shows the vehicle in a situation similar to a highway. Within the “Focus Driving” mode, the wings are rotated to the inside and “wrap” around the car as well as the driver for a stronger sense of safety, while he concentrates on his goals. The vehicle is also a bit shorter and more streamlined in the course of this scene, generated with the help of a virtual HDR environment as well as motion blur effects. The image was computed on the BMW render cluster to reduce the production time from several hours to a couple of minutes. Minor color adjustments were done in Adobe Photoshop.

Highway, Appendix VIII

Curvy / Rural, Appendix IX

The rendered image on this page shows the concept vehicle within a rural setting. The car knows its position on the curvy mountain road, based on GPS geo-location data. Therefore, it changed into the so-called "Cruising Mode". Being in this mode, the wings rotate constantly to the left and right, to balance the weight of the car. Thus, it is possible to take narrow curves and sharp turns with a dynamic style of driving. They basically behave like a downhill skier and trigger this special experience, reserved for curvy streets. Hassenzahl refers to appeal, as soon as products create positive emotional reactions (38).

The depicted city scenario below uses assets from the built-in library of Autodesk VRED Pro, just as the other action renderings do. The vehicle has its wings wide open. This style of driving is called "Exploration Mode" and renders the car longer, to adapt for slower urban speeds. Also, it offers more space within the interior to convey a feeling of ease and relaxation within the stressful traffic of the city. The driver is able to discover interesting things and places on every corner of the street. Basically, every mode of driving can be activated manually. The driver can adjust the vehicle according to his current mood.

City / Urban, Appendix X

COCKPIT ANIMATION

A video animation of the cockpit was created for the purpose of illustrating the driving qualities of the vehicle. It shows the behavior of the car and its wings from the ego perspective of the driver within the relevant driving situations on a highway, a curvy rural street, as well as the immediate proximity of a mega city. Further, the video shows how spoken audio feedback between the car and the driver could be designed. Special attention was paid to the change into another driving mode. However, according to Dul and Weerdmeester, the acoustic communication of information should be handled with care, as it could bother the driver rather quickly or can not be discerned clearly from natural human voices (48-49). Furthermore, simultaneously running tasks such as driving and speaking create a greater cognitive workload and increase the likeliness of an accident (Driver Focus-Telematics Working Group 68).

Driver's Perspective: Interior View, Cockpit

Highway Situation / Focus Driving, Appendix XII

The picture shows the car within a highway scenario. Kinetic layers on the dashboard and light signals warn in front of a sudden obstacle. In this dangerous situation, the vehicle simply has to work. Nevertheless, it also can be fun to react to non-lethal occurrences such as manhole covers or potholes. The driver plays some kind of game while he tries to avoid them. Researchers within the field of user experience identify this behavior as pragmatic and hedonic user goals (Bevan 3). The "player" seems to pursue self-imposed objectives, such as evasion, and concurrently experiences emotional stimulation.

Rural Situation / Cruising Mode, Appendix XIV

The moving wings of the automobile lean into the respective direction, for example during a curvy situation on a narrow mountain or coastal road. They shift and balance the weight of the vehicle and offer protection from objects on the roadside. Basically, they act like lateral shields. In addition, the kinetic layers on the dashboard warn in case of a deviation from the suggested ideal line. Multiple sensor arrays on the vehicle provide the required internal data for a safe passage on this road section. Therefore, even novice drivers will be able to master challenging tracks with joy and fun in a positive driving experience.

The car is in "Exploration Mode" and notices the interest of the driver in the emerging skyline of a nearby mega city. Therefore, the vehicle suggests an attractive spot on the route. As it fits to the driver's current mood, he accepts and stops right at a nearby parking place to enjoy the nice view. Hence, the car becomes a companion and fulfills further needs than mobility alone. This means that the possibilities of the Internet of Things turn the real world into a hyperlink with roads as data highways. Rehder and Hentschel predict that "places will become anchor points" and potentially provide "context-relevant information" (12).

Urban Situation / Exploration Mode, Appendix XVI

Axel Springer Auto Verlag GmbH

REFLECTION.

THE SUM OF ALL PARTS.

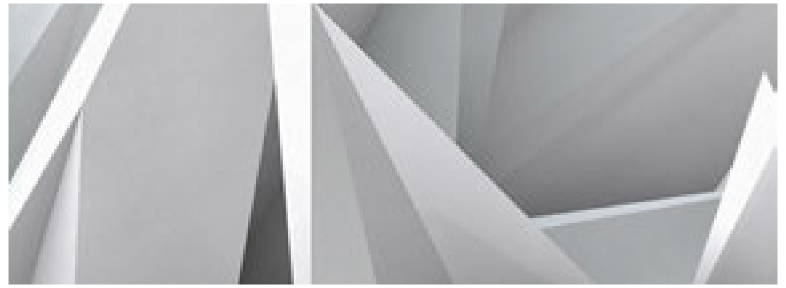
This chapter summarizes and concludes the thesis project. For this purpose, various benefits of the concept vehicle will be pointed out for potential customers as well as the BMW Group. Challenges regarding the design process will be discussed as part of a retrospective. It is the intention to analyze and improve the procedural methods for prospective applications. The following outlook compares the developed vision of the future with the present day and reconsiders the initially defined design goals.

The customer benefits lie firstly in the area of aesthetics, but also in the way information is being processed and communicated through the concept. Moreover, the vehicle was designed for the pleasures of driving and offers the potential for a positive user experience. For the BMW Group, the advantages lie in the ability to communicate their core brand values. Moreover, a diversified future product portfolio of automatically driving cars and manual ones, presents strategic flexibility within different market segments.

DESIGN BENEFITS

The aesthetical customer benefits manifest themselves through the natural communication with the concept vehicle. It interacts with the driver without the use of LCD screens. The advanced integration of automobile and driving environment results in an innovative connection of motion and emotion for the driver as the centerpiece of the design. Moreover, the driving experience will be influenced positively by presenting content from personal clouds in the right amount, right time, and right place. It will be enriching instead of distracting.

Further advantages regarding the experience of driving lie in the sensual perception of time and space. The strong sense for both originates from the interior and exterior of the vehicle, adapting to the current situation. Gestural changes regarding interface elements, such as the wings and kinetic layers, communicate information subconsciously to the driver. The focus lies on the context-based adaption to the current user's mindset. Besides reorganization, the elements also provide a safe, exciting, or relaxed feeling with the included driving modes. A short overview can be found on page 62.



Thought Cloud

Sebastian Duda, shutterstock.com

Uwe Krejci, gettyimages.com

The strengths of the concept lie further in the possibility to communicate core brand values such as dynamism, premium mobility, as well as connectivity. The "Sheer Driving Pleasure" is in BMW's DNA and differentiates the company from other manufacturers. Future drivers of the concept vehicle can enjoy a positive experience, as the car was designed especially for this purpose. Ultimately, those emotions and the resulting enthusiasm for the vehicle contributes to the so-called "brand equity and increases the likelihood of repeat purchasing and lifelong customer relationships" (Wheeler 158).

A diversification of the future product portfolio addresses various market segments as well as target groups. Consequently, products and innovations can be channeled and distributed selectively. Moreover, the general corporate risks are going to be dispersed and reduced. Kalmbach et al. advises to strive for openness and flexibility to harness chances in an holistic manner (81). This could be done by exerting influence through corporate politics. For instance, the promotion of broadly based goals, as well as slim decision-making processes by the formulation of coherent strategies and measures, could result in possible market opportunities as well as advantages.

BMW Group

BMW Group

Ollyy, shutterstock.com

RETROSPECTIVE

The interaction and interface concept was developed with a younger generation of future drivers in mind. However, it has to be ensured that all age groups are able to understand and use the system, as the world population grows older, especially within today's first world countries (UN Population Fund 4). The use of gestural choreographies and motion sequences for communication purposes creates good preconditions for this goal. The concept of interaction originates from a familiar physical world and addresses drivers intuitively as well as nonverbally.

In hindsight, the development of an universally comprehensible interaction concept, as well as the creation of the NURBS surfaces, were the most challenging tasks within the scope of this thesis work. The form language of BMW, with its dynamic and sharp changes between convexity and concavity, is one of the most complex inside the industry. Furthermore, it had to be ensured that the motions of the wings change the perceived expression of the vehicle, without tearing the car visually apart. Hence, lateral signature lines and the interplay between positive and negative space had to be maintained.

OUTLOOK

Driving a car can be very complex. One has to simultaneously observe the course of the street, other road users, as well as sudden changes and obstacles. Of course it is also fun, but the pleasures of driving can not stand in the way of safety. Therefore, complex digital services such as e-mails, websites or integrated apps should not be used excessively or only whilst the car is in parking mode. Visual and acoustic user interactions could be one solution for this problem. But ultimately, the modality of the interaction has to meet the requirements of the task (Ablaßmeier 194).

Later developments could possibly cover a helmet or respectively the visor of the driver. The conceivable, literally transparent, graphical user interface (GUI) with augmented reality elements could be the ideal place for an unobtrusive addition, "users don't even feel that it is there" (Mandel 11). Likewise, the concept could be optimized for a future serial production or scaled within further design loops, to fit other brands of the BMW Group. Nevertheless, the concept should always maintain the holistic approach to communication regarding physical and digital, as well as the interior and exterior of the car.

CLOSING WORDS

For the purposes of quality assurance it should be noted that a profound usability analysis as well as end user testing are strongly recommended to consider human factors in the operation of the concept. Hence, Lehto and Buck warn about several problems regarding efficiency and effectiveness in different groups of people while dealing with various tasks (547). Thereafter, the human machine interaction (HMI) should ideally conclude in a positive, trouble-free experience for the driver. The interaction and interface design takes on a key role in this matter and influences the results either positively or negatively.

BIBLIOGRAPHY

Ablaßmeier, Markus. “Multimodales, kontextadaptives Informationsmanagement im Automobil [Multimodal, Context-Adaptive Information Management Within the Automobile].” Diss. Technische Universität München [Munich], Germany, 2008. Print.

Arx Pax, LLC. “On The Hendo Hoverboard: How It Works and Demonstration.” *YouTube.com.* RaptorTech, 27 Oct. 2014. Web. 01 Dec. 2015.

Bertoncello, Michele, and Dominik Wee. “Ten Ways Autonomous Driving Could Redefine the Automotive World.” *McKinsey.com.* McKinsey & Company, 06/2015. Web. 22 Nov. 2015.

Bevan, Nigel. “UX, Usability and ISO Standards.” *The 26th Annual CHI Conference on Human Factors in Computing Systems.* New York, NY: ACM, 2008. Print.

Blom, Lynne Anne, and L. Tarin Chaplin. *The Intimate Act of Choreography.* Pittsburgh, PA: University of Pittsburgh Press, 1982. *Apple iBooks* file.

“Choreography.” *Wikipedia: The Free Encyclopedia.* Wikimedia Foundation, Inc. 30 Oct. 2015. Web. 30 Nov. 2015.

Cooper, Alan, Robert Reimann, and David Cronin. *About Face: The Essentials of Interaction Design.*

Indianapolis, IN: Wiley Publishing, Inc., 2007. Print.

Culshaw, Brian. “Future Perspectives: Opportunities, Risks and Requirements in Adaptronics.” *Adaptronics and Smart Structures: Basics, Materials, Design, and Applications.* Ed. Hartmut Janocha. Berlin, Germany: Springer Verlag, 2007. 507-519. Print.

Driver Focus-Telematics Working Group. *Statement of Principles, Criteria and Verification Procedures on Driver Interactions with Advanced In-Vehicle Information and Communication Systems.* Washington, DC: Alliance of Automobile Manufacturers (AAM), 2006. Print.

Dul, Jan, and Bernard Weerdmeester. *Ergonomics for Beginners: A Quick Reference Guide.* Boca Raton, FL: CRC Press, 2008. Print.

Gellatly, Andrew W., et al. “Journey: General Motors’ Move to Incorporate Contextual Design Into its Next Generation of Automotive HMI Designs.” *Second International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI).* New York, NY: ACM, 2010. Print.

“Gesture.” *Wikipedia: The Free Encyclopedia.* Wikimedia Foundation, Inc. 30 Oct. 2015. Web. 30 Nov. 2015.

Gobé, Mark. *Emotional Branding: The New Paradigm for Connecting Brands to People.* New York, NY: Allworth Press, 2001. Print.

Hallnäs, Lars. “On the Foundations of Interaction Design Aesthetics: Revisiting the Notions of Form and Expression.” *International Journal of Design* 5.1 (2011): 73-84. Print.

Hartson, Rex, and Pardha S. Pyla. The UX Book: *Process and Guidelines for Ensuring a Quality User Experience.* Waltham, MA: Elsevier, 2012. Print.

Hassenzahl, Marc. “The Thing and I: Understanding the Relationship Between User and Product.” *Funology: From Usability to Enjoyment.* Ed. Mark A. Blythe, et al. Dordrecht, Netherlands: Kluwer Academic Publishers, 2003. 31-42. Print.

“in a (constant) state of flux.” *McGraw-Hill’s Dictionary of American Idioms and Phrasal Verbs.* 2005. Print.

ISO 9241-210: Human-Centered Design for Interactive Systems. Geneva, Switzerland: International Organization for Standardization, 2010. Print.

Kalmbach, Ralf, et al. “Automotive Landscape 2025: Opportunities and Challenges Ahead.” *RolandBerger.com.* Roland Berger Strategy Consultants, 03/2011. Web. 22 Nov. 2015.

Katz, Joel. *Designing Information: Human Factors and Common Sense in Information Design.* Hoboken, NJ: John Wiley & Sons, Inc., 2012. Print.

Kreylos, Oliver. “Augmented Reality Sandbox.” *YouTube.com.* Christopher Young, 18 Feb. 2014. Web. 26 Nov. 2015.

Kliën, Michael. “Choreography as an Aesthetics of Change.” Diss. Edinburgh College of Art, 2008. Print.

Kurzweil, Ray. “The Law of Accelerating Returns.” *KurzweilAI.net.* KurzweilAINetwork, 7 March 2001. Web. 20 March 2015.

Lehto, Mark R., and James R. Buck. *Introduction to Human Factors and Ergonomics for Engineers.* New York, NY: Taylor & Francis Group, LLC, 2008. Print.

Levi, Matt, et al. “Make Body Language Your Superpower.” *YouTube.com.* Stanford Graduate School of Business, 14 May 2014. Web. 26 Nov. 2015.

Macey, Stuart, and Geoff Wardle. *H-Point: The Fundamentals of Car Design and Packaging.* Culver City, CA: Design Studio Press, 2008. Print.

MakerBot Industries, LLC. “MakerBot Replicator Desktop 3D Printer (Fifth Generation Model).” *YouTube.com.* MakerBot, 6 Jan. 2014. Web. 26 Nov. 2015.

Mandel, Theo. *The Elements of User Interface Design.* New York, NY: John Wiley & Sons, Inc., 1997. Print.

Manyika, James, et al. “The Internet of Things: Mapping the Value Beyond the Hype.” *McKinsey.com.* McKinsey & Company, 06/2015. Web. 22 Nov 2015.

McKinsey & Company. “Automobilindustrie muss Premium neu erfinden [Automobile Industry Needs to Reinvent Premium].” *McKinsey.com.* McKinsey & Company, 02/2010. Web. 22 Nov. 2015.

MIT Media Lab. “InFORM - Interacting With a Dynamic Shape Display.” *YouTube.com.* Tangiblemedia, 12 Nov. 2013. Web. 26 Nov. 2015.

Mohr, Detlev, et al. “The Road to 2020 and Beyond: What’s Driving the Global Automotive Industry?”

McKinsey.com. McKinsey & Company, 08/2013. Web. 22 Nov 2015.

Navarro, Joe. *What Every BODY is Saying.* New York, NY: HarperCollins, 2008. Print.

Overbeeke, Kees, et al. “Let’s Make Things Engaging.” *Funology: From Usability to Enjoyment.* Ed. Mark A. Blythe, et al. Dordrecht, Netherlands: Kluwer Academic Publishers, 2003. 7-17. Print.

Pease, Allan and Barbara. *The Definitive Book of Body Language: How to Read Others’ Thoughts by Their Gestures.* Buderim, Australia: Pease International, 2004. Print.

Pega Design & Engineering. “Tech Tap Interaction Device.” *YouTube.com.* ThePEGAdesign, 18 June 2009. Web. 26 Nov. 2015.

Quantum Experience Ltd. “Quantum Locking and Flux Pinning - Quantum Levitation.” *YouTube.com.* The Sci Guys, 28 July 2015. Web. 01 Dec. 2015.

Rayej, Shima. “How Do Self-Driving Cars Work?” *Robohub.org.* Robohub, 03 June 2014. Web. 29 Nov. 2015.

Rehder, Torsten, and René Hentschel. “The Outernet: Say Hello to the Wild World Web!” *TrendONE.de.*

TrendONE White Paper, 2009. Web. 22 Nov. 2015.

Sclater, Neil. *Mechanisms and Mechanical Devices - Sourcebook.* New York, NY: McGraw-Hill, 2011. Print.

Sengers, Phoebe. "The Engineering of Experience." *Funology: From Usability to Enjoyment.* Ed. Mark A. Blythe, et al. Dordrecht, Netherlands: Kluwer Academic Publishers, 2003. 19-29. Print.

Shaer, Orit, and Eva Hornecker. "Tangible User Interfaces: Past, Present, and Future Directions." *Foundations and Trends in Human-Computer Interaction* 3.1/2 (2009): 1-137. Print.

Toyota Motor Corporation. "The Lexus Hoverboard: The Story." *YouTube.com.* Lexus International, 04 Aug. 2015. Web. 01 Dec. 2015.

United Nations Climate Change Secretariat. *Climate Action Now: Summary for Policymakers 2015.* Bonn, Germany: United Nations Climate Change Secretariat, 2015. Print.

United Nations Population Division. *World Urbanization Prospects: The 2014 Revision, Highlights.* New York, NY: United Nations, 2014. Print.

United Nations Population Fund (UNFPA). *State of World Population 2014: The Power of 1.8 Billion.* New York, NY: United Nations Population Fund (UNFPA), 2014. Print.

Vanderbilt, Tom. *Traffic: Why We Drive the Way We Do (and What It Says About Us).* New York, NY: Alfred A. Knopf, 2008. Print.

Wheeler, Alina. *Designing Brand Identity: A Complete Guide to Creating, Building, and Maintaining Strong Brands.* Hoboken, NJ: John Wiley & Sons, Inc., 2006. Print.

APPENDICES

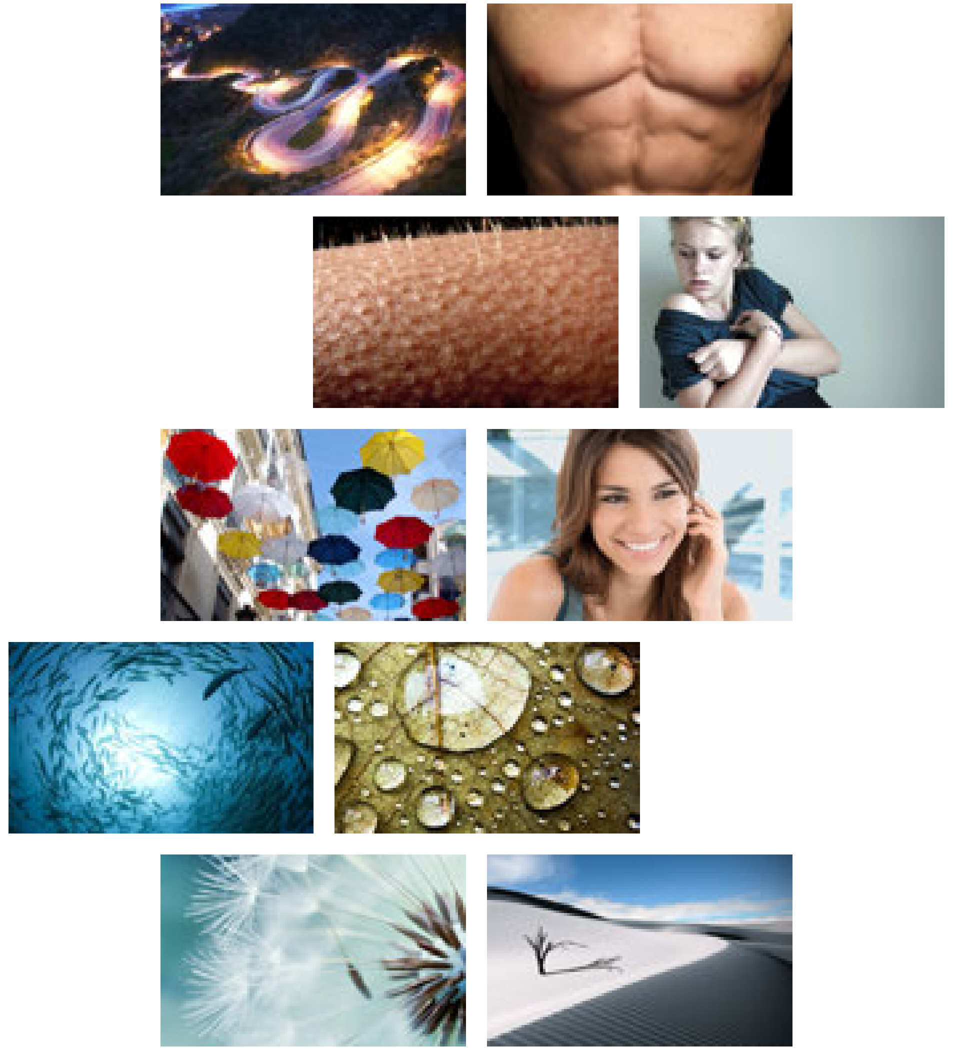
Mountain Road. hdwpics.com
Male Body. Tsvetomir Georgiev, cgsociety.org

Goose Bumps. MaryLane, flickr.com
Anxious Girl. Kennedy Garrett, flickr.com

Umbrellas. freepik.com
Empathy. becomegorgeous.com

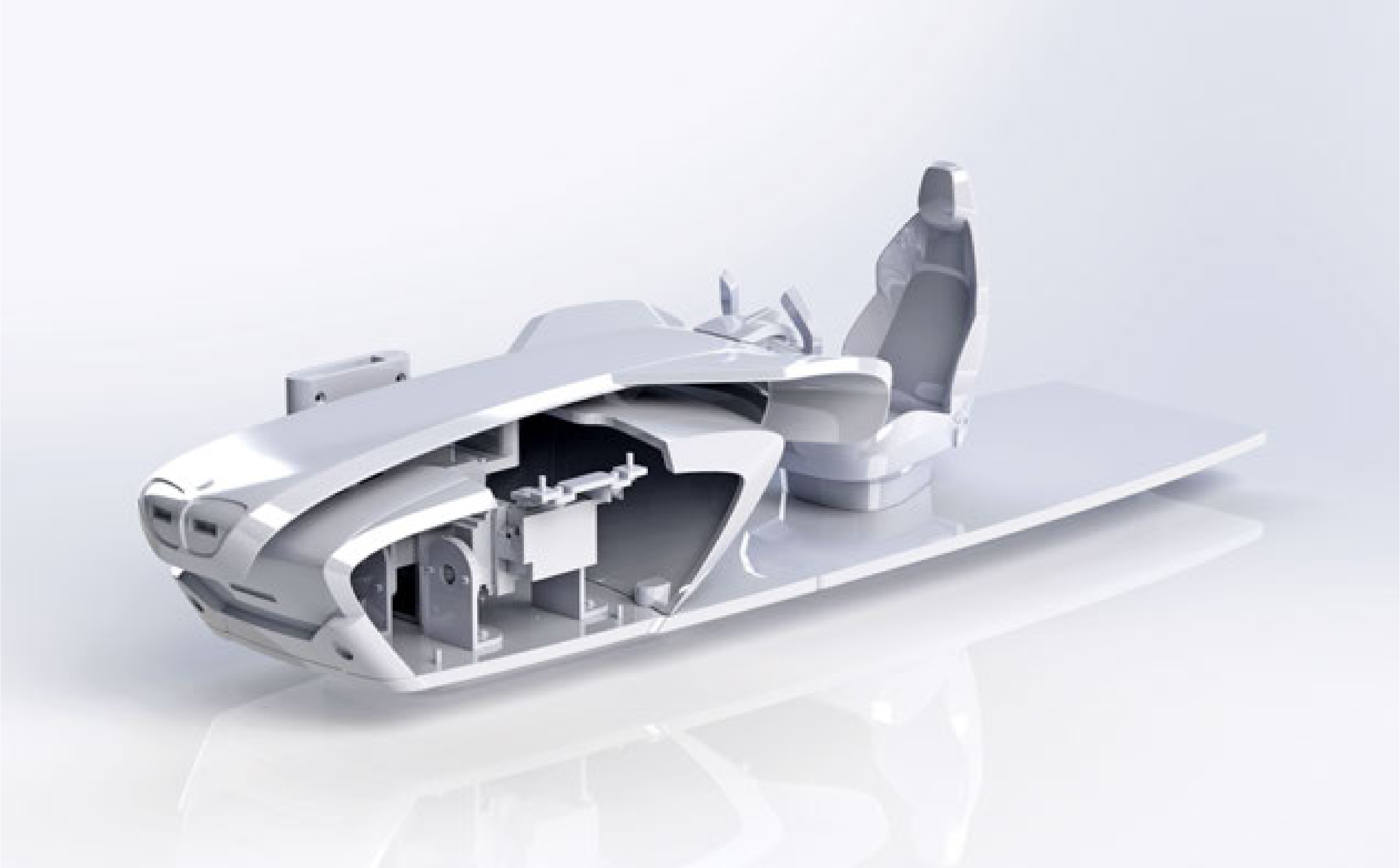
Fish Swarm. dreamstime.com
Leaf With Water Drops. wallpaperlist.com

Dandelion. Samsung Electronics
Dunes. Fraggie, wallpaperstock.net

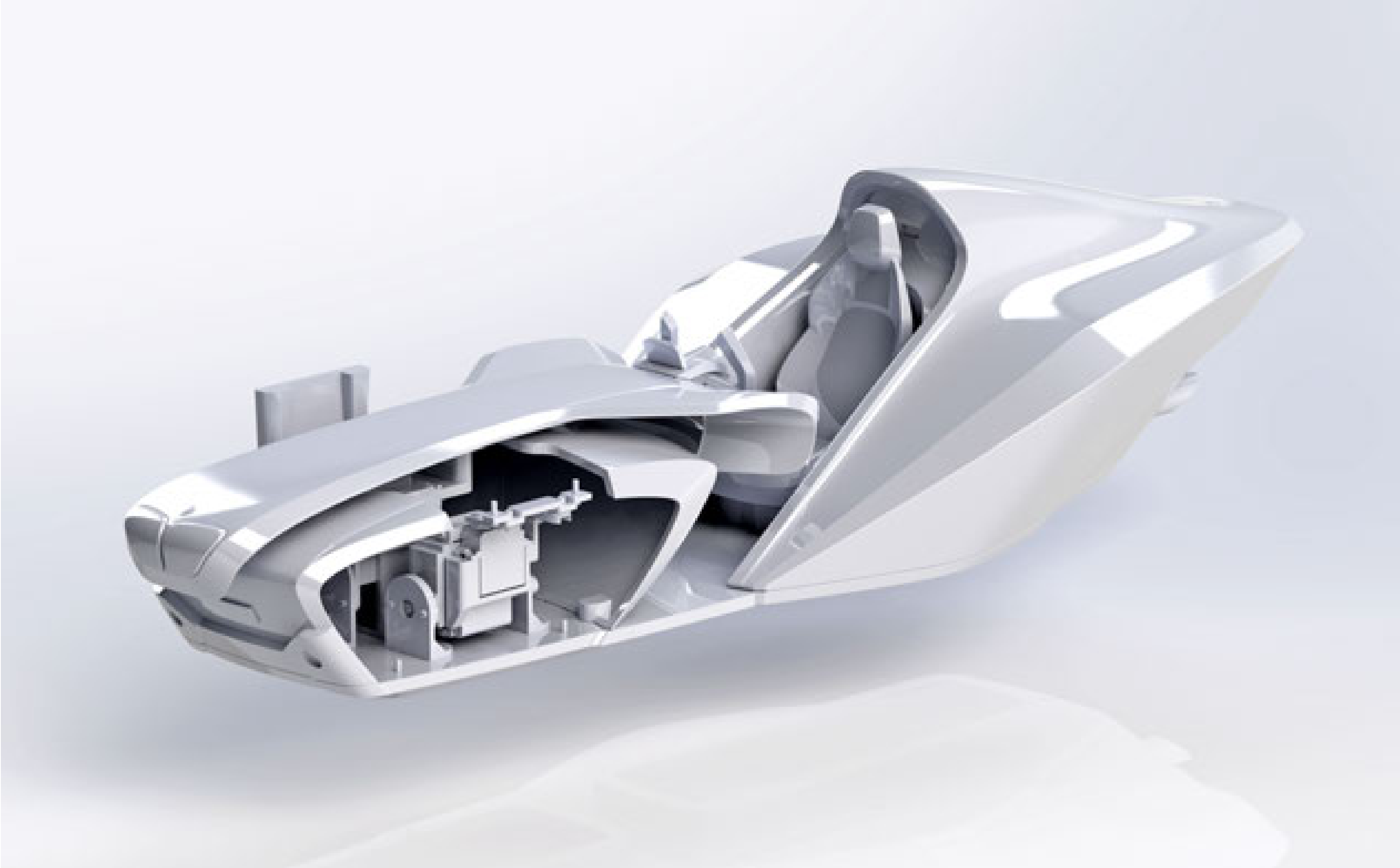


Appendix I: Mood Board

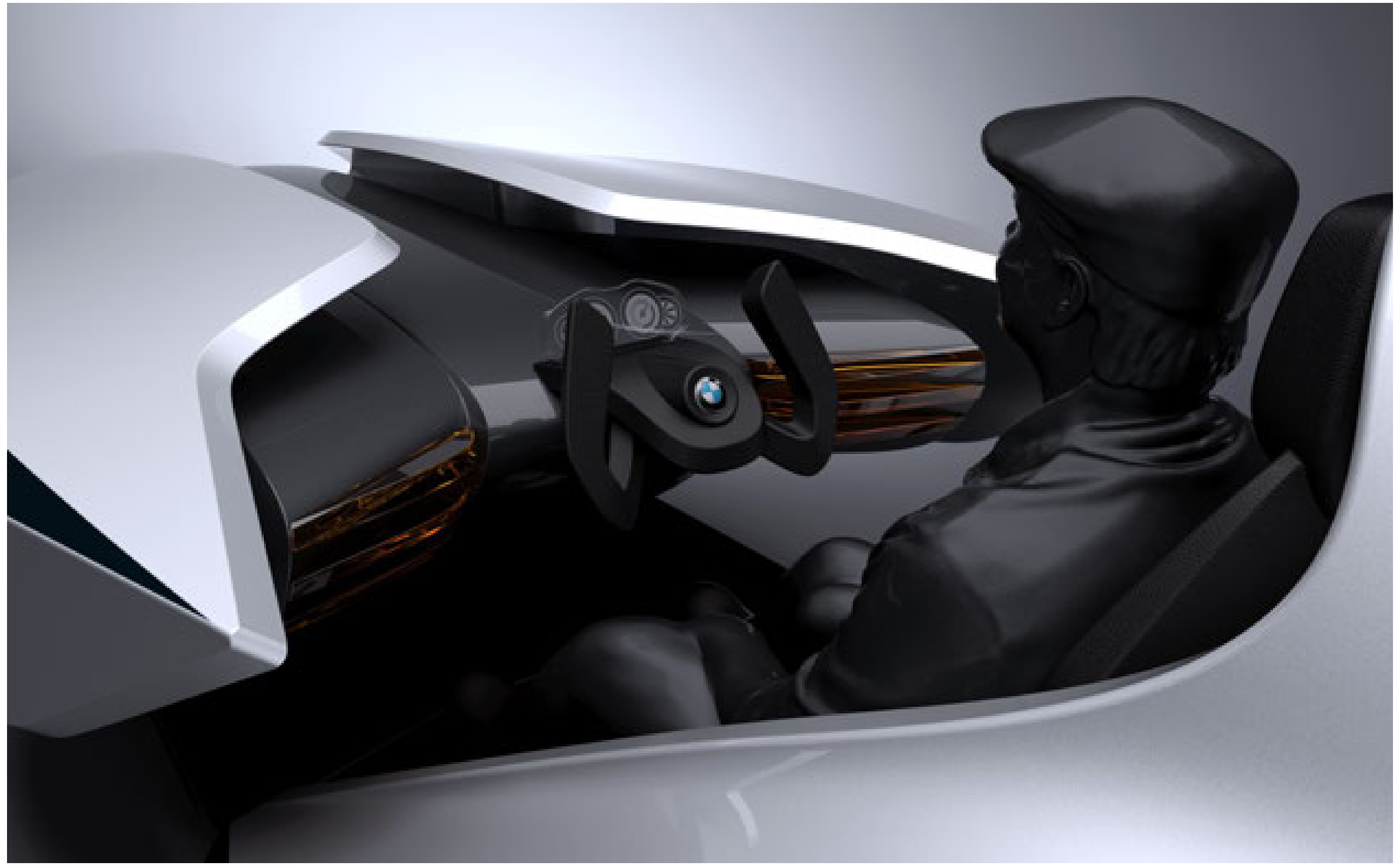
Appendix II: Servo Housing v1, Armature v2, Wide / Organic



Appendix III: Servo Housing v2, Armature v2, Slim / Bumper

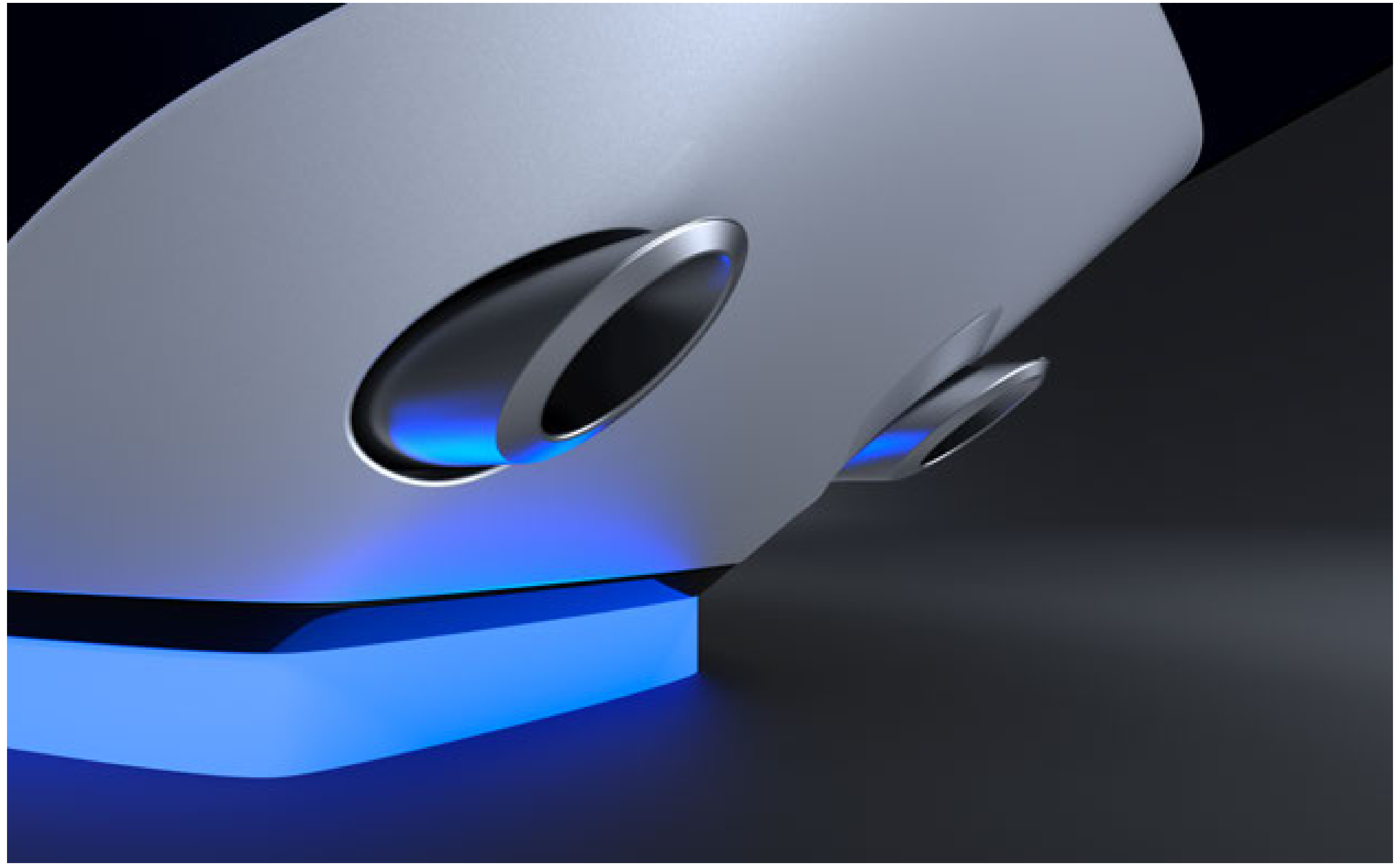


Appendix IV: Servo Housing v3, Armature v3, Slim / Back

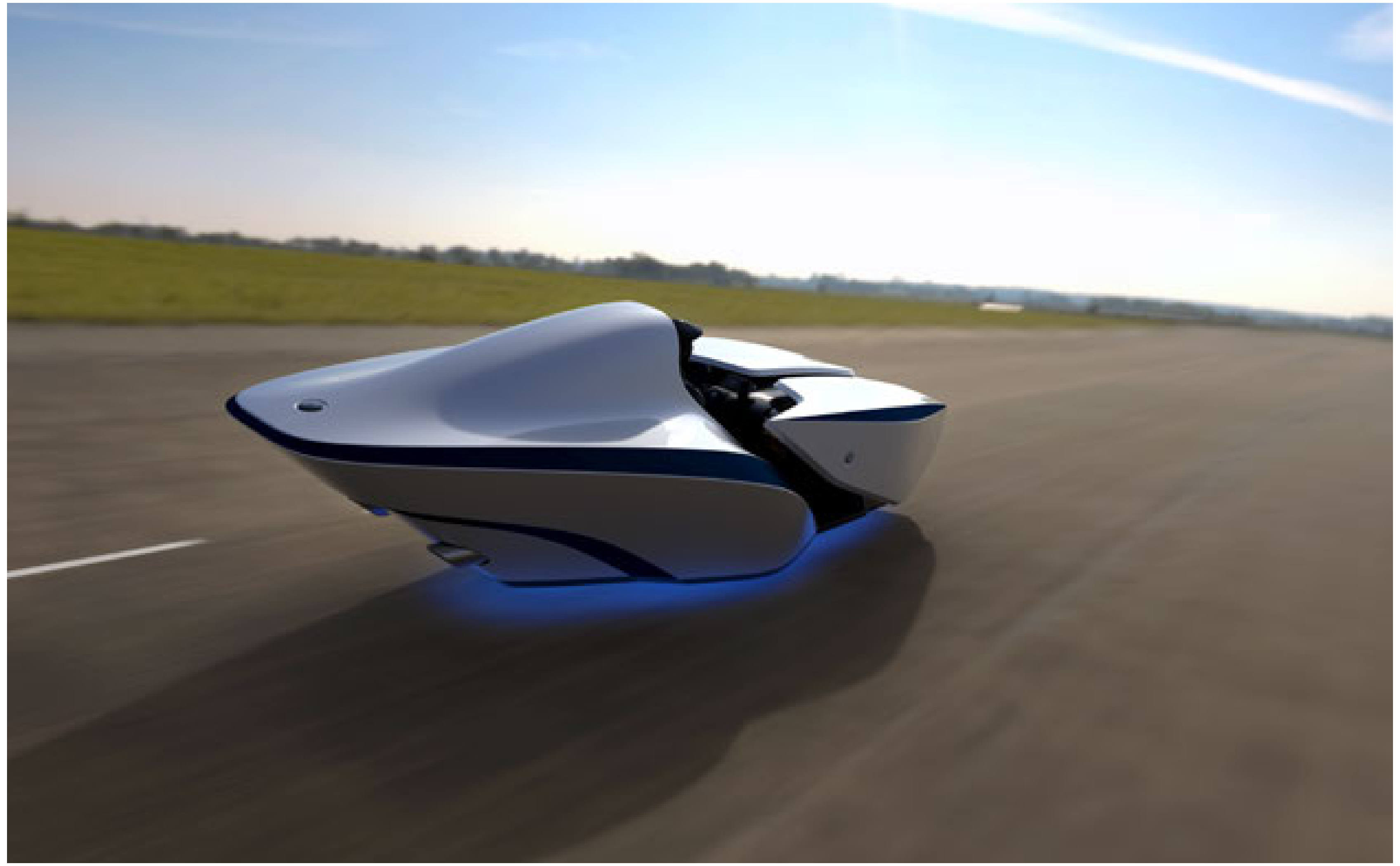


Appendix V: Cockpit

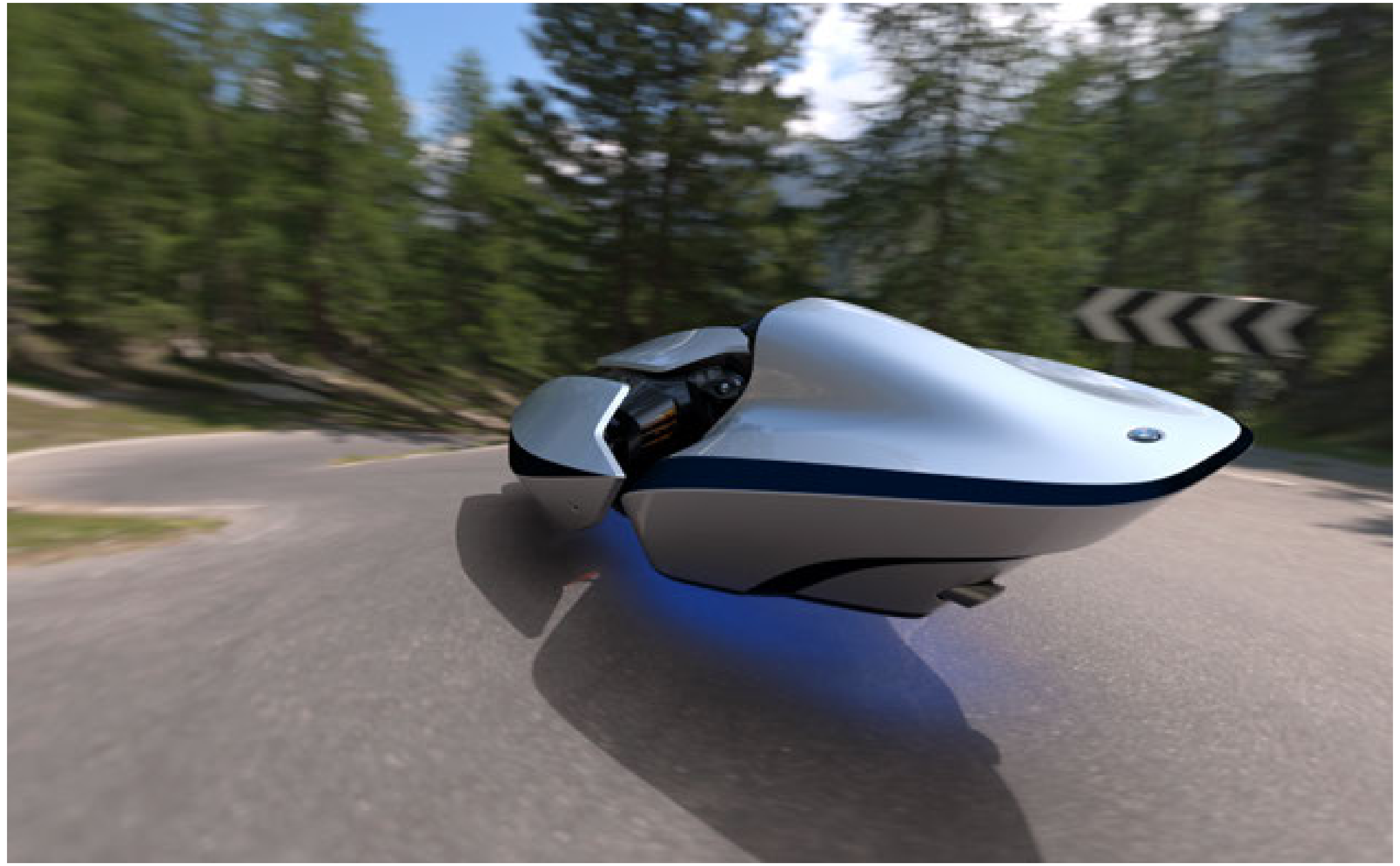
Appendix VI: Driver



Appendix VII: Rear Side



Appendix VIII: Highway



Appendix IX: Curvy / Rural

Appendix X: City / Urban

Appendix XI: Highway Situation / Focus Driving

Appendix XII: Highway Situation / Focus Driving

Appendix XIII: Rural Situation / Cruising Mode

Appendix XIV: Rural Situation / Cruising Mode

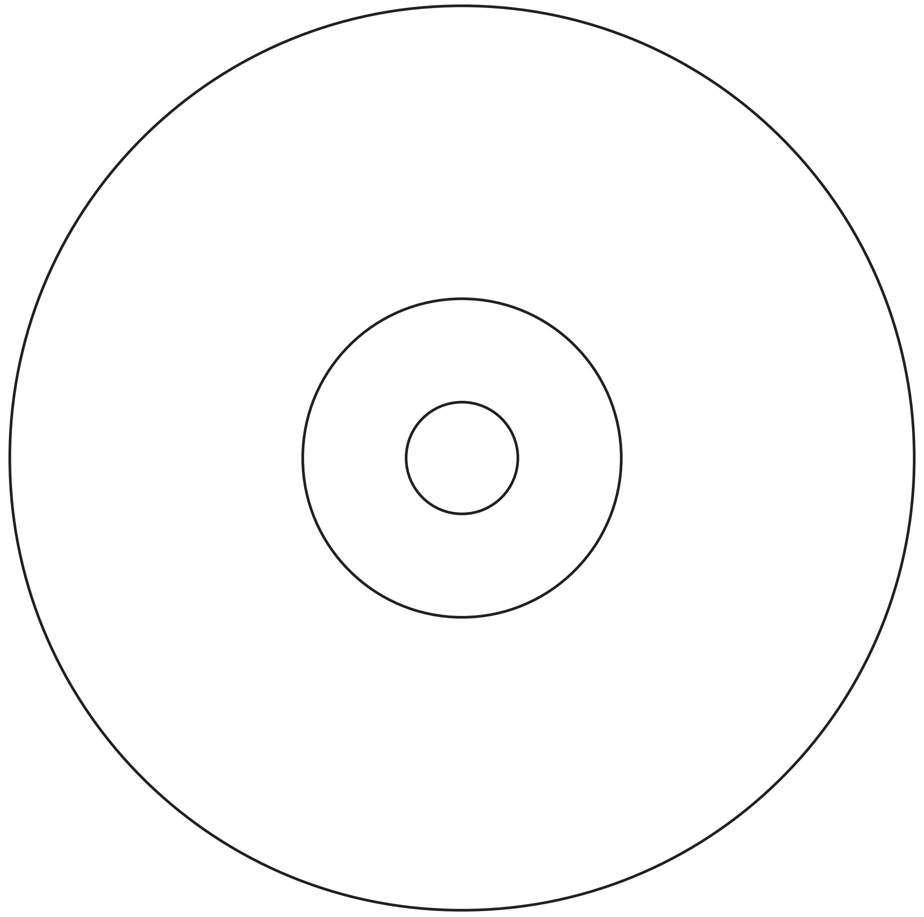
Appendix XV: Urban Situation / Exploration Mode

Appendix XVI: Urban Situation / Exploration Mode

NOSTALGIA.

FOR THE FUTURE.

- APPENDICES
- ARDUINO CODE
- PRESENTATION POSTER
- PRESENTATION SLIDES
- THESIS BOOK
- VIDEO COCKPIT
- VIDEO MODEL



MICHAEL MEIER

Jahnstr. 28
92696 Flossenbuerg
Germany
+49 176 96918888
mmeier@pratt.edu
www.mmeier.info

BMW GROUP

Dr. Michael Herrler
Knorrstr. 147
80807 Munich
Germany
+49 89 83240311
michael.herrler@bmw.de

PRATT INSTITUTE

Henry HyukJae Yoo
200 Willoughby Avenue
Brooklyn, NY 11205
United States
+1 (917) 923-9399
henryyoodesign@gmail.com