RHINO 7400

URBAN MAINTENANCE VEHICLE

A Master's thesis project by
Theis Bennicke & Mark Rytman
In Colaboration with: Timan A/S
Product Presentation

MSc04 Industrial Design | Group 5 | Aalborg University | May 2015

A concept development of an Urban Maintanence Vehicle developed as a collaboration between Timan A/S and students from Aalborg University.

INTRODUCTION

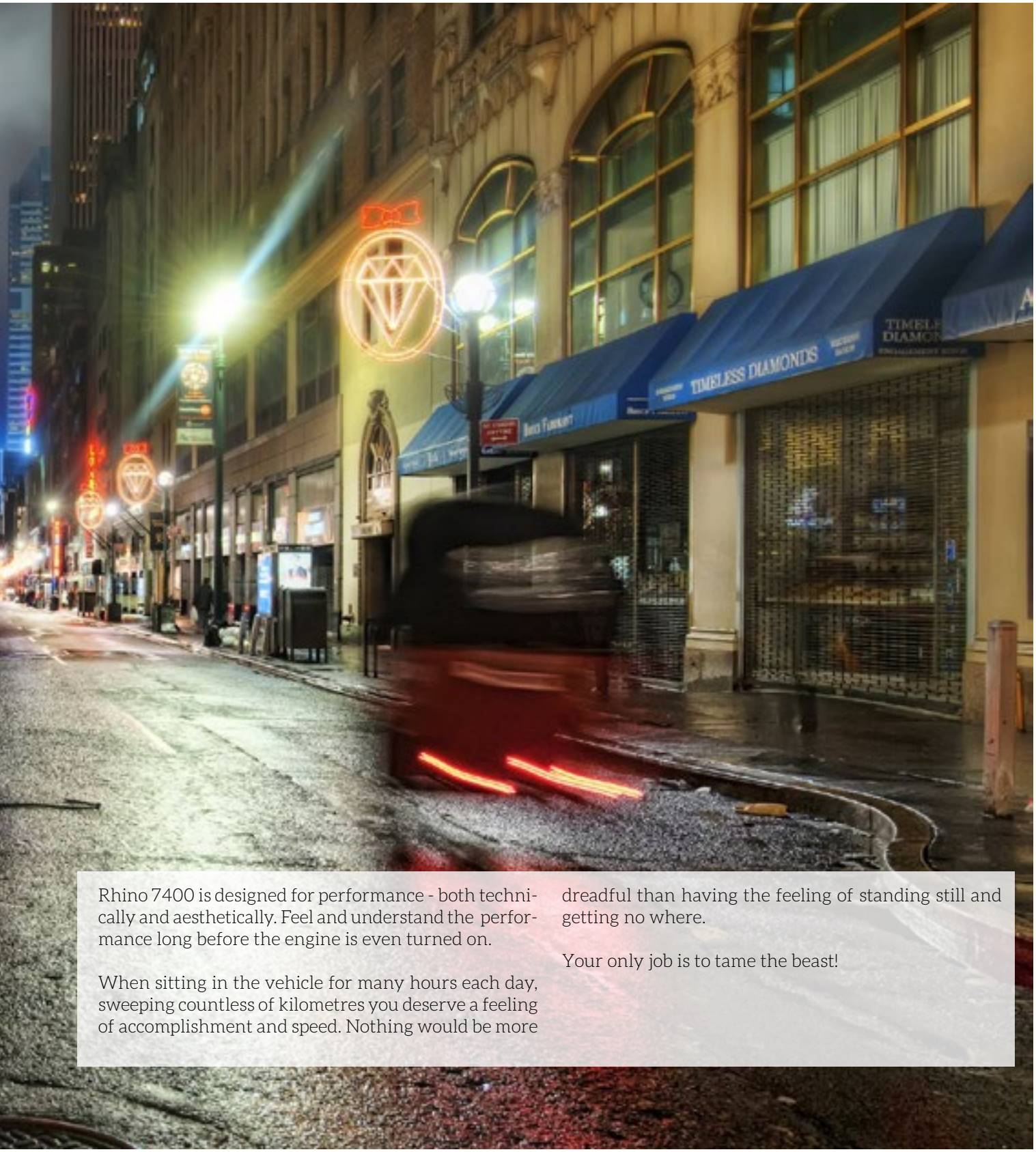
As the cities and municipalities grow, the requirements for maintanance vehicles increase accordingly. Bigger cities means coverage of longer distances, more hours spend in the machines, and larger amounts of waste. The vehicles must therefore facilitate such issues by adapting technologies and capacities to ensure desired performance.

Many of the existing players on the market seem to excel in this aspect with their strong technology driven approach but seems to pay little attention to design language and vehicle identity. This vehicle concept is therefore a result of a user driven design process with main focus on emotional values in order to push the boundaries and explore product solution diverging from a market with otherwise dominant players.

Theis Bennicke

Mark Rytman


PERFORMANCE
AS LANGUAGE



Rhino 7400 is designed for performance - both technically and aesthetically. Feel and understand the performance long before the engine is even turned on.

When sitting in the vehicle for many hours each day, sweeping countless of kilometres you deserve a feeling of accomplishment and speed. Nothing would be more dreadful than having the feeling of standing still and getting no where.

Your only job is to tame the beast!

REINVENTED CONFIDENCE

Get the confidence you need and the respect you deserve when facing crowds on your way!

Being a city sweeper is not the most prestigious job title and drivers testify how they are disrespected and interrupted in their work rutines by drunk people in the early mornings or groups of youth showing off to each other by polishing their shoes on the brushes or surfing on top of the vehicle. The drivers are unable to defend themselves as getting out of the vehicle would invite to increased trouble.

"Sometimes it feels like being a monkey trapped in a glass cage"

Testified by driver

Have your confidence reinvented as you can now face the crowds with the Rhino 7400 and rely on it to keep people off your path. The aggressive design indicates power and brutality - a machine to push forward despite any obsticle. The glass cage, putting the driver on display, has been transformed into a secure controll room of a beast.


Tiger
Heineken

RHINO **7400**

The overall lines of the vehicle draws an object with a high degree of forward motion. It starts as an aggresive flat front leaning forward and directing focus towards the street. The two individually controlled rotary brushes create a fist-like element used in the fight against trash as it brutally throws it towards the consuming suction head. The front is the interface with the ground and from here the lines continue backwards to the waste container in an upward motion. The rear of vehicle is substantially lighter in its expression in order to increase the sense of movement and focus of the brushes. The brushes define the pupose of the vehicle and play a vital part in the expression.

Rhino 7400 is not intended as an aerodynamic vehicle despite its forward leaning motion but is designed to appear aggressive. The angry looking headlights are a main player when evoking the right emotions as a big part of the vehicles personality comes from its equivalent to eye - the headlights. These are slim and slanting inwards in order to mimic an angry face, as well as they are offset back into the frame.

Coloration wise the vehicle has two parts. The main body which is colorful and forward leaning and which gives the vehicle its overall expression. The second part is a neutral colored base to support the main body both visually and structurally as it takes very little focus.

DESIGN DETAILS

When seing the vehicle from the front your eyes are guided down to the suction head between the brushes due to the linework in the lights and fenders. The brushes create a sense of a gateway to lead the trash straight to suction head and the overall expression puts focus on the process of picking up trash.

When seen from the rear the vehicle has an exhaust-like expression. This accents the feeling of movement as you are standing in a jetstream after the sweeper has blasted by. Tail lights are likewise designed to accents the open shells and allowing for plenty of mesh for airflow.

In front of the rear wheels a big air intake is placed on each side. This functions as the entrance for the vast air amounts that will pass through the engine cooler and exit in the rear. These intake, as the exhaust-like rear end, gives associations to jet engines and radiates movement.

Strobe- and work lights are integrated in the roof structure of the cabins chamfered corners and won't therefore add to the vehicles total height by being mounted on top of the roof.

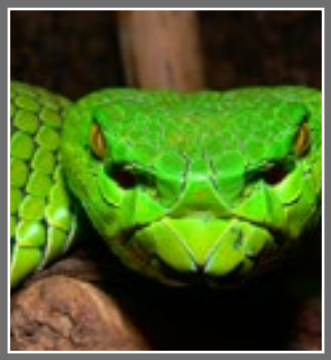
COLOR CHOICES

Having the role of a beast, Rhino 7400 comes in a selection of colors inspired by poisonous animals. Such warning colors communicates danger and encourage people to step out of your way and keep to themselves.

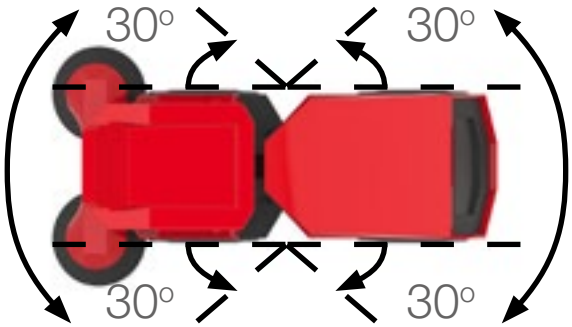
The strong colors will in addition increase focus on the labour done by the drivers. The demanding task to keep the city clean won't happen unnoticed in the shadows but be brought into daylight by proud drivers. The job title might get a little more prestige when you are able to say "yes, I'm the one in the yellow beast blasting through the city".

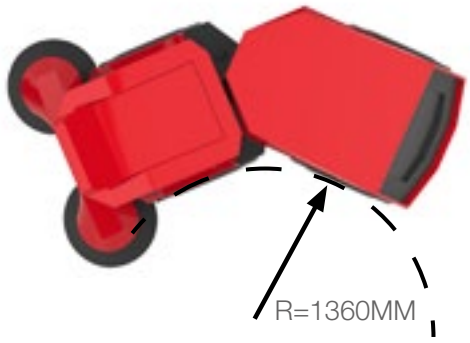
Following colors are available:

- SIGNATURE RED
- ELECTRIC BLUE
- VIVID GREEN
- INTENSE YELLOW



MANEUVERABILITY





Rhino 7400 is equipped with articulated steering with a turning radius of only 1360mm. This enables the driver to access challenging areas and sweeping tight corners. Being articulated means that you can move the whole front from side to side even without driving forwards and will therefore extend the reach of your brushes significantly.

The articulated joint is centered between the wheel bases which means that front and rear wheels will follow exact same trajectory. This increases the security of the driver as they have much better understanding of the vehicles perimeter. If the front passes through the obsticles, so will the back.

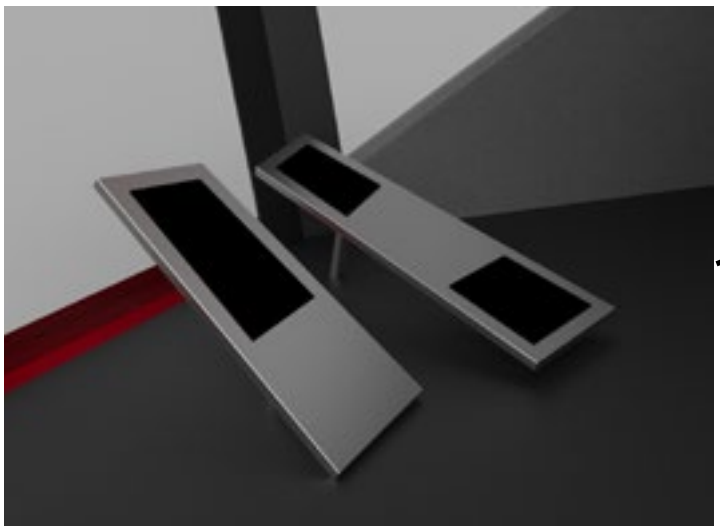
CONFIGURATIONS

The vehicle is designed and optimized for street sweeping but with the possibility of detaching the sweeper configuration. It can hereby function as a traditional tool-carrier with the multitude of possibilities it brings - eg. lawn mower, snow blade, gas burner etc.

User studies showed, however, that this type of vehicle would only be used for two functions: sweeper in the summer and snow kit in the winter.

Detaching the sweeper configuration decreases the overall expression of the vehicle, but leaves a basis machine with higher focus on engine power as the visual competition with the waste container is eliminated.

INTERACTION



All interaction with the vehicle goes through a symmetrical layout in the center of the cab. Large monitors installed in the roof of the vehicle display the video feed from the rear cameraes and ensures a clear picture of obsticles.

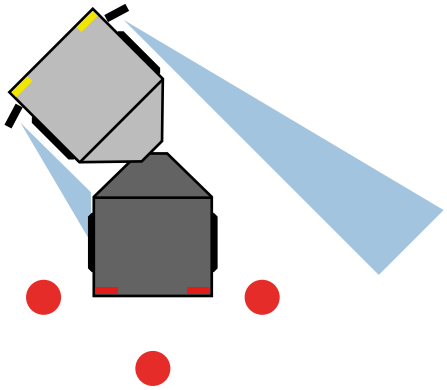
All controll of the vehicle, tools, radio, A/C and navigation happens through the steering unit with its integrated touchscreen. Pedals in the floor controll the speed of the vehicle with a gas- and a brake pedal.

The vehicle requires no additional arm console for tool adjustsments, as seen in most competing products, and the layout offers an undisturbed visibility to the front tools and for manauvering.

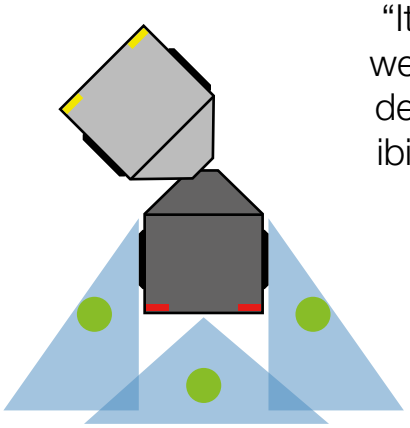
EXTENDED VISIBILITY

One of the big challenges of driving an articulated vehicle is to ensure a clear overview of rear obstickles. Side mirrors fail as soons as the vehicle starts turning as the one mirror points straight into the vehicles own side and the other points away. Wide angle mirrors won't even be able to cover the drastic twist of the vehicle of up to 60° to each side.

Rhino 7400 is therefore equipped with side- and rear cameras to allow the user for confident driving. The side cameras are mounted on the vehicles rear body and are therefore able to follow the movement when turning. The rear camera is centered on the back to give a clear overview of obsticles straight behind and turns on automatically when reversing. The rest of the time the center monitor displays the feed from a camera placed under the vehicle to monitor the status of the suction head.



Traditional side mirrors



Rhino 7400's camera setup

"It happens almost weekly that we bump into a bike rider or pedestriant due to lack of rear visibility. Not necessesarily serious injuries but you feel bad."

Testified by driver

Rear camera enabled

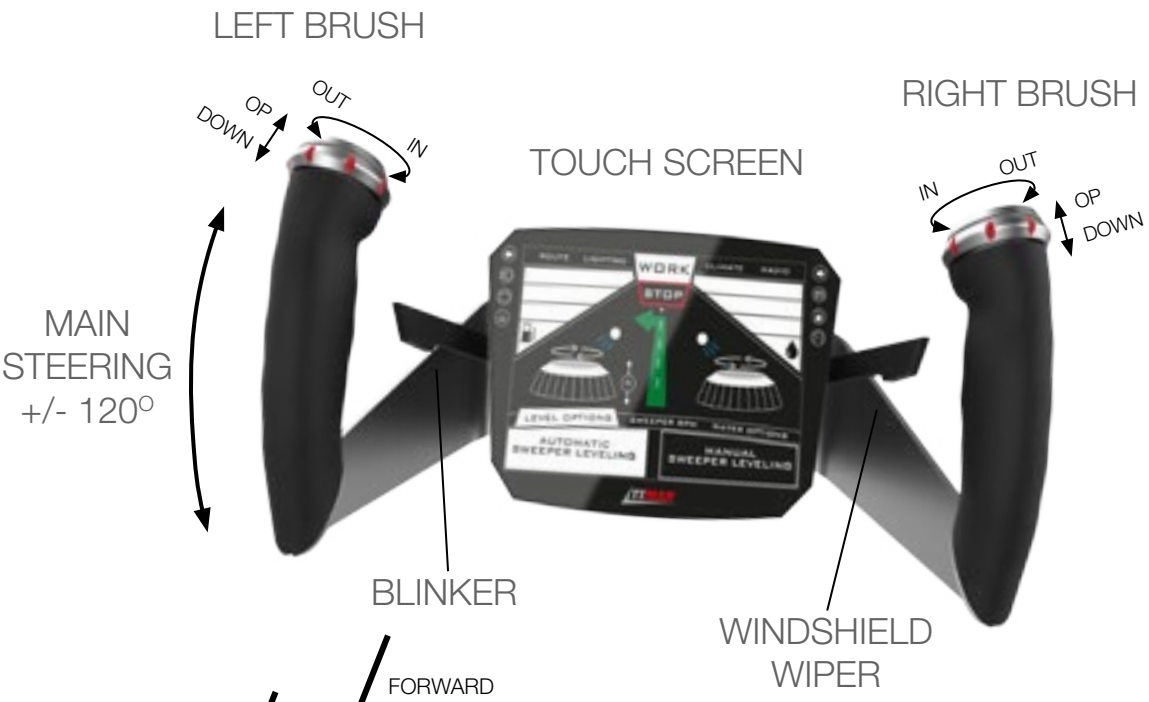
Suction head camera enabled

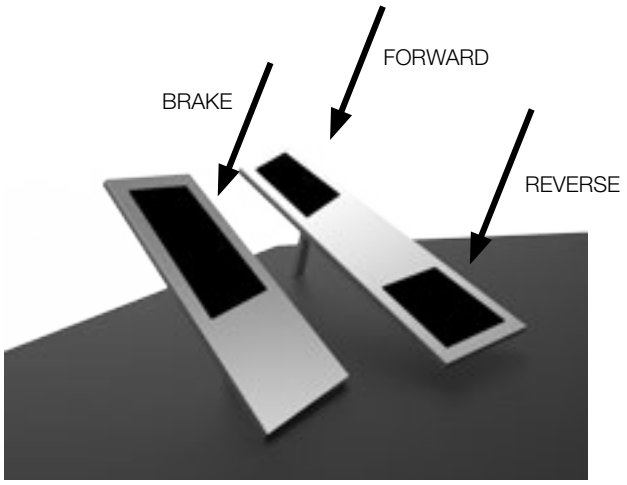
CONTROLLING THE VEHICLE

The steering is inspired by the race world and turns only 120 degrees clock- and counter clockwise . This enables an uninterrupted and secure grip with both hands as the vehicle rams through the streets. The steering uses the drive-by-wire principle and is programmed with a progressive sensitivity. The more you turn, the more the intensity increases. This lets you turn the tight corners with low speed without compromising you precission on the straighter and faster stretches . Where similar vehicles needs up to 5 rotations from right to left, Rhino 7400 does it with less than one - more convenient and much faster.

Tool controls are integrated in the steering handles as on-going adjustments can be done easily without loosing grip of the steering. Your left thumb controls your left brush and the right controlls the right - as the brushes can be controlled individually.
Switches for control of blinkers and windshield wiper are similar to regular cars and easily decoded.

The center of the steering unit holds a touch screen for information of the vehicle and for less frequently used controls - typically as you start your work rutine.





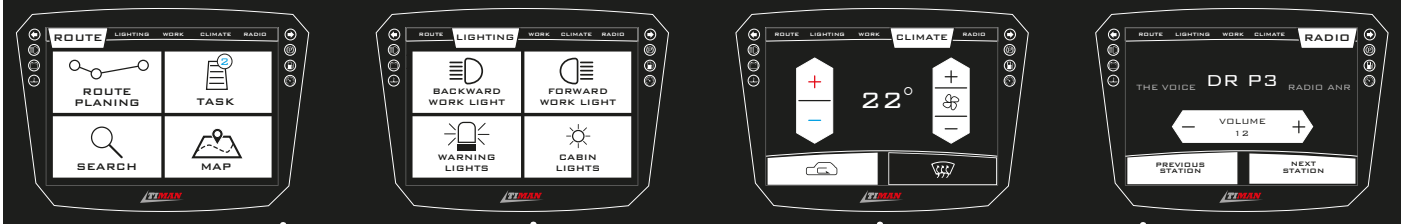
The vehicle has no gears or clutch, but uses a dual action gas pedal which drives you forward when pushing the front half and drives you backwards when pushing the rear half. Adjusting the pedal can also serve as a hydraulic brake. The speed is therefore mainly controlled with one pedal only but in case of emergencies a mechanical and more reliable brake system is incorporated.

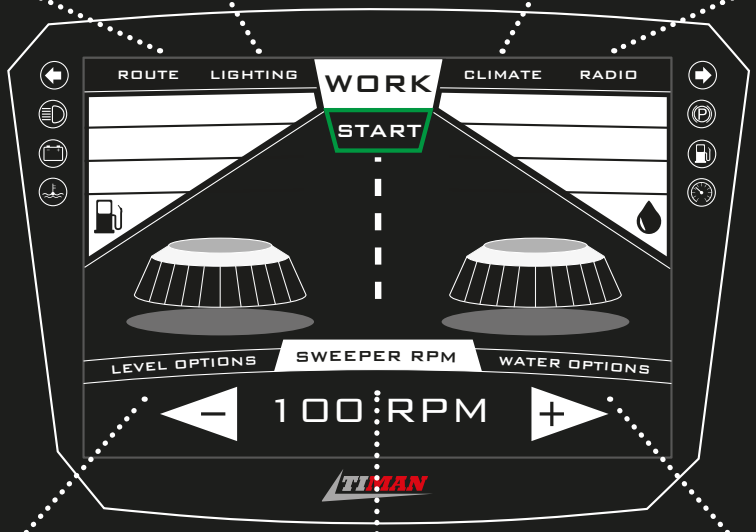
The “Projected Capacitive Touch”-screen (PCAP) can be used with dirty, wet and cold fingers and even if wearing gloves.

The interface has only two layers in order to be easily conceived. First and primary layer is controller by stationary menu tabs and includes navigation, light control, tool control, A/C and radio. Second layer is controlled by menu tabs varying according to the main menu tab.

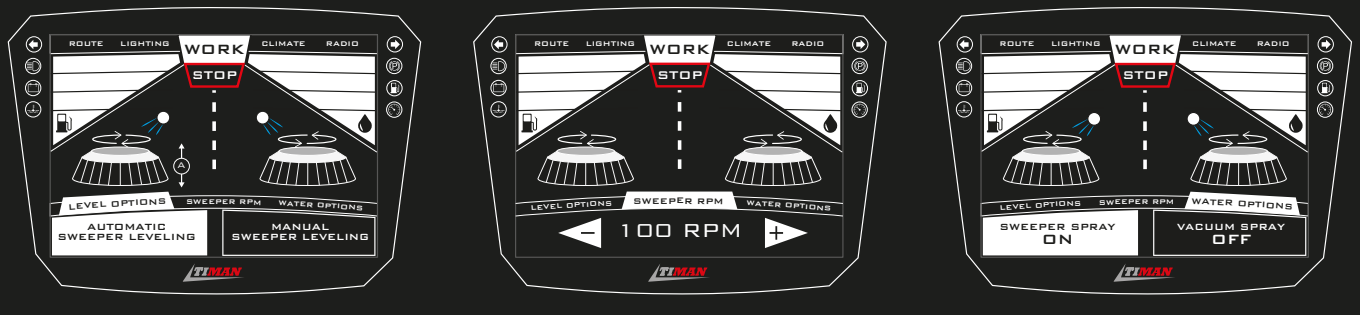
By integrating navigation into the system, possibilities for exhanging workplans with the manager open up. You don’t any longer have to hold a number of paper sheets and look for those small street names of the printed map. Your route can remotely be updated and you’ll know it right away. The navigation also makes the job a lot easier for temporary employed people or other newcomers.

PRIMARY OPTIONS





SECONDARY OPTIONS



ERGONOMICS

INTERFACE ADJUSTMENTS

The interface is able to accomodate the various sizes of drivers due to adjustments in seat and steering unit. You are hereby able to find an adjustment that fits you and allows for a comfortable reach to the pedals as well as the steering unit.

User studies showed the importance of the ergonomics in the choice of machine, whether asking the drivers themselves or talking to managers and people in charge of the purchase. Often the drivers have a big say in the final choice, so it's important to feel comfortable.

ACCESS SPACE

When the wide door opens, it allows for an easy entering of the vehicle. The sidepanel is attached to the door and only remaining part is the wheel well.

Access is made more convenient with an assisting footstep in order to increase the height of the step necessary to the cabin floor (450mm).

The steering unit can be rotated upwards and seat adjusted to rear position to increase the access space even further.

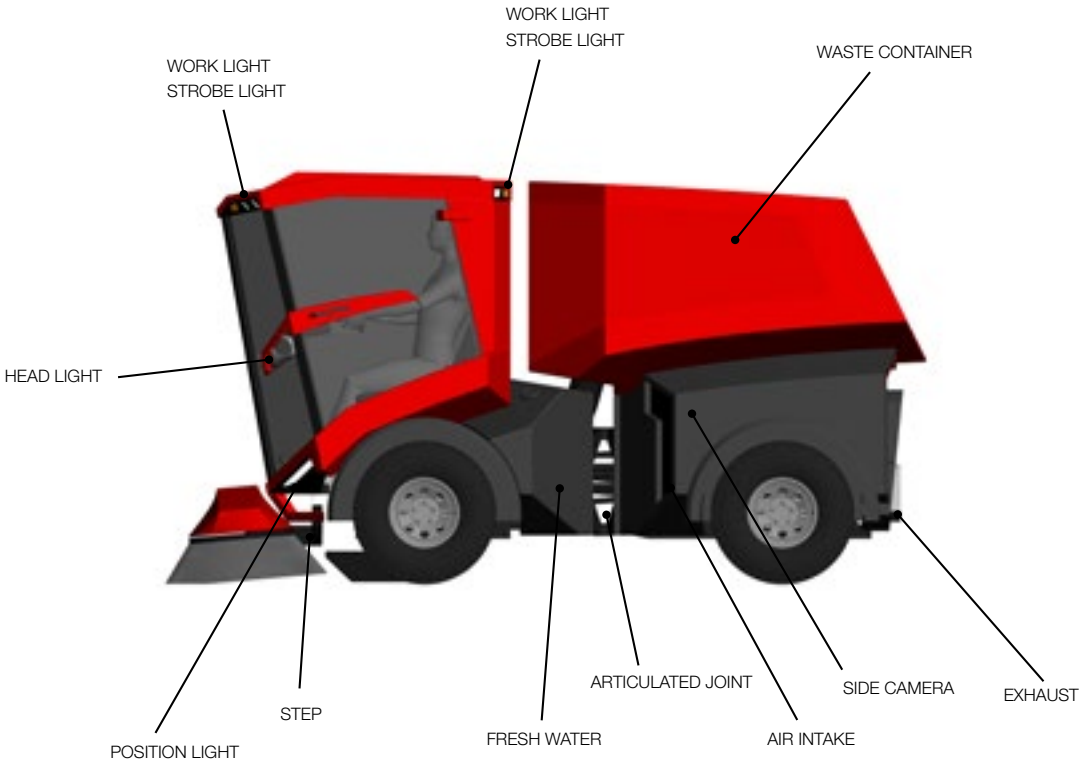
VISIBILITY TO TOOLS

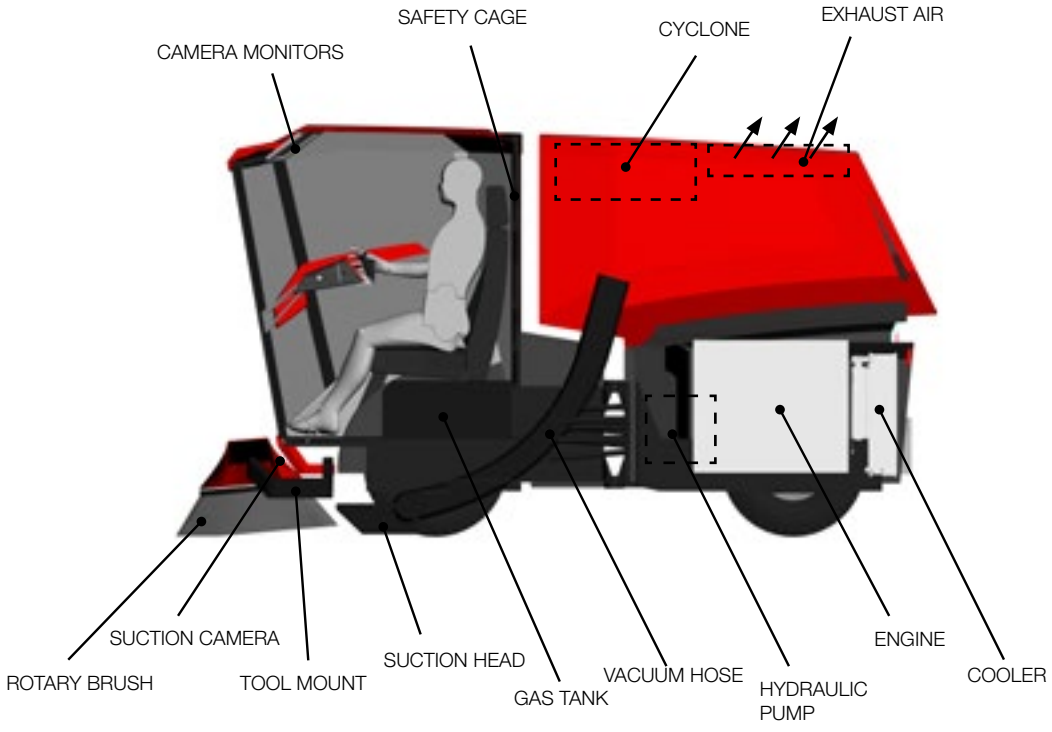
The corner pillar is split into two in order to maintain access space and width in the cabin. At the same time visibility to the front tool has been optimized as you get a clear view of your brushes front edge. It is now easy to judge distances to obsticles and ensure clean edges without having to shift body position numerous times during a work day.

THE ARCHITECTURE

The vehicle exists of a front- and a rear part. The front part houses the drivers cab with seat and steering unit, as well as fuel tank and fresh water tanks. The drivers cab is positioned as low as suction head allows for with its required movement up and down. The front tools are mounted in front of the cab and moves up and down as well as sideways.

The rear part of the vehicle houses the engine with cooler and hydraulic systems. Tools can be attached either on the back or on the top and for the city sweeper configuration, a waste container is mounted. An internal cyclone creates a vacuum to suck up trash via the suction head. Side cameras are mounted on each side to give the driver a clear image of rear obsticles.


WORK LIGHT
STROBE LIGHT
WORK LIGHT
STROBE LIGHT
WASTE CONTAINER
HEAD LIGHT
POSITION LIGHT
STEP
FRESH WATER
ARTICULATED JOINT
AIR INTAKE
SIDE CAMERA
EXHAUST


CAMERA MONITORS
SAFETY CAGE
CYCLONE
EXHAUST AIR
ROTARY BRUSH
SUCTION CAMERA
TOOL MOUNT
SUCTION HEAD
GAS TANK
VACUUM HOSE
HYDRAULIC
PUMP
ENGINE
COOLER

OVERALL ASSEMBLY

A steel frame (1) with the articulated joint funtions as a backbone of the whole vehicle. This unit is 10mm sheet metal welded and powder coated.

Suspension, hydraulic motors, wheels and engine are bolted on to the frame (2) as well as a cage for the drivers cab. The cage protects the driver in case of a crash but also works as a structural element.

Wheel wells, fuel and water tanks and engine cover are mounted (3). The front windshield is glued into position in order to increase strength in the cab structure. Roof and back panels are mounted onto the cage.

The inner covers are mounted behind and above the driver to hide the cage. Seat and steering unit is installed (4). Work and strobe lights are installed in the process and the engine cover is equipped with a dark mesh in the air- intake and exhaust.

The doors are assembled independently and finally mounted on the vehicle (5). The vehicle is now ready for tools.


1


2


4


5


3

PRODUCTION OF PLASTIC COVERS

THE PROCESS OF VACUUM MOLDING

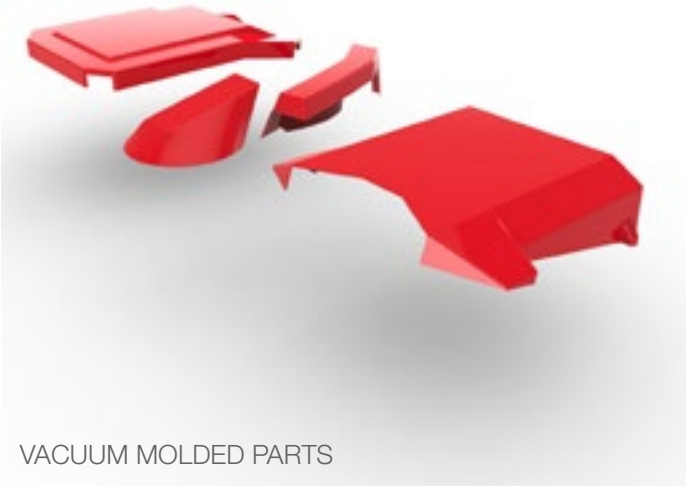
The vehicles covers are primarily vacuum molded from sheet of plastic with a solid color. Changing color is therefore a matter of choosing a different sheet.

Vacuum molding provides cheaper products than e.g. injectionmolding due to the cheaper tool price. It comes, however, with a number of requirements. The parts can't have fine details and must have appropriate draft angles for demolding. It furthermore requires post processing to trim the exact part.

The parts for Rhino 7400 are designed in a way that the requirements are met, and the production of a few hundred pr. year can begin.

In order to save mold costs, wheel wells are identical for all four wheels and come from the same mold. Gas and water tanks are rotomolded to achieve an enclosed container with a desired exterior.

VACUUM MOLD WITH FINISHED PART



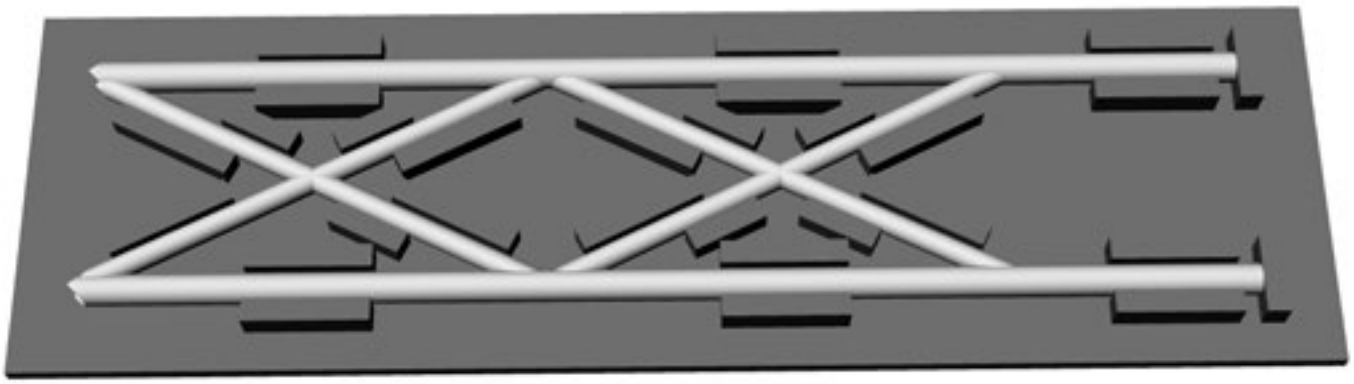
VACUUM MOLDED PARTS

PRODUCTION OF STEEL CAGE

The cage is constructed of smaller pipes welded together and finally painted. The cutting process happens with automated CNC pipe cutting equipment that cuts the ends at the desired angle and shape. Many of the pipes have varying lengths and it is therefore a necessity with the CNC equipment to avoid labour heavy work. The machine is set up for a given pipe unit and produces a number before being set up for the next pipe.

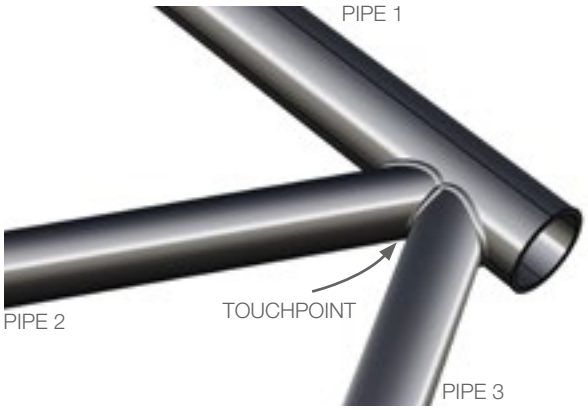
Welding the pipes together in a complex three dimensional shape would be time consuming and hard to perform accurately if done only by measuring. A weld template is therefore constructed before production of Rhino 7400 initiates - a template to hold the pipes in their desired position before being tacked by the welder. When the whole frame is tacked together he initiates the structural weld with attention to heat distribution and internal tension.

The cage is finally powder coated in order to achieve a uniform and clean looking surface in the desired color. The front parts, holding the windshield, will be visible from both internally and externally.



The window frames are constructed by two standard profiles welded together. This ensures a cheap and strong construction that behaves as a closed pipe. The weld seems will be covered by either a rubber seal for the door opening, or by the tinted glass edges where the window is glued onto the frame.

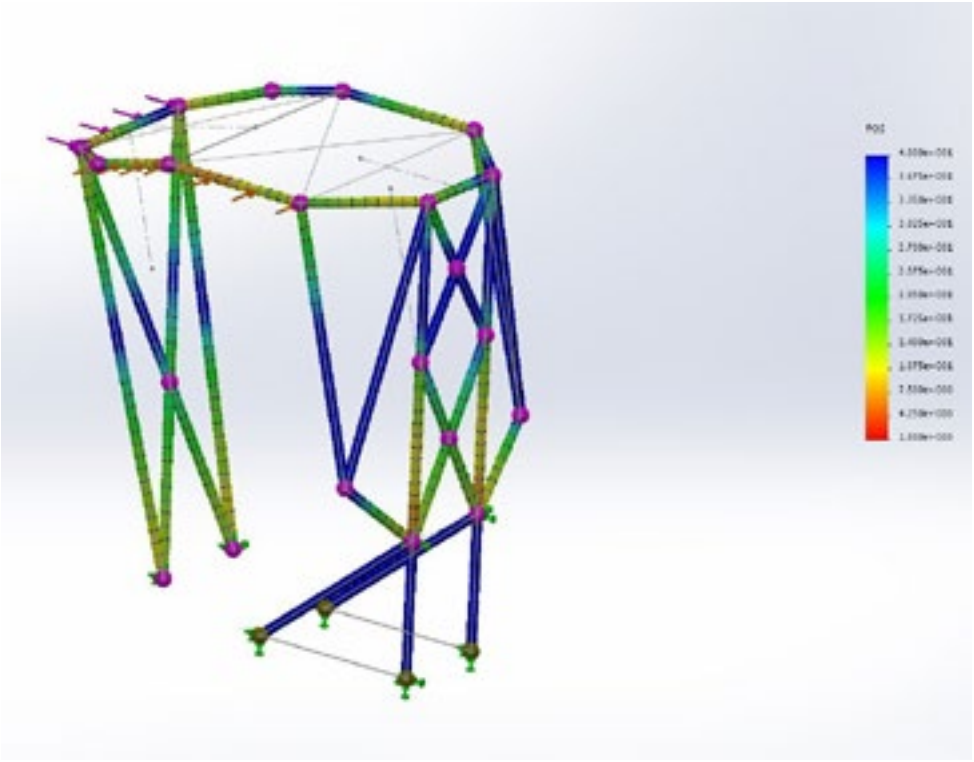
The round pipes allow for a smooth and strong weld since secondary pipes (2 and 3) meet symmetrically around their touch point - this despite any twist or irregular angle from the main pipe (1). A little gap is left between the pipes in order to ensure that the weld burns deep enough and offers full strength.



A simulated crash with 1000N applied from the front and 1000N from the side, gave the protective cage a factor of safety of 6,2.

The strength comes primarily from the glued-in windshield and the cross bars behind the driver. Those to elements work as discs and the top frame connecting them helps them support each other to avoid twist.

One of the weakest areas in the structure is at the side of the top frame where the side force is applied. Should a crash happen the force would exceed the yield strength of this structure, then the driver might still be protected in the center of the vehicle despite deformalities on the top frame. A factor of safety of 6,2 is, however, considered sufficient.



FACT SHEET

DIMENSIONS

HEIGHT	2010MM
WIDTH	1250MM
LENGHT - BASIS MACHINE	3350MM
LENGTH - SWEEPER SETUP	3710MM
CLEARANCE	250MM
WHEEL BASE	1750MM
TURN RADIUS	1360MM

CAPACITIES

FUEL	80L
FRESH WATER	150L
WASTE CONTAINER	1300L

DRIVE

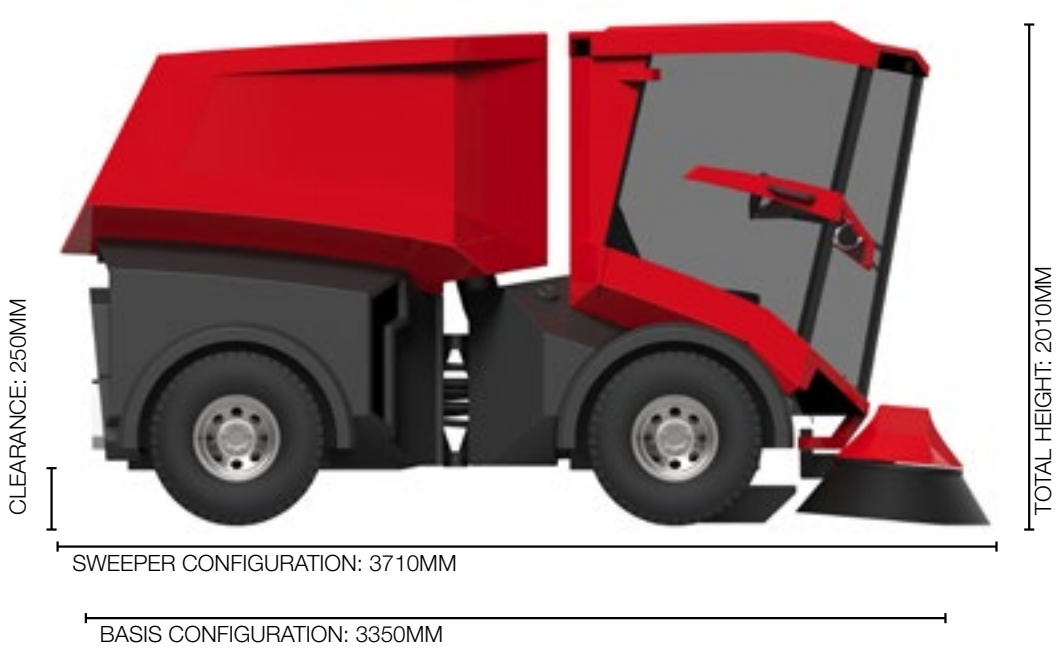
WHEELS	230/75-R14
BRAKES	DRUM BRAKES, REAR
SPEED - TRANSPORT	40KM/H
SPEED - WORK	12KM/T
SUSPENSION	INDIVIDUAL ON ALL 4 WHEELS
STEERING	ARTICULATED

INTERIOR

HEIGHT - FLOOR TO CEILING	1490MM
HEIGHT - SEAT TO CEILING	1040MM
WIDTH	950MM
SIDE CAMERAS	RIGHT + LEFT

OPTIONAL

EQUIPMENT	AIRCONDITION
	STROBE LIGHT
	SUCTION HEAD CAMERA
COLORS	SIGNATURE RED
	VIVID GREEN
	ELECTRIC BLUE
	INTENSE YELLOW



A city sweeper will often be placed in situations where size is crucial. The design offers therefore a compact lay-out with a high degree of space optimization and a high volume/size ratio.

This results in a rigid contour and boxy appearance when seen orthogonally from side, rear, front or top. However, on the street it will be seen in perspective which dissolves the rigid appearance in addintion to the linework and the colorscheme.

Illustrations

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DEPARTMENT OF ARCHITECTURE, DESIGN & MEDIA TECHNOLOGY

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Process Report

MSc04 Industrial Design | Group 5 | Aalborg University | May 2015

INDUSTRIAL DESIGN MASTER THESIS PROJECT

Architecture & Design
Industrial Design
Aalborg University

Spring 2015

PROJECT TITLE	Rhino 7400 - Urban Maintenance Vehicle
PROJECT PERIOD	Feb 1st - May 27th
GROUP NUMBER	MSc04-ID05
MAIN SUPERVISOR	Louise Møller Nielsen
TECHNICAL SUPERVISOR	Jørgen Asbøll Kepler
COLABORATION PARTNERS	Timan A/S

PROCESS REPORT

PAGES	96
COPIES	7

PRODUCT REPORT

PAGES	28
COPIES	7

PREFACE

This report documents the process of the 10th semester industrial design master thesis project, Rhino 7400 - Urban maintenance vehicle. The documentation for the project consist of the following report, a product report and technical drawings. The appendix can found on the supplied USB drive, includeding the printet material in PDF. Furthermore pictures and video not used directly can be found on the USB drive as additional process documentation.

Theis Bennicke

Mark Rytman

SUMMARY

The following master thesis project describes the development of a new tool carrier - the Rhino 7400.
The project is done in collaboration with the danish company Timan A/S who designs and manufactures tool-carriers.
During the initial researh for the project, the design team found the world of tool-carriers to be a classic example of function over form, and function over user friendliness. This resulting in users feeling incapable and insecure when piloting the vehicles. The design team has challenged the function over form approach and created a vehicle based on an emotional value deduced to a specific vehicle identity. The project deals with the integration of this vehicle identity in regards to function, aestetichs and human machine interaction. This in an atempt to provide the end user of the vehicle with a feeling of confidence and security, ultimately resulting in a more effecient and comfortable work environment.

ACKNOLEDGEMENTS

As a user-inspired project, the end result would never have come to be without the insight provided by our user groups.
First off we would like to thank the entreprenurial division of Aalborg municipality for taking the time to provide us with deep insight into the world of city cleaning, and later on participating in concept evaluation.
This also goes out to Himmerland housing society, whose drivers happely assisted us.

A special thanks goes to Henning Pedersen at Timan A/S for providing us with the insight in their organisation and suplying us with a VPM 3400 tool-carrier used in the ideation process.

Lastly we want to thank our supervisors Louise Møller Nielsen and Jørgen Asbøll Kepler. A special thanks goes to Louise for pushing us out of our comfort zone and not only make this project a show of capabilities but also a great learning experience.

CONTENT

PROJECT APPROACH

PHASE PLAN

The project is managed taking ofset in Ulrich & Eppinger's model for generic product development. ULRICH, T., K. and EPPINGER, D., S (2012)
The model consists of a number of consequent phases followed by a review to confirm that the project is ready for next phase. This stage-gate approach is adopted into the project but with a slight change in the indexation of phases, with the biggest difference in "research & framing" having a dedicated phase.

PHASE 00 PROJECT SCOPING	**PHASE 01** RESEARCH & FRAMING	**PHASE 02** IDEATION & SELECTION
2.Feb - 13.Feb	16.Feb - 27.Feb	2.Mar - 20.Mar
PURPOSE To get an understanding of the justification for the project. Some data is provided by Timan A/S due to research prior to this project and the phase is therefore mainly for introduction to the assignment.	**PURPOSE** To ensure a strong foundation for further concept development. The market and users are studied in order to locate needs and increase the value of the product. Company market position is defined and competitors mapped.	**PURPOSE** Concept opportunities are investigated and tested against the defined requriments. Best 3 potential concept is chosen for detailing.
OUTPUT - Project introduction - Initial delimitation - Phase plan	**OUTPUT** - Project framework - Requirements and wishes - Wanted product values	**OUTPUT** - One feasible concept with potential for further development
METHODS - Microsoft project	**METHODS** - Interviews - Antropological studies - Litterature studies - Lerdahl pyramid - Competitor mapping - Positioning map	**METHODS** - Bodystorming - Brainstorming - Sketching - Mockups - Tests on user

PHASE 03
SYSTEM DESIGN

23.Mar - 10.Apr

PURPOSE

The product architecture is designed in the detail with focus on the various configurations and interfaces. Suppliers are identified and assembly schemes are initiated.

OUTPUT

- A completed product architecture.
- aesthetics near completion

METHODS

- Litterature studies
- CAD

PHASE 04
DETAILING

13.Apr - 1.May

PURPOSE

Most relevant parts of the project are designed in detail with focus on stress and material properties, as well as production and tolerances.

OUTPUT

- Most relevant parts finished at a near production ready state.

METHODS

- CAD
- FEM analysis
- Mock-ups

PHASE 05
END PHASE

4.May - 20.May

PURPOSE

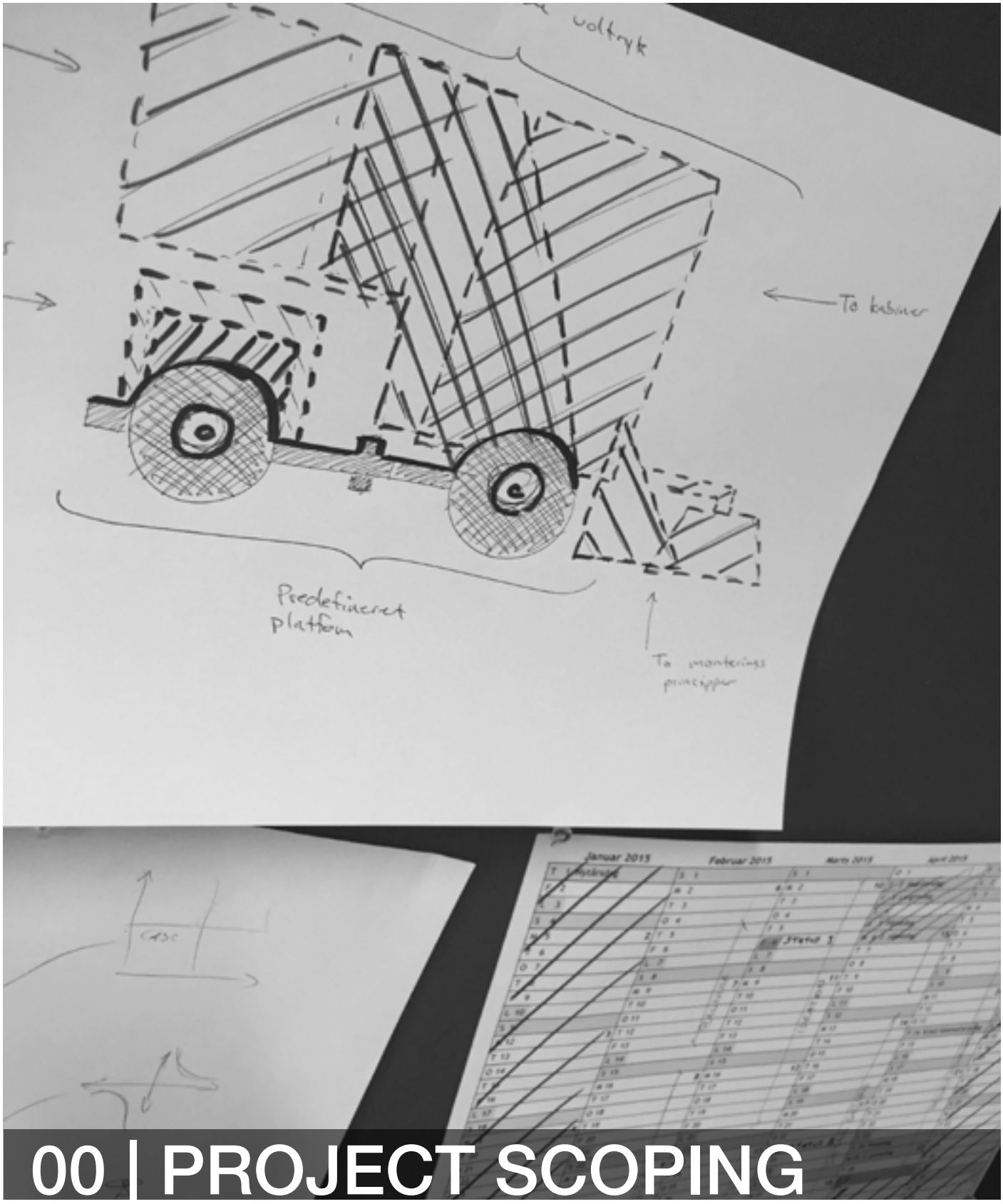
Final phase for evaluation of the product, as well as production of presentational material.

OUTPUT

- Process report
- Product report
- Presentational models

METHODS

- Computer Rendering
- Photo representation
- Detailed models
- Feedback from company



00 | PROJECT SCOPING

INTRODUCTION

THE COMPANY

The project team has chosen to work in collaboration with a minor company operating within the field of small utility vehicles for urban maintenance and more heavy duty work. The members in the project group have a common interest for technical products and Timan A/S became a natural choice for partner company. Timan A/S started in a garage 10 years ago with the work of 3 brothers building a tool-carrier named Tool-Trac. The tool-carrier was equiped with a hydraulic arm enabeling the vehicle to lift small loads. This had not been done before and enabled this hybrid machine to not only work as a tool-carrier but also as a mini loader.
Timan A/S then acquired the competing company, VPM Maskiner, introducing their tool-carrier, a vehicle called VPM3400, to the Timan A/S product range.
The company is located in Tim, Ringkøbing, with most of its production and all assembly. Working with a company would be an educational challenge in terms of communication and responsibilities with an external customer and was considered as a good test of gained competencies throughout the education.

TIMAN A/S DESIGN OBJECTIVES

During an introductory meeting with the management of Timan A/S, the following task was presented to the project-team.
Timan A/S currently manifacture and sell their own combi-loader the Tool-Trac, and the more traditional tool-carrier aquried from VPM Maskiner - the VPM3400.
Timan A/S wants to update both vehicles and is developing a new vehicle-platform meant to function as a base for both a new compact combi-loader and a new tool-carrier. The platform consist of a rolling chassis with hydraulic 4 wheel-drive, articulated steering and is accompanied by two turbo-diesel engine sizes.
Timan A/S requests to the project team is to come up with design suggestions for the two new vehicles.
Primary interest is in the traditional tool-carrier as this type of vehicle is in high demand in the German marked where maintenance of huge urban areas is important. Timan A/S has entered this marked with their current tool-carrier the VPM3400, but would like to be a bigger player.
The requested task is foremost the styling of the vehicles since users and functions have been identified from Timan A/S point of view. However they are also open for the project team to question and challenge these decisions.
Furthermore Timan A/S would like the design to have unique aesthetics and functional features to differentiate them from competitors, and create a stronger Timan A/S identity.
Being a medium sized business, the choises of manufacturing processes is also important. Timan A/S opts for a solution within their production capabilities.

ill. 1 - The VPM3400

ill. 2 - The Tool-Trac

WHAT IS A TOOL-CARRIER?

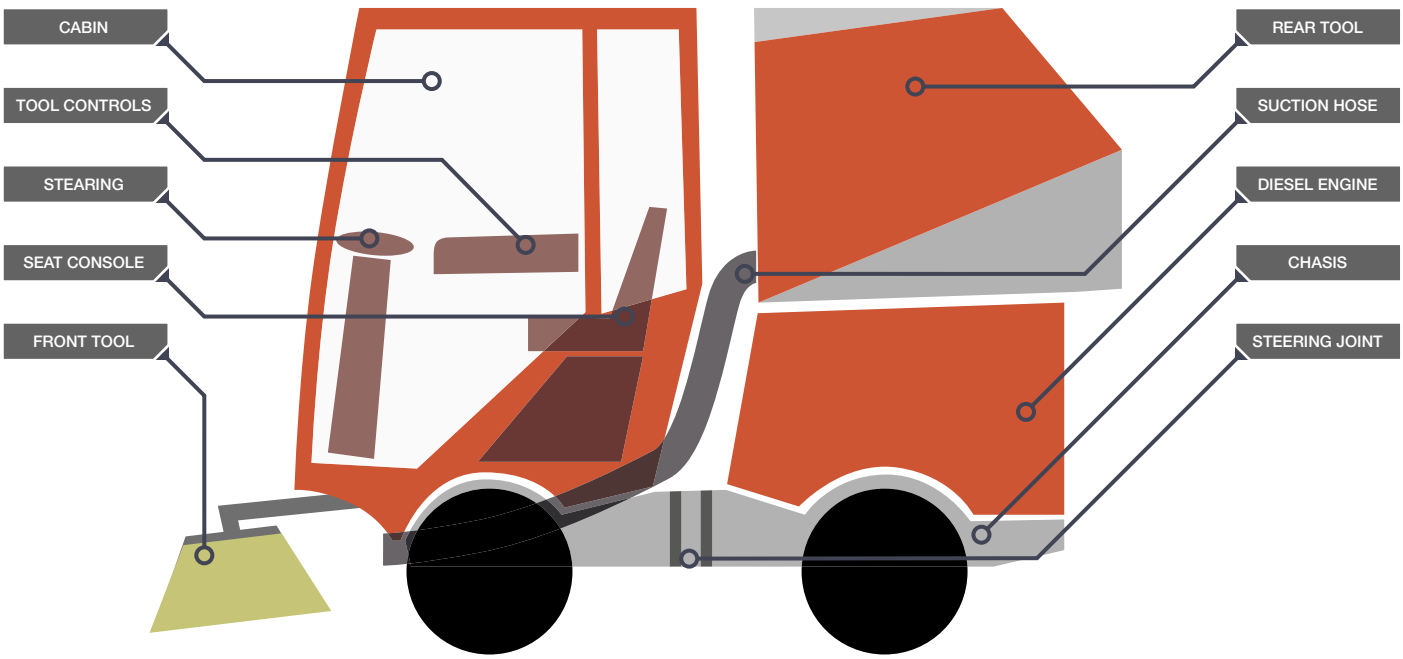
MACHINE USAGE

One of the key aspects with tool-carriers is their ability to perform on a multitude of assignments. They are therfore marketed to a wide spectre of users across job descriptions and requirements. One common parameter is that their work area is dependant on the season, and where the machines might differentiate in their summer duties, all machines are used for snow controll during the winter season.
One could say that the tool-carriers are the Swiss Army knife within the field of maintenace vehicles.

ill. 3 - Machine usage

PRODUCT ARCHITECTURE

The product architecture of tool-carriers is very common. The vehicles are build on a chassis with articulated steering. Then fitted with a hydraulic motors on every wheel making it a 4 wheel drive vehicle. The motors are then controlled via a hydrostatic transmission, pumping hydraulic fluid into the wheel motors. The hydrostatic transmission is typically powered by a small diesel engine. The engine is usually placed on the back of the vehicle to create even weight distribution when the cabin section is installed. The vehicles is controlled by a traditional steering wheel, and gas/breake pedals. A console with tool controls is then typically placed close to the right arm of the driver. Lastly tools can be fitted to the front, and the back of the vehicle depending on the type of task at hand.
The reason for this vehicle platform is that the simplicity of articulated steering makes for both a cheeper and easier serviceable vehicle, and makes it very maneuverable.
The hydraulic system can the power both the wheels, the steering and the connected tools.

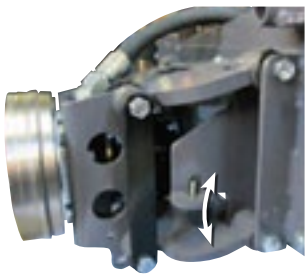


ill. 4 - Typical tool-carrier, with sweeping-kit, product architecture

TOOL-CARRIERS OFFERED BY TIMAN A/S

THE VPM 3400

The VPM3400 was originally developed by the company VPM back in 2010. Unfortunately the company went bankrupt, and the VPM3400 rights was bought by Timan A/S who now manufacture the vehicle.
The VPM3400 was developed as a direct competitor to multiple very popular tool-carriers at the time, but differentiated it self in one key aspect - the comfort.
As one of the few in its class, the VPM3400 is fitted with independent suspension on each wheel, and has the most silent cabin in the class as well. This makes it a very comfortable experience piloting the vehicle, and extends the time the user is able to use it.
Unfortunately this is where the differentiating factors begins to drop. From tool possibilities to interaction the VPM3400 is very similar or below par compared to the competition, and has not been able to punch a hole in the market for Timan A/S. As sales manager from Timan A/S Birger Pedersen says, "it is first when a customer has tried the VPM and felt the comfort of the vehicle, that they consider it over a tool-carrier from the more established brands".



ill. 5 - The VPM3400 tool-carrier

THE TOOL-TRAC

The Tool-Trac was the vehicle that started Timan A/S. The three brothers constructed this tool-carrier in a garage and the vehicle since achieved success. The Tool-Trac differentiated itself in having a hydraulic lifting arm. This was not seen before when the vehicle was launched, and proved to hit a niche market within the tool-carrier universe. The lifting arm enabled it to do even more diverse tasks that the traditional tool-carries couldn't do. The more masculine and heavy-duty appearance also made the vehicle stand out from the competition. The Tool-Trac however is fairly expensive in relation to other tool-carriers, and it is nearing the age of 10 years. This means that competitors has implemented features outdating the Tool-Trac, and at a lower price point. The Tool-Trac is primarily sold to countries with more snowy conditions, as its hydraulic arm can accommodate both snow controlling tools, and showel/scrapers to move piles of snow.
The vehicles more rugged design with large wheels also inspires to more heavy duty tasks.

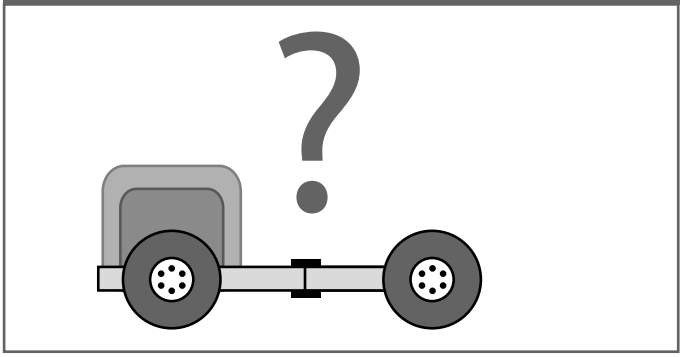
ill. 6 - The TOOL-TRAC tool-carrier

PROJECT SCOPING

PRODUCT OPPURTUNITY

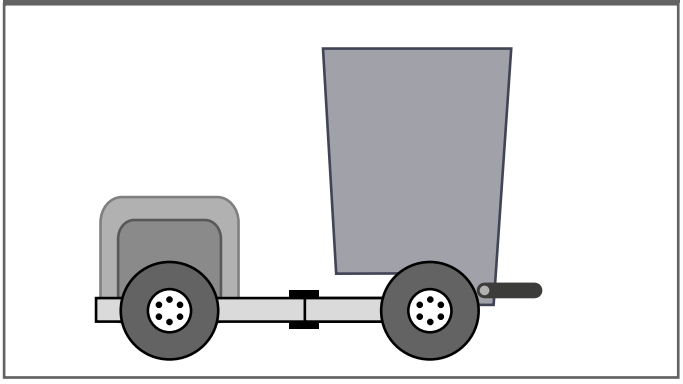
An opportunity rises with the development of Timan A/S new vehicle platform.
Designing the two configurations, one a hybrid between a mini-loader and a tool-carrier, the other a traditional tool-carrier, presents a very relevant project task for the team members. Even though Timan A/S presents the task as a styling oriented assignment, the project team sees the opportunity for utilizing multiple skill-sets obtained throughout the education. Fields like machine/human interaction, ergonomics, aesthetics, technical/mechanical solutions and tectonics can all be utilized in a project like this and thereby makes it highly relevant for the semester.
The market of these type of maintenance vehicles is a very red ocean, making differentiation from competitors even more important. Timan A/S is therefore also looking towards establishing a more recognizable identity through these new vehicles. The project team sees this as an opportunity to take a more value based approach utilizing the value/vision based methodology TOLLESTRUP, C. (2004) and thereby introduce new value in this saturated marked by identifying neglected needs, and thus differentiate Timan A/S and therby reduce the number of competitors. CHAN KIM, W. and MAUBORGNE, R. (2005)

PLATFORM



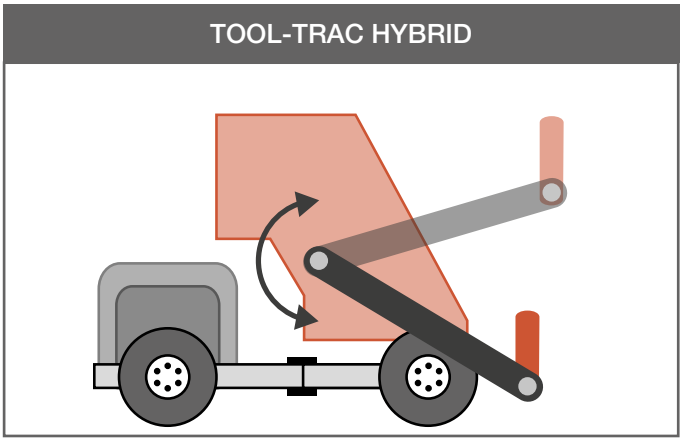
ill. 7 - New vehicle platform developed by Timan A/S

TRADITIONAL TOOL-CARRIER



ill. 8 - Typical elements for a tool-carrier configuration

TOOL-TRAC HYBRID

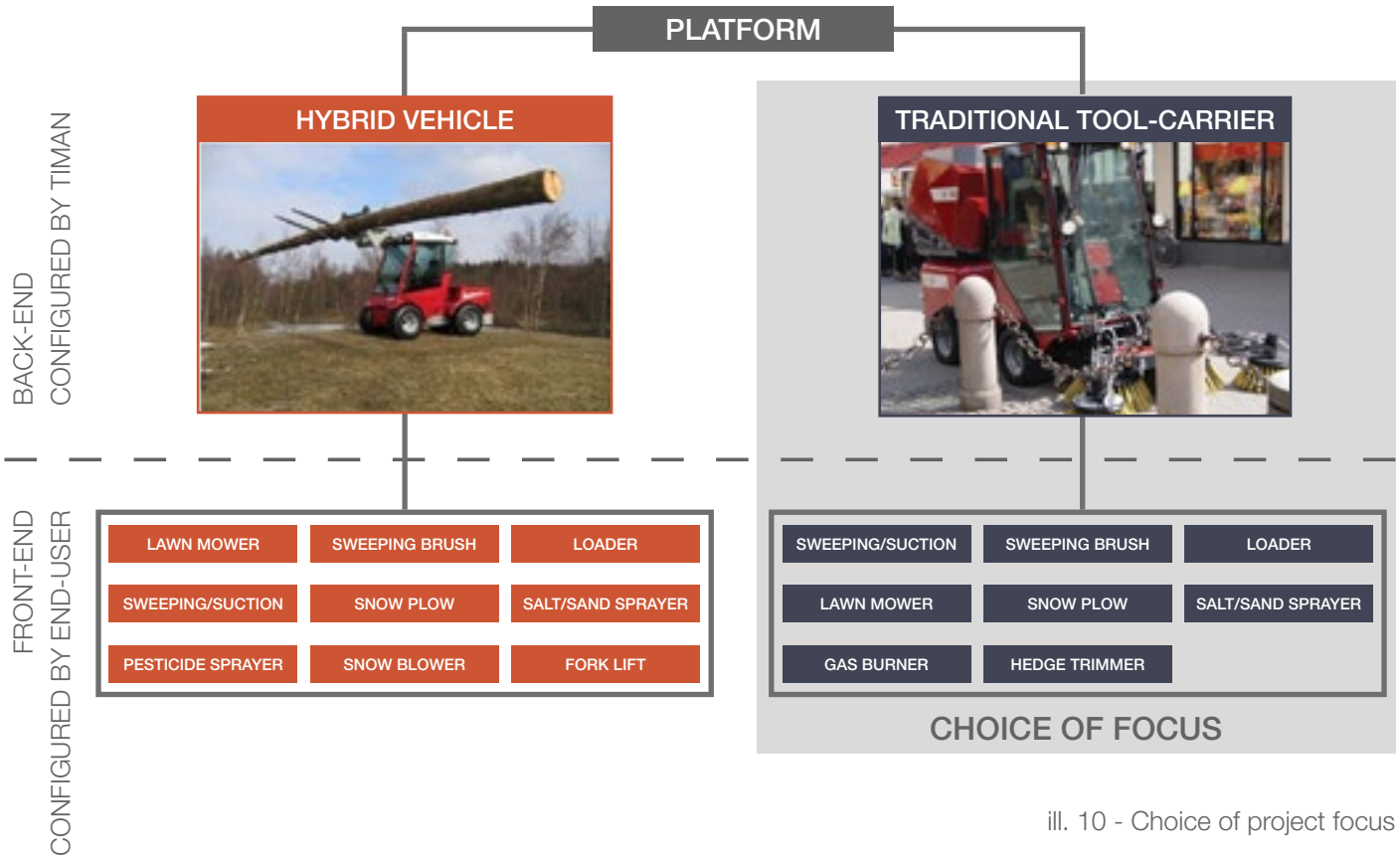


ill. 9 - Elements for the Tool-Trac hybrid configuration

INITIAL DILIMITATION

URBAN MAINTENANCE

Based upon the design objectives, the project team chooses to focus on the development of a tradtional tool-carrier for urban maintenance ill. 10. This is done both in order to accommodate the task provided by Timan A/S but also because this is the most demanded vehicle both in the danish market but also in countries like germany.
The project team however chooses to take a step back from Timan A/S framing of the project as a styling task , and initiate an independent divergent research phase to ascertain exactly what a tool-carrier is, what its uses are, if there is need for new value, and compare this with the assumptions made by Timan A/S in relation to users, functions and market. This is done to make sure that the project has a solid foundation for concept development.



ill. 10 - Choice of project focus

MARKET ANALYSIS

POSISITIONING

The market of city-cleaning is populated by a large varity of vehicles, all with a specific area of expertise.
Large specialized cleaning trucks takes care of main roads. Smaller medium sized vehicles takes care of pathways, downtown squares and other less accesible places. Lastly theres the compact vehicles capable of entering very narrow and inacessable places such as bike lanes and paths between buildings.
Timan A/S wants to position themselves in the medium sized market segment due to a high demand on this type of vehicle. Especially the german marked seeks these vehicles due to the expansion of cities and municipalitys.

This market segment is populated by both traditional tool-carriers to sweeping oriented tool carriers to specialized sweeping only vehicles.
To hit the german markets demand for sweeping vehicles, and the nordic market where multifunctionality is wanted, Timan A/S is positioning themselves in the category of tool-carriers oriented towards sweeping. This meens that the vehicles primary objective will be city sweeping, but can be fitted with other tools should the need arrise.
This category is dominated by a couple of big players that would become direct competitors to the new Timan A/S vehicle.

ill. 11 - Competitor map

UNDERSTANDING THE COMPETITION

NILFISK CITY-RANGER 3500

WITH	1130mm
LENGHT	4080mm
HEIGHT	1900mm
WASTE CAPACITY	1,4m3
PRICE	>700,000DKK

ill. 12 - Nilfisk City-Ranger 3500

HAKO CITYMASTER 1600

WITH	1375mm
LENGHT	4015mm
HEIGHT	2215mm
WASTE CAPACITY	1,2m3
PRICE	>500,000DKK

ill. 13 - Hako Citymaster 1600

Two of the larger players in the field of sweeping oriented tool-carriers are german Hako and danish Nilfisk-Egholm. Both companies produce vehicles that can be considered direct competitors for Timan A/S.

However by studying the different models, and the market in general, it has become clear for the project team that the field of tool-carries in general, is affected by incremental innovation INNOVATION TOOLBOX (2012).
This means that competing factors often are related to more technical aspects such as wastetank capacity, turning radius, engine emissions etc. These are factors that the everyday user of the vehicle might not feel directly, and seem more oriented towards a buyer with technical understanding.

It is challenging to locate compeeting factors related to the end-user such as interface features, ergonomic improvements or the overall styling of the vehicle.
This supports the project team initial descition to utilise a value vision based aproach in the creation of the new vehicle.

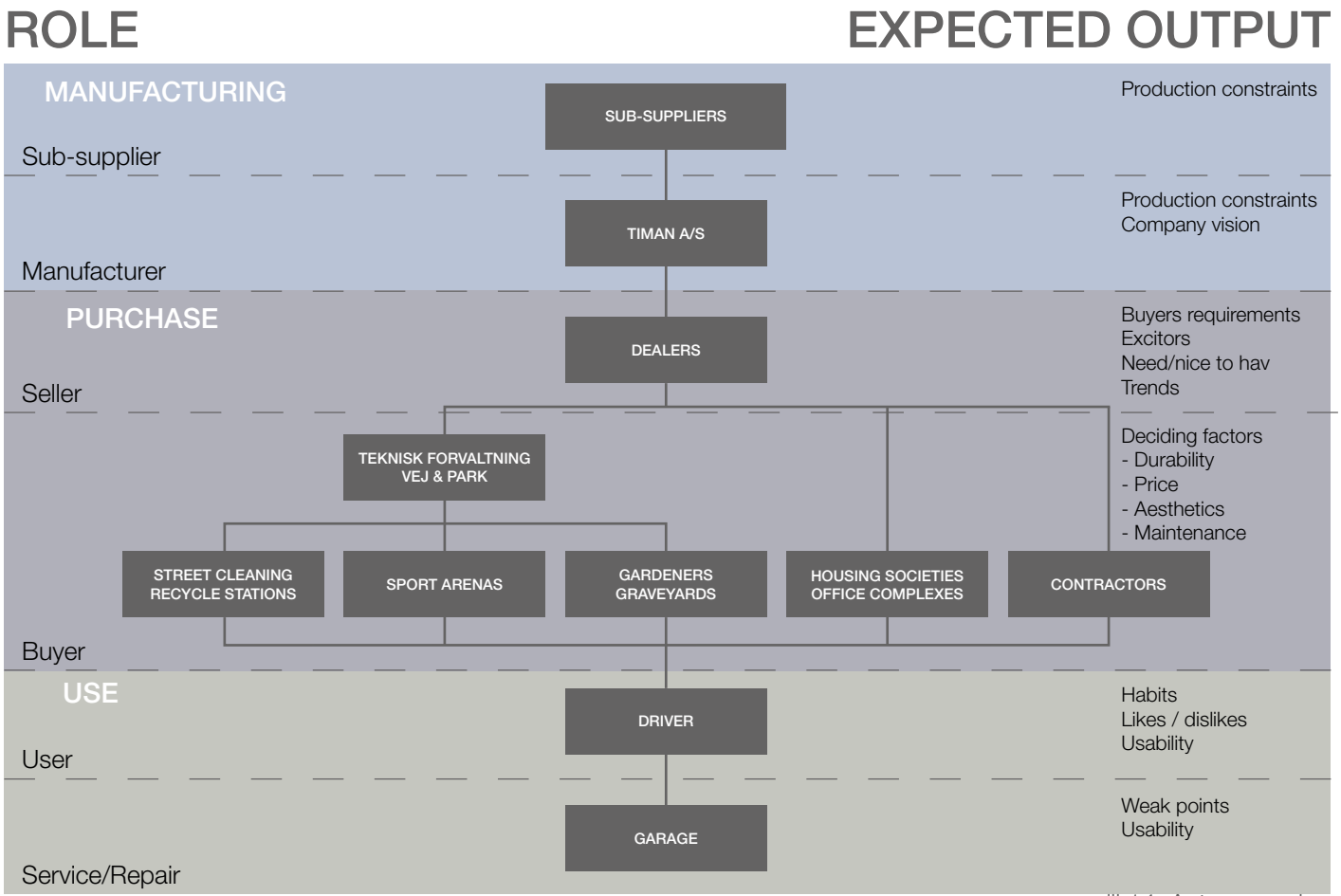
01 | RESEARCH & FRAMING

THE WORLD OF TOOL-CARRIERS

INVESTIGATION OF RELEVANT ACTORS

To establish a level of knowledge and insight within the field of tool-carriers the project team seeks out relevant actors. This initial collection of data will be used to look for apparent problems and neglected needs that the project team can deduct to needed product value and establish requirements to support these, thus homing in on the final project framing.
More specialised and technical research will be presented during the system design phase when it is relevant for the task at hand.

Fig. 14 below illustrates the network from manufacturer, to sales, to use, to maintenance and can be divided into three primary levels:
1) 'Manufacturer' can provide insights concerning production constraints and company vision.
2) 'Purchase' provides insights from seller and buyer with typical focuspoints and determining factors.
3) 'Use' provides insight in issues during use and can reveal areas in need of improvement.
All of these insights are needed in order to get a better understanding of the world of tool-carriers. What it takes to produce, buy and use them. Therefore every level must be investigated.



ill 14. Actor mapping

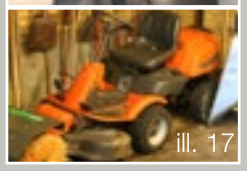
USE

Nørresundby Cemetery

Graveyards are potential users for the versatile tool-carriers due to a variety of daily jobs.
This graveyard had an older Nilfisk tool carrier that were used with a brush during winter and a suction configuration the remaining time. These where the only two functions used on the vehicle. Other relevant jobs were performed with designated machines. Especially a compact loader was popular due to its lifting capabilities and quick mobility.


ill. 15


ill.16


ill. 17

Himmerland Housing Society

A visit to Himmerland Housing Society revealed tool carriers of various brands and ages. Machines are added to the machinepark when districts are joined. The tool carriers have only two functions: snow kit for winter and sweeper/suction for the remaining part of the year. Other jobs such as lawnmoving was performed by specialized machines that performed better than the tool-carrier fitted with a moving tool. Machines are used across the staff and must be easy to use both in terms of interaction and maneuverability. The staff had experienced that one of the machines was more popular and used more because of its user-friendliness.


ill. 18

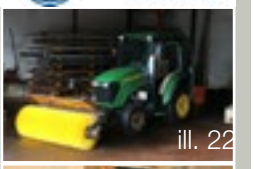

ill. 19


ill. 20


ill. 21

Aalborg Municipality

The entreprenurial division is in charge of street cleaning in all of Aalborg.
The department has three large designated sweeping/suction trucks used to clean main streets in the city.
Furthermore they have three smaller vehicles dedicated to street sweeping.
These were used to clean the less accesible parts of downtown Aalborg as well as paths and was the primary work horses.
In addition they have a number of mini tractors and a traditional tool-carrier. The tool-carrier was fitted with a sweeping kit, and used to clean extremely inaccesible parts of Aalborg due to its compact size and manuverebility. The department employs seasonal workers and the drivers often have limited experienced. This meant a minimum of two days training period to master the vehicle and its functions.
The drivers daily spend up to 8 hours in the machines covering both transport and cleaning time.


ill. 22

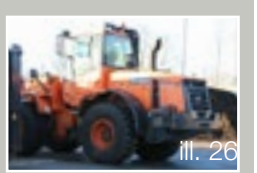

ill. 23

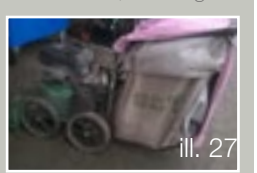

ill. 24


ill. 25

Recycle stations

Another segment in the target group is recycle stations with their paved areas and large amounts of dirt. However, visits to two sites reveals that the toolcarrier isn't attractive. Either they use smaller and much cheaper alternatives or else the need products to perform in other areas.


ill. 26
Over Kæret, Aalborg


ill. 27
Brønderslev recycle

PURCHASE

Almas A/S

Despite only doing business with competitors, Jan Sørensen highlights the great comfort and the handy size of VPM 3400. However, in his experience customers are intrigued with quick tool shift and easy usability - easy to show, easy to sell.


ill. 28

Nørresundby Cemetery

Manager Tinna Schmidt Petersen informs that price isn't primary factor in terms of purchase. The garteners tries out several machines and the decision is weighted heavily from these experiences. It's important that the machine is easy to use for all employees and performs well on its jobs.


ill. 29

Hjallerup Maskinforretning A/S

Claus Kjær Jørgensen explains how the complex tool carriers are threatened by cheaper alternatives. Mini tractors allow for less configurations and less maneuverability but comes with an attractive price of less than 2/3 of a tool carrier. a few VPM 3400 are sold annually, with a snowkit, and sweeping/suction kit.

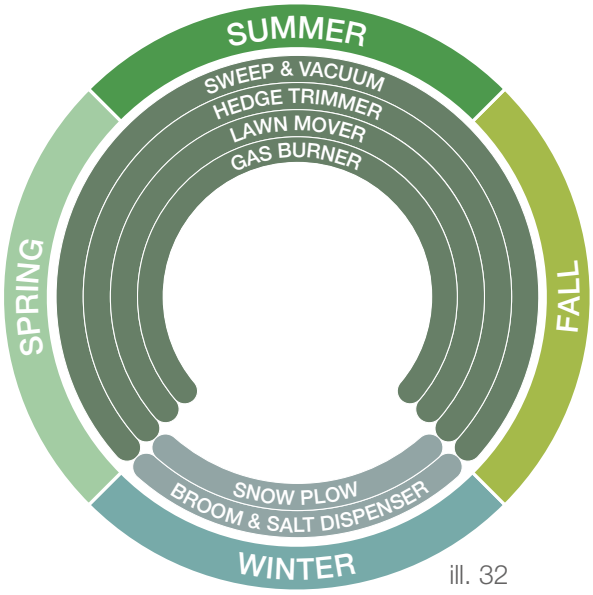

ill. 30

Aalborg Municipality

Bjarne Svane Nielsen, in charge of purchases, expresses how performance and working environment are prioritized highest in term of purchase. The drivers give input to machine choice and if it lives up to expectations throug a test period, price negoation is initiated.


ill. 31

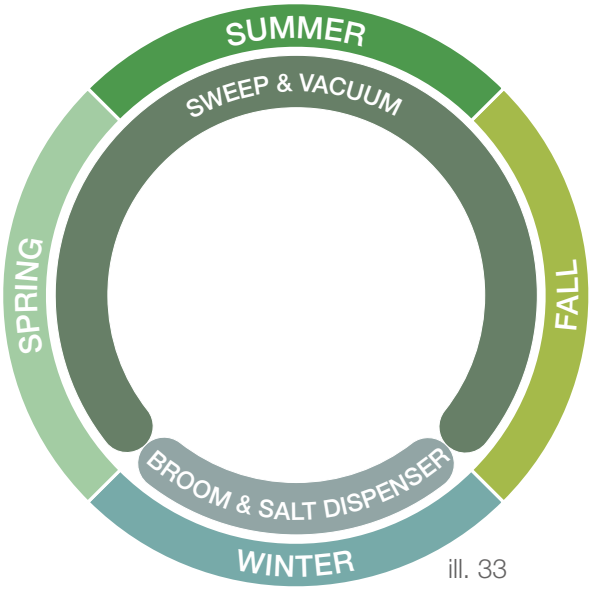
INTENDED USE



ill. 32

Common for the visited representatives is how the tool-carriers seem to be used for a limited number of tasks. During winter a winter package is mounted consisting of a front snow broom and a rear salt dispenser. The rest of the year the machines work with cleaning - being sweeping, suction or a combination of the two.

ACTUAL USE

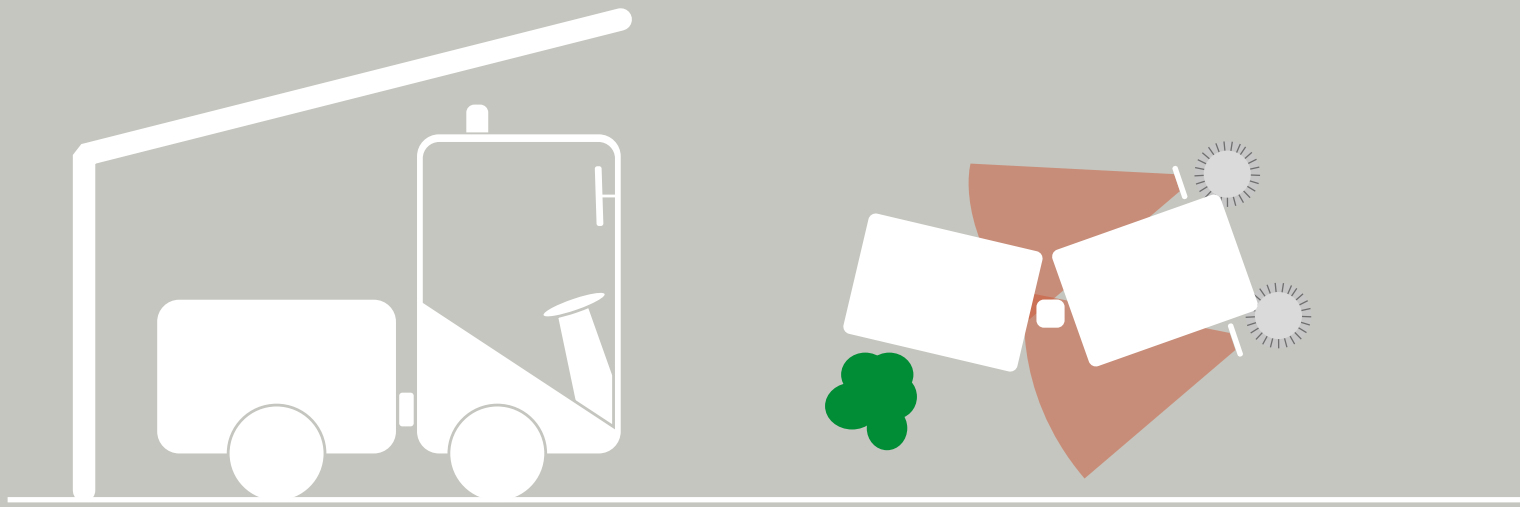


ill. 33

Remaining jobs are performed with specialized machinery with much higher performance.
This prooves that though tool-carriers can be fitted with a huge number of tools, most of the time only the sweeping and snow controling configurations are used thus lowering the need for quick tool shift and a garage full of tools.

LOCATED PROBLEMS IN DAILY USAGE

PRIMARY PROBLEMS



1) Complex control

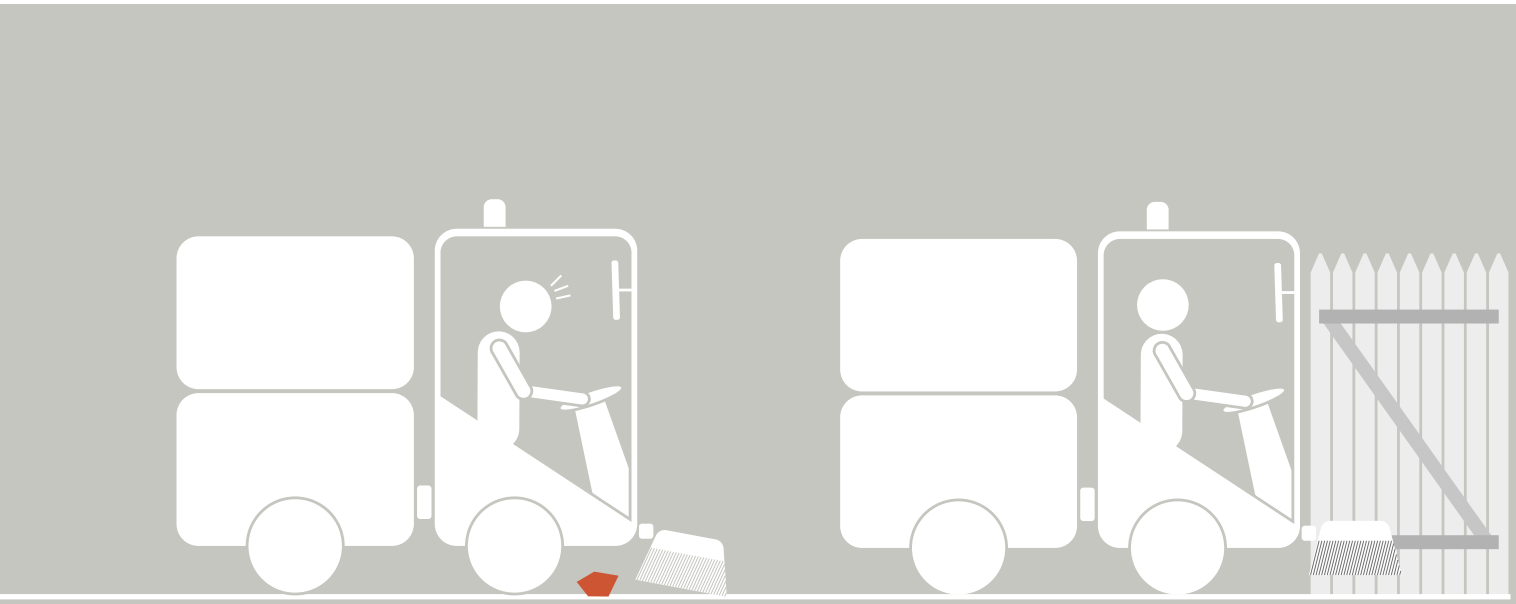
The Hako 1250 controlls for the front tool is distributed all over the cabin with several steps in order to start sweeping. It scares the users and the machine logs to few hours. *"I rarely use the machine despite an actual need. I forgot all the controlls and you don't want to ask for help all the time" - Driver*

ill. 35 - Citymaster 1250, Hako

2) Poor visibility from vehicle

Due to the articulated steering, the mirrors mounted on the cabin section moves undesireable in relation to the rear section effectevily making them useless when the vehicle is in a articulated state going around opsticles. The drivers had often experienced accidentaly pulling out in front of bikes and pedestriants.

ill. 36 - S2, Boschung



ill. 34 - Issue mapping

3) Poor visibility to suction head

Small windows placed in the floor of the vehicles allows for the driver to monitor the suction head placed underneath, but the windows are often so small and dirty that it hinders the view significantly. A light is also required for driving in the dark, and early mornings.

4) External parts hitting obsticles

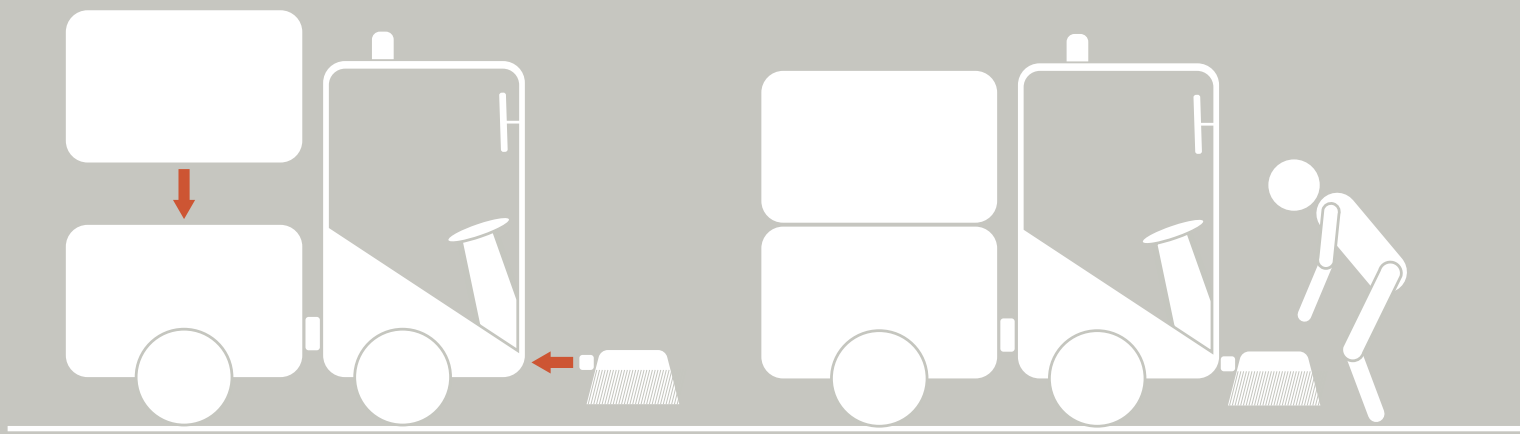
External parts like side mirros and rotor light exceeds the machines otherwise compact design and results in impact with obsticles such a sign posts and branches from hedges and trees. A more streamlined design could avoid this issue.

ill. 37 - Swingo 200, Schmidt ill. 38-Citymaster 1250, Hako

ill. 39 - Swingo 200, Schmidt

LOCATED PROBLEMS IN DAILY USAGE

SECONDARY PROBLEMS



5) Difficult tool attachment

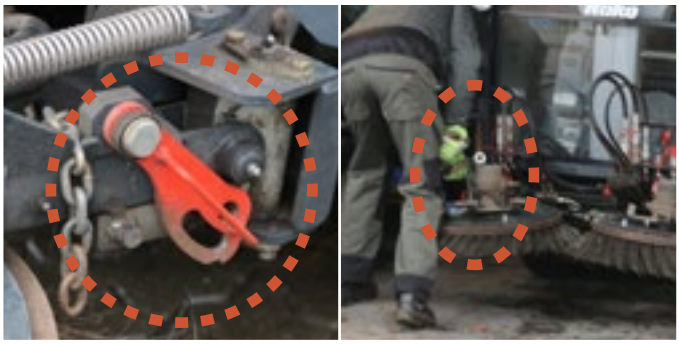
Timan salesman highlights the issue of connecting the hydraulics on the VPM. It can be time and energy consuming and is less convenient than e.g. many tractor solutions. Nilfisk salesman supports the statement with own experiences of customers intrigued by Nilfisk's quick attachment.

6) Manual handling

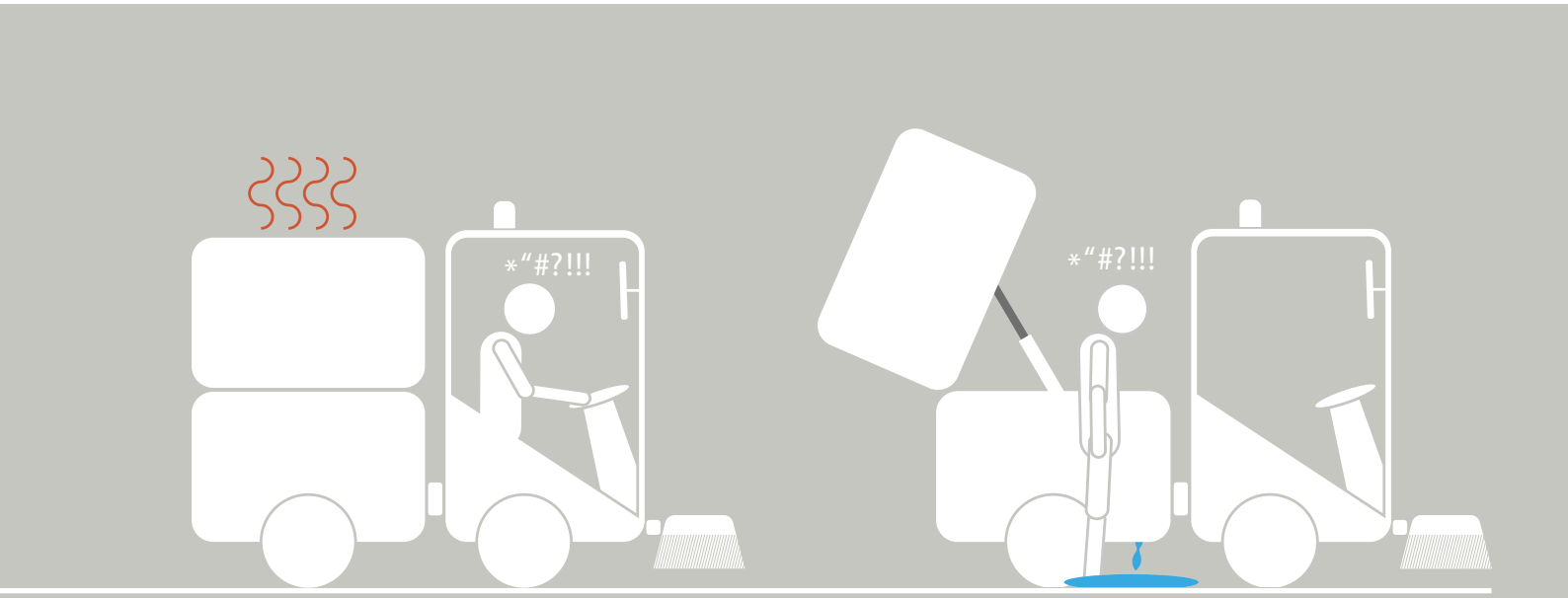
In the tool-carrier used by Himmerland Boligseskab, the driver has several contacts with the front tool that leads to the driver getting in and out of the machine as well as working positions with poor ergonomics. The photos shows a safety lock used under transportation and a lubrication process.

ill. 41 - Quick-couplers City Ranger 2250, Nilfisk

ill. 42 - Traditional couplers VPM 3400, Timan



ill. 43 - Citymaster 1250, Hako



ill. 40 - Issue mapping

7) Badly placed oil-cooler

The cooler for the hydraulic oil system is cooled by the recycled cleaning water. If this water is used up during sommertime and hot conditions, the vehicle runs hot and shuts down. Other models have a dedicated oil cooler making it independent of the water systems.

ill. 44 - S2, Boschung

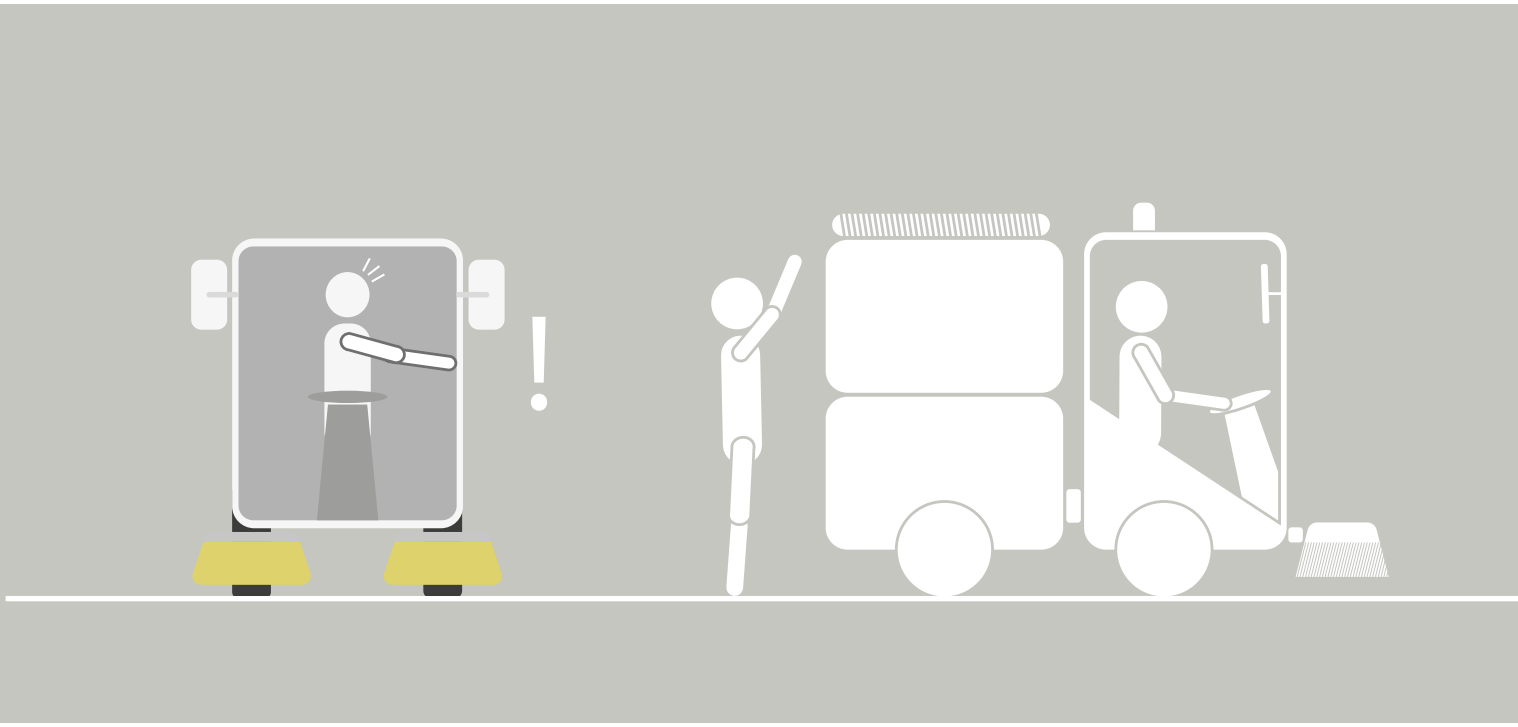
8) Water empties on your feet

When sweeping in the rain, the vehicle sucs up a lot of exess water from the streets. This water have to be emtied at some point. On the Boschung S2 one have to get out of the cabin, raise the waste-tank and first then pull a lever to begin the emtying. The water rushes out from the buttom of the vehicle and soaks your feet if you dont stand on the correct side of the vehicle.

ill. 45 - S2, Boschung

LOCATED PROBLEMS IN DAILY USAGE

TERTIARY PROBLEMS



9) “Suicide” doors hitting mirrors

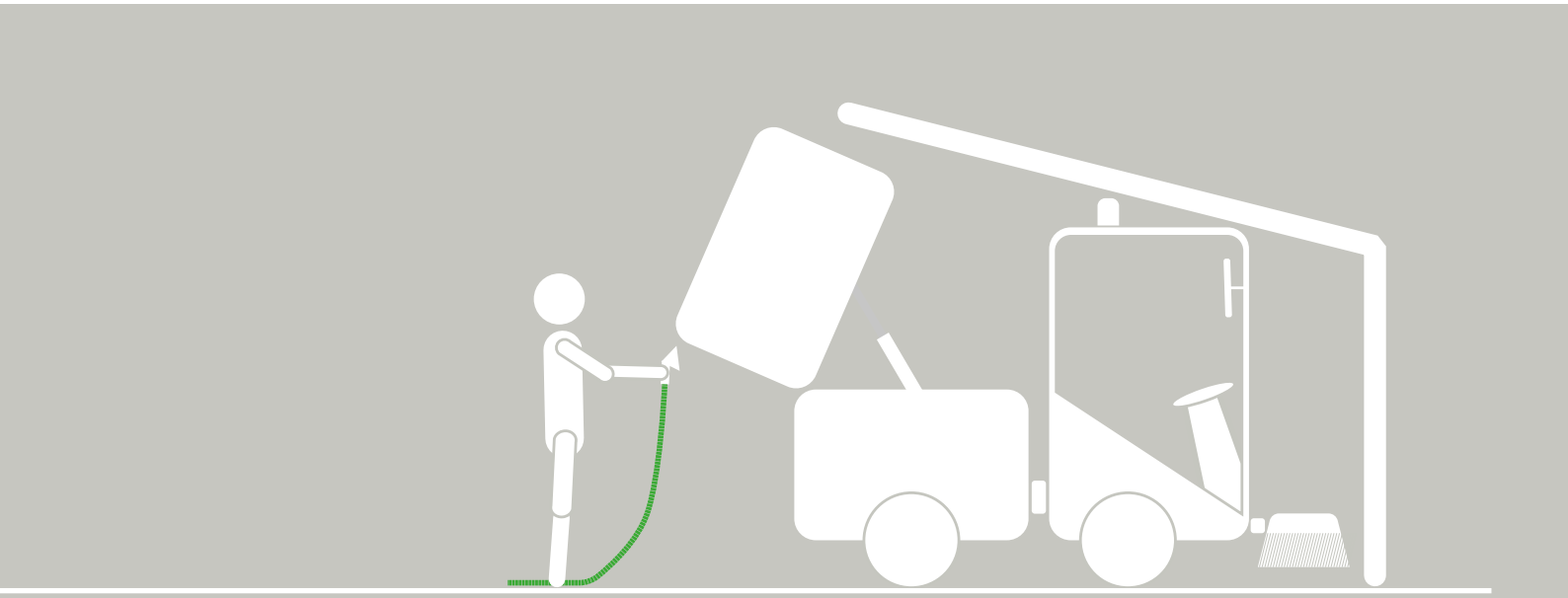
The doors on the Boschung S2 is hinged towards the back of the cabin and opens from the front. When the mirrors are adjusted the left door canot be opened without hitting the mirror. This could be dangerous in an emergancy. If the vehicle should accidentally move with the doors open, a suicide door would also be torn off instead of just closing.

ill. 47 - S2, Boschung

10) Vacuumhose: a two-man job

Some users explained how it’s a two-man job to use the hand carried suction head. One will slowly drive the machine while the other walks with the external hose. The driving job will be rather simple and might not require the full resources from an extra worker.

ill. 48 - Citymaster 1250, Hako



ill. 46 - Issue mapping

11) Bad storage of vacuum hose

None of the 3 machines below scores high in terms of the manual suction hose. Some machines doesn't have the hose integrated in the machine and must be brought seperately while others are too difficult to access. The Hako e.g. requires access from both sides in addition to a bit of climbing.

ill. 49 - Swingo 200, Schmidt

ill. 50 - Park Ranger 2100,Nilfisk

ill. 51 Citymaster 1250,Hako

12) Hard to clean

Shadowing a user cleaning his machine revealed a difficult process. The machine, Hako 1250, allowed for poor access to the waste container and was designed with many edges and small surfaces. The result is a lot of back splash on the user.

ill. 52 Citymaster 1250,Hako

ill. 53 - Swingo 200, Schmidt

PROBLEM SUM-UP

HOMING IN ON THE FRAMING

One of the more interesting findings while visiting the different actors, ranging from users to managers, was how much influence the end user, the drivers, had on the choice of vehicle when a new purchase was up. It was not just a managing decision based on numbers, but very much on the drivers experience of the vehicle.
However, at the entreprenurial department of Aalborg municipality, the project team did an interesting observation. The department had just bought a new medium sized sweeper - the Boschung S2 URBAN-SWEEPER (2015).
Almost all the identyfied issues revolved around this vehicle in particular, ranging from complex human machine interface to poor visibility from the cabin.
This meant that the guys at the department weren't happy to use it. It simply made them insecure to use the vehicle.
One thing was to master the complex controls consisting of scattered buttons and complex semiotics, but as stated several of the guys had even experienced hitting cyclist and pedestrians due the poor visibility from the vehicle.
Besides the technical issues creating insecuritry, several drivers had also had the feeling of being a monkey in a glass cage when sweeping the city at night. Drunk people often approached the vehicles, climbing on to them, and trying to "polish" their shoes on the brooms and in general obstructing the work of the drivers.

A framing of the project was beginning to appear at this point for the design team.
A feeling of insecurity is the last thing a driver sitting in these vehicles for 8 hours a day wants to feel.
Creating a vehicle that would keep the driver feeling secure and confident could be the diffirentiating factor for a succesful vehicle.
This presented the design team with an initial value mission. How to create a tool-carrier that inspires confidence and makes the drivers feel secure to do their job effectively.
One could argue that solving the issues of bad visibility and complex interface alone would help this problem, however as this value mission is very emotional in nature the design team saw an oppurtunity in utilizing a more emotional approach.
Instead of focusing only on improving the functional problems and thus risk creating just another function over form tool-carrier, the challenge would be to integrate these solutions in a emotional value based design proposision.
One place where this approach is highly used is in automotive design.
Designing a car is very much an emotional process. The designers want the user of the car to have an experience. In our case, the fealing of confidence and security.
This would also present a different way of approaching the design of a tool-carrier instead of the function over form approach currently utilized.

"How can a tool-carrier be designed utilizing an emotional value based design process, integrating functional solutions, and improved human machine interface, with emotional driven aestetichs to give the driver a feeling of confidence and security while working"

EMOTIONAL VALUE

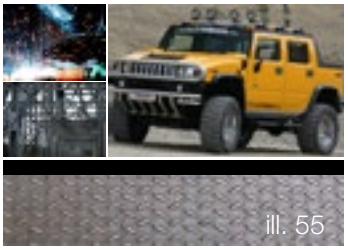
GETTING TO KNOW THE USER

The project team held a small workshop to get a deeper understanding and insight in the users as persons and how they would like to be seen when driving the streets. This was also an atempt to uncover what emotional factors the design team could utilize in the further development to counteract the feeling of being insecure.

First part of the workshop was conducted as a group discussion with focus on getting behind the facade and getting to know the users. It was revealed how all workshop participants lived in urban areas and therefore related more to cars than utility vehicles when aesthetics of the machines was discussed.
Nurmerous qustions was asked about what kind of products they used in their everyday life, ranging from cars to kitchen aplianses, all in order to gain an understanding of which aesthetic features that triggered them.

At the second part of the workshop the participants were one by one asked to prioritize six un-named moodboards according to desired image when sweeping the streets. Moodboards can be found as APPENDIX A. The answers were calculated and a strong tendency amongst the five participants reveiled that what the moodboard titled "Power" consisting of offroad vehicles and industrialized rugged scenes, was the most interesting. General conversation and comments such as "Then the curb, at least, won't be a problem" gave an indication that performance is highly priotized - in fact the participant initially stated that style doesn't matter if it performs. The results from the moodboards could indicate that the users looks for a product that expresses a such performance visually.
Luxuary and future almost shares the second place. This indicates that the users are very aware of vehicle comfort, and that they are open for new and alternative solutions.

ill. 54 - Workshop with employees from Aalborg Municipality



ill. 55

Power
27 points

ill. 56

Luxury
19 points

ill. 57

Future
18 points

ill. 58

Urban
17 points

ill. 59

Eco
13 points

ill. 60

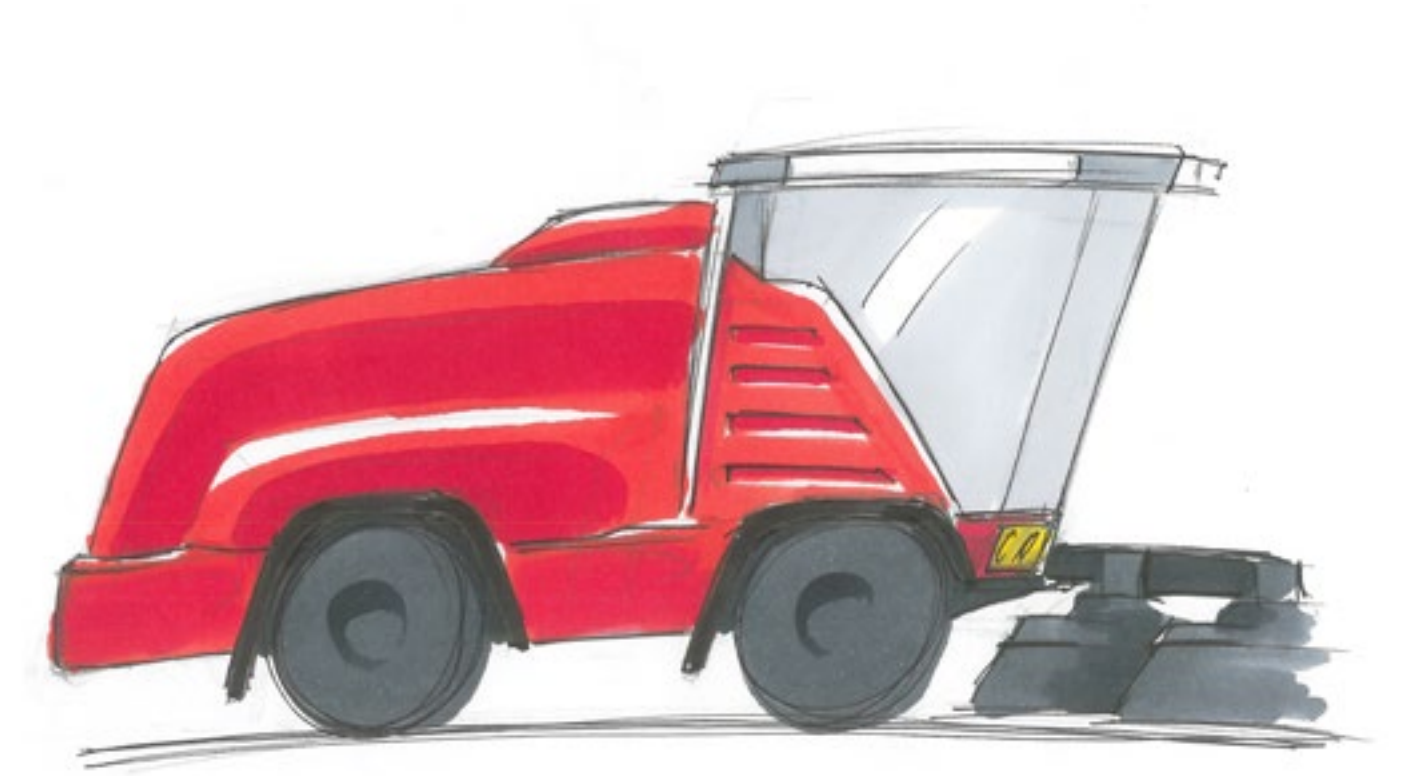
Speed
11 points

WHAT IS POWER AND PERFORMANCE?

THE ELEPHANT

Based on the workshop with the drivers at Aalborg municipality, the project team decided to create 3 initial vehicle concepts based on different interpretations of the words power and performance. These concepts would then be presented for the drivers to try and establish what the identity of the vehicle should be to fullfill the keywords power and performance.

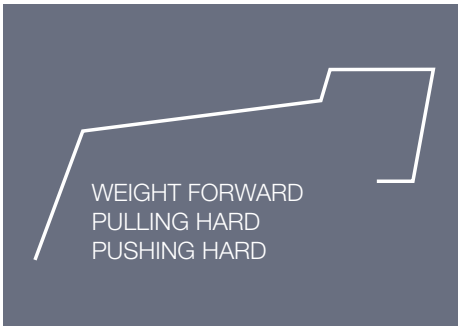
The design team turned to the animal kingdom for inspiration. It is not unusual for automotive design to take offset in nature, and the search for a vehicle identity started here. The first concept, the elephant, is a strong but peacefull vehicle. It's calmly doing its job and gives a friendly but certain indication to others to get out of its way due to the power of it size and mass.



ill 61. The elephant identity

ill 62. The wild elephant

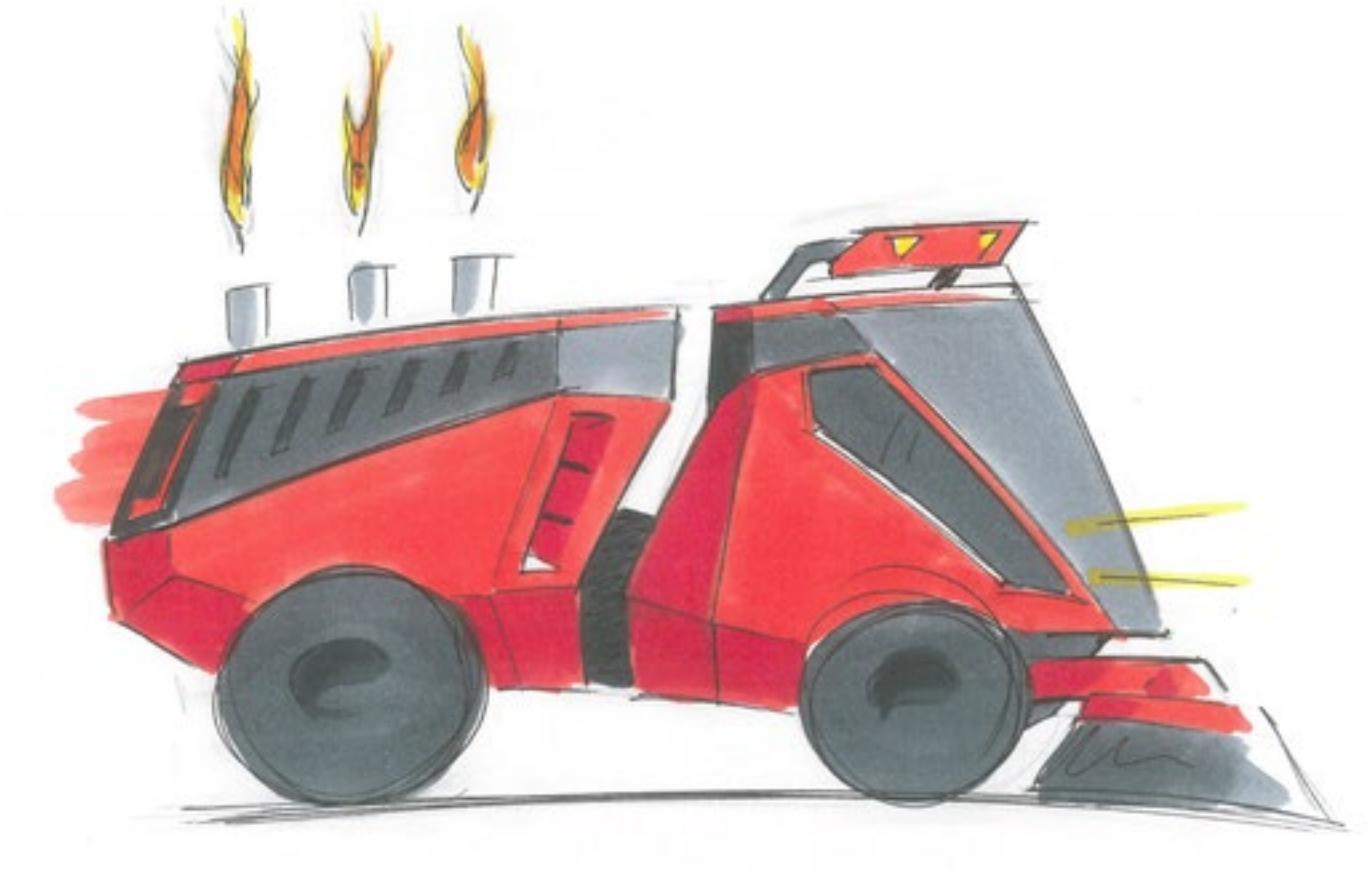
ill 63. Vehicle representation



ill 64. Identity lines

THE TASMANIAN DEVIL

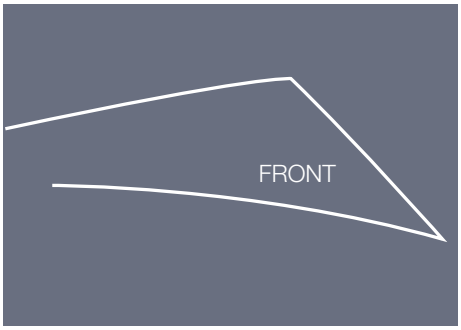
The tasmanian devil is in many ways the direct opposite to the elephant. Charging foward in a fast pace with its windshield tilted back like the ears of a aggressive predator, this vehicle races around tearing up garbage on the street. With its angular and more aerodynamic outer shell it cuts through the air and everything in its path.
Performance is everything with this vehicle, as it propels the driver through his daily route in a record time.
Just be carefull to not get in its way!



ill 65. The tasmanian devil identity

ill 66. The wild tasmanian devil

ill 67. Vehicle representation



ill 68. Identity lines

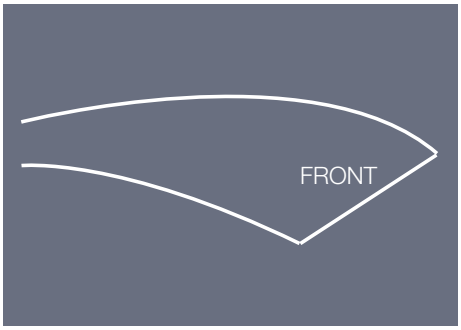
THE RHINOCEROS

Posseses some of the same qulities as the elephant, however the rhino can be much more agressive when it needs to be. This vehicle charges the garbage with is forward tilted windshield and horizotally floating lines. It combines the mass and majestical features from the elephant, with the agressivenes of the tasmanian devil. Power and performance in harmony.
The driver of this vehicle will not have to worry about confidence as he charges the street, consumes the garbage and gets the job done!

ill 69. The rhinoceros identity

ill 70. The wild rhino

ill 80. Vehicle representation



ill 81. Identity lines

USER REACTION

UNANIMOUS AGREEMENT

With the 3 initial concepts created, the design team returned to the entreprenurial department of Aalborg municipality to present them.
The drawings was layed out and the drivers was asked to just pick the one they liked the most.
At first they had a hard time to look past functionality and many decided that the elephant would be the most practical one, and propablly had the best visibility from the cabin. It was clear that they where choosing with reason and logic and not with the heart.
After this initial round, the design team asked the drivers to try and look past function and logic, and only focus on the identity of the vehicle as establishing a vehicle identity was the primary function of the concepts.
With this new approach the drivers immidiatly chose the rhinoceros. It was even a unanimous opinion of the 6 drivers present during the presentation.
The combination of agression and a massive body was well recieved, and coupled with the forward momentum of the horizontal downsloaping lines, convinced the drivers.
However many expressed a concern regarding the foward leaning cabin in terms of forwards visibility. This was the reason they haden't chosen the concept to begin with.
This is a valid concern and was noted in regards to further development.

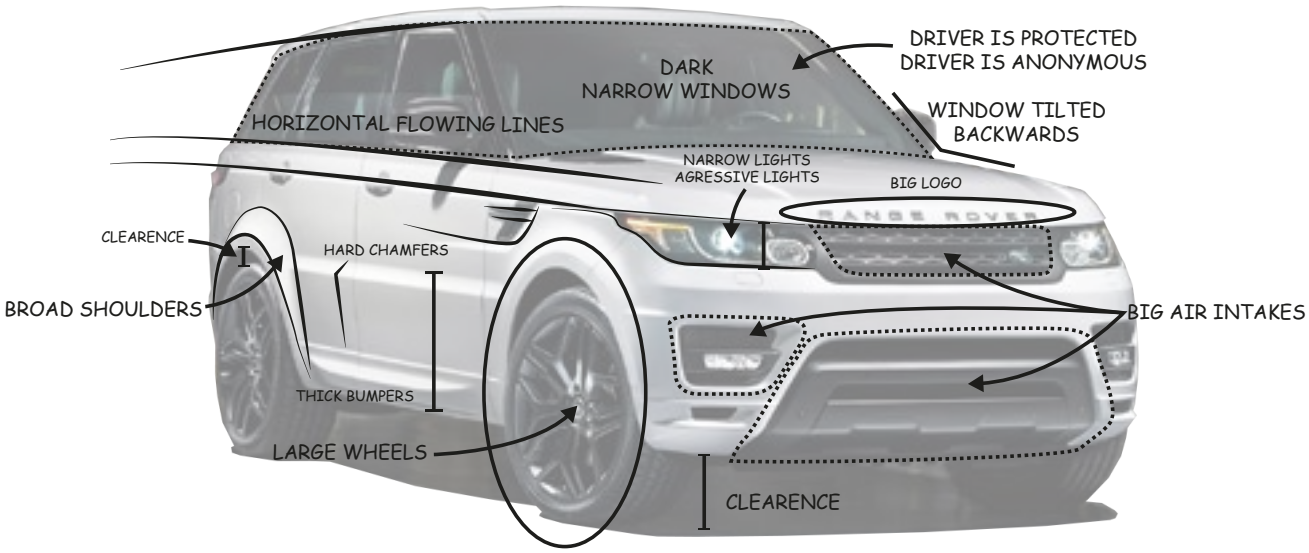
ill 82. Side view

ill 83. Rear view

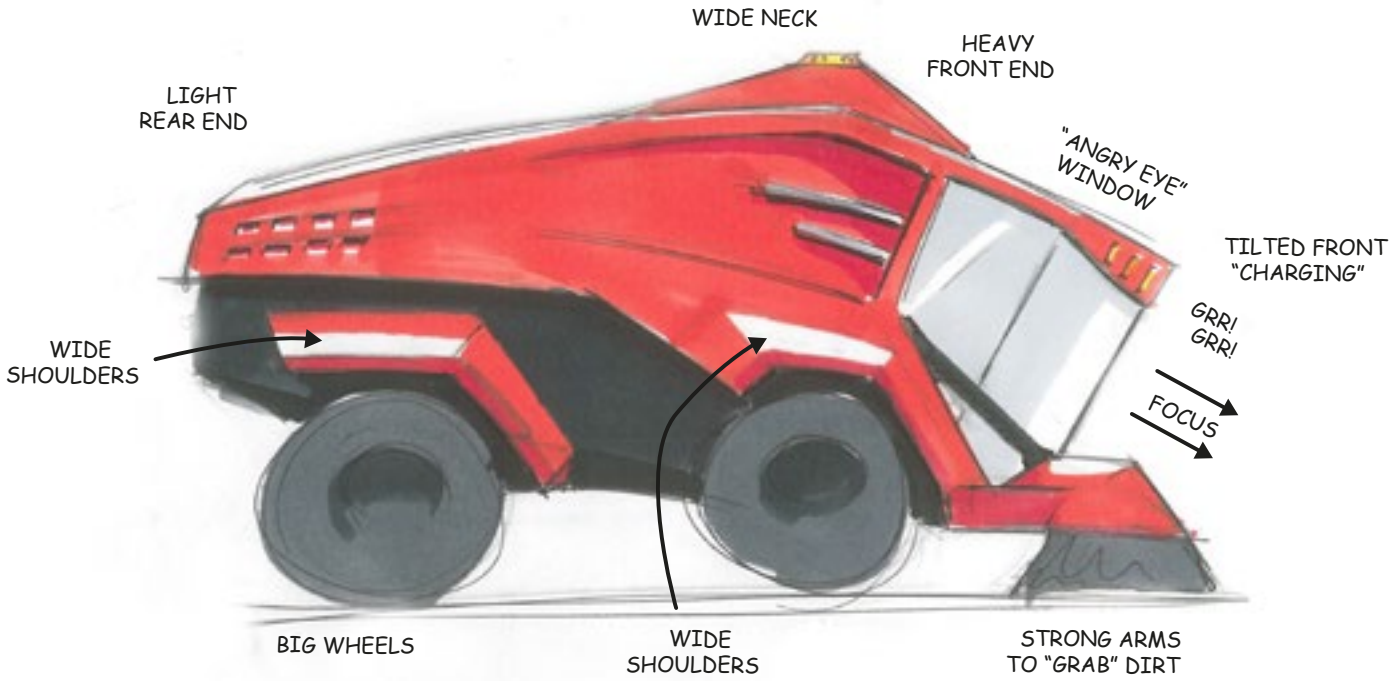
ill 84. Front view

BREAKING DOWN THE AESTHETICS

WHAT MAKES UP THE RHINO



ill 85. Range Rover analysis



ill 86. Rhino Analysis

Having established a baseline identity for the vehicle, the design team needed to break down the aestetics of the rhino concept to try and deduce what kind of form features the wanted properties ill 86.
From the car world the Range Rover Sport had already been chosen as a vehicular representation of the rhino, and to get a second reference the aestetics of this car was also analysed ill 85.

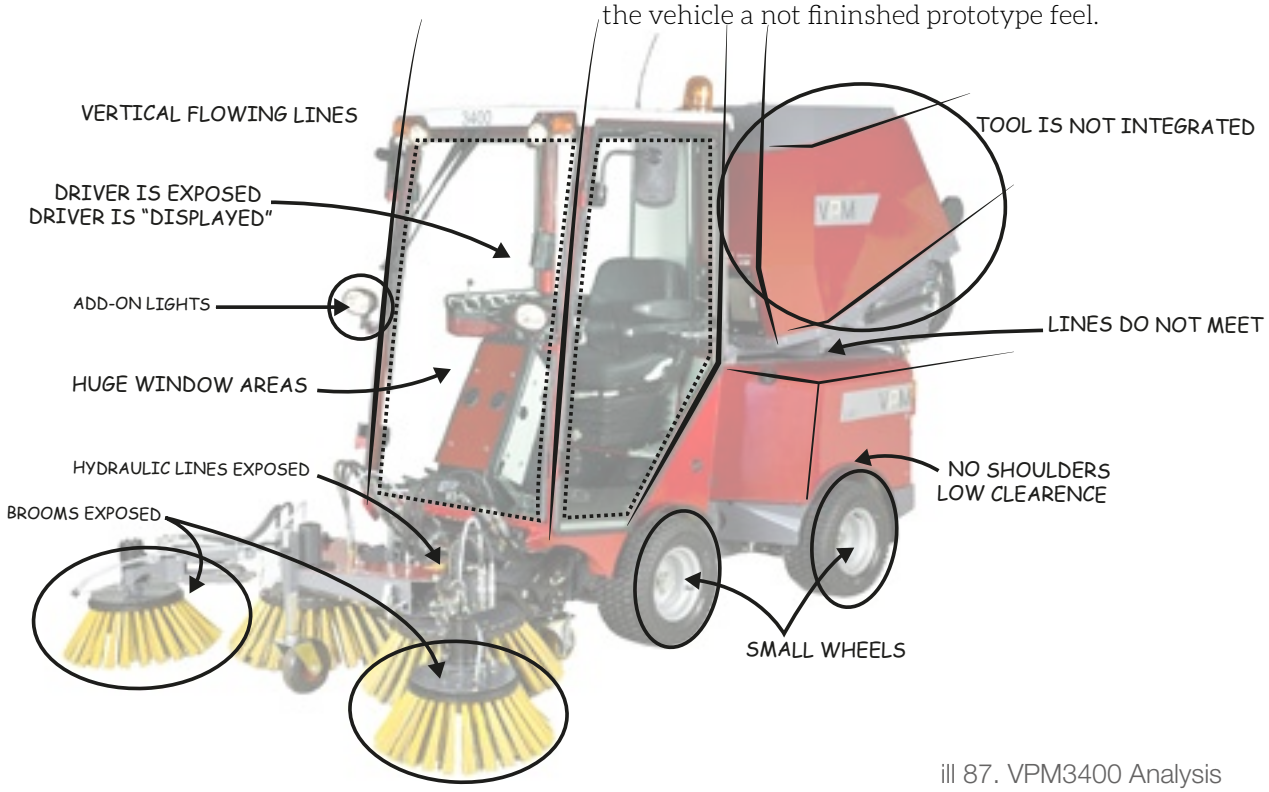
Horizontal lines
Both vehicles was dominated by long sloaping horizontal lines, giving the impression of forward movement.
When looking at the VPM 3400 ill 87. it becomes clear that this is the exact opposite of the tool-carrier's vertical flowing lines that practically brings it to a stand still.

Glass Area
The glass area is another feature that differs. On the Range Rover and the rhino concept, the windows are narrow and tinted in a dark colour. this gives a proctective apperance, shielding the driver. The exact opposite is the case with the VPM 3400. With its large windows it almost displays the driver.

Wheel size and wheel arches
The wheel sizes also differ a lot between the vehicles. The larger wheels placed in bulky wheel arches gives the Range Rover and the Rhino concept a much more masculin appearance, with a assumption that they can climb any obsticle.
The small wheels and non existing shoulders of the VPM 3400 gives it a toycar appearance, and makes it more a tool than a vehicle.

Chamfers and airscoops
Chamfers are widely used in the Range Rover and rhino aesthetics. They emphasize the horizontal lines, and gives a more bulky apperance signaling weight and strenght.
Cupled with airscoops, the vehicles radiate performance.
Chamfers are also used on the VPM 3400 however they emphasize the vertical lines, slowing down the vehicle.

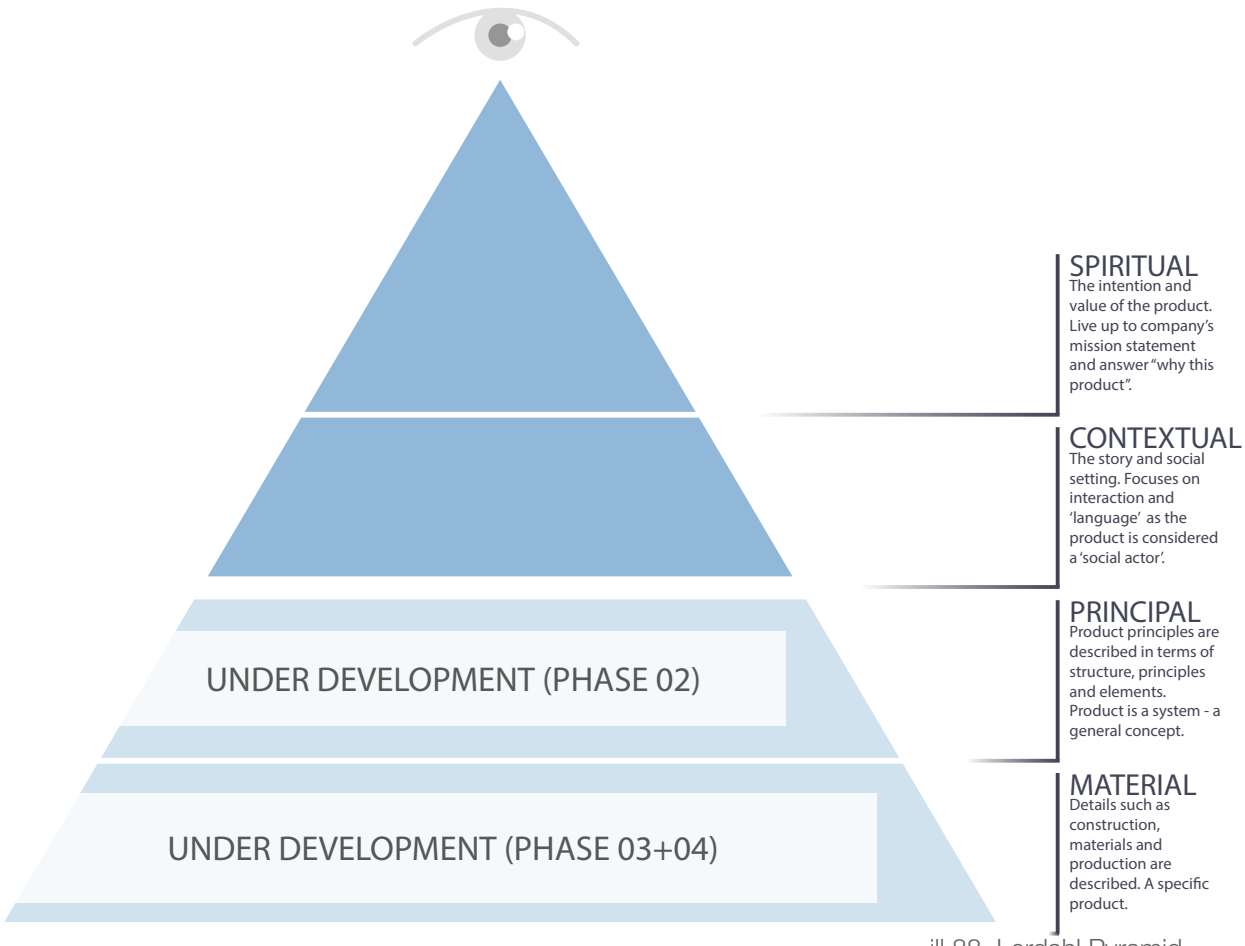
Integration of elements
The rhino and the Range Rover both work with integration of lights and other elements in their overall design. The VPM 3400 has a lot of add on parts not integrated in the design such as the headlights, and hydraulic lines. It gives the vehicle a not fininshed prototype feel.



ill 87. VPM3400 Analysis

FRAMING

UTILIZING THE LERDAHL PYRAMID



ill 88. Lerdahl Pyramid

In order to frame the project the team has been using the Lerdahl pyramid TOLLESTRUP, C. (2004) and is a this stage ready to lock down the first two stages.
The first two stages is abstract in their nature, the spiritual stage describes the intention and the value of the product and can be condensed to "why this product". This value was deduced during the actor visits and interviews with the drivers.
The second level, the contextual level, describes the interaction of the product. The product is considered a social actor and this level focuses on how the product interacts and integrates in it surroundings.
This level is based upon the drivers reaction to the identities of the initial concepts.
The last two levels becomes more materialistic and concrete. They explain how to achieve the spiritual and contextual levels. Based uppon the analysis of the rhino concept, and the located functional issues, the project team can produce an initial level of principals for the design - however the ideation phase is meant for elaborating and testing out these initial pricipals and condense them to more tangible demands, enabling the team to proceed to the final phases of development.

SPIRITUAL - VALUE MISSION

“ Have your confidence reinvented as you can now face the crowds with the Rhino tool-carrier - a machine designed to push forward, securely and effortlessly, despite any obsticle.

CONTEXTUAL - INTERACTION VISION

“ The rhino charges through the street only held back by its rider. With the beast tamed, cleaning the street becomes childs play, and the job is done before you know it.
People will look with awe and respect as this beast devours the filthy trash contaminating their streets.

ill 89. Rhino identity

DESIGN GUIDELINES

EXTERIOR
- Sufficient visibility when reversing
- Clear visibility to front tool
- Clear visibility to suction head under cab
- Adjustable control surfaces for users in all sizes
- Reduce external obstructive parts

INTERIOR
Optimized for sweeping jobs
- Ergonomically placed controlls
- Intuitive layout
- Easy control of vehicle and tools
- Easy communication of machine data (e.g. screen)
- (visible warnings lights w/ audio - Timan)

AESTETICH FEATURES
- Horizontal floating lines
- Heavy and rugged appearance
- Front focusing on the trash by tilting forward
- Integration of features such as lighting, antennas etc.
- Use of chamfers and big wheels to inspire masculin feel
- Broad wheel arches with high wheel clearence.

EMOTIONAL VALUE
- Give the feeling of power, comfort and hightech
- Ride the beast
- Radiate performance
- Inspire confidence and reduce insecurity

02 | IDEATION & SELECTION

THE IDEATION PHASE

SPLITTING INTO TWO TRACKS

Having established that that the primary areas of focus revolves around creating a feeling of confidence and security while using the vehicle, the design team splits up the ideation phase into two track.
One is the ideation of the exterior of the vehicle. This contains the process of integrating solutions to the primary technical issues with the overall identity of the vehicle.
The second track revolves around the interior of the vehicle. The complex interaction was one the key issues in the creation of insecurity and thereby is an important factor in the design of the new vehicle.

IDEATION TOOLS

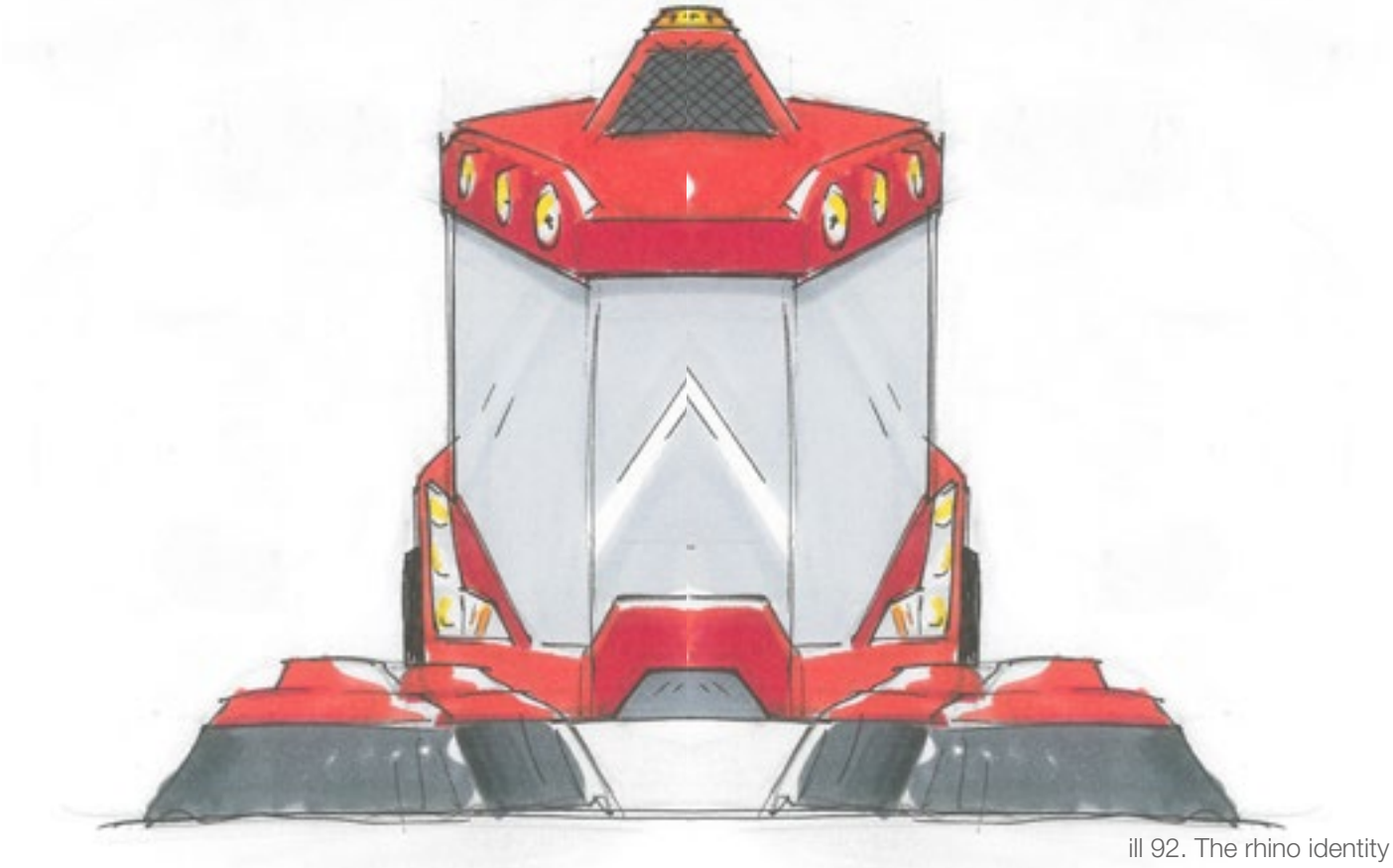
The nature of the project and the scale of the product opened up for a very hands on aproach to the ideation. Through out the process the design team has been in a constant itteration between pen and paper and a modular physical mockup in scale 1:1. This enabled the design team to bodystorm and test theoretical solution in real life. This has been crucial throughout the project since its hard to get a spacial and ergonomic understanding from a two dimensional sketch.
The modular natur of the mockup made it possible to quickly alter its configuration to test out features and aesthetical properties.
These experiences was then condenced to more tangible requirements used in the finalizing stages of product development.

ill 90. Mockup assembly

ill 91. Mockup assembly

FORWARDS VISIBILITY

PLACEMENT OF COLOUMS AND ROOF ANGLE



ill 92. The rhino identity

ill 93. Tilting coloums

ill 94. Narowing from top

ill 95. Normal window

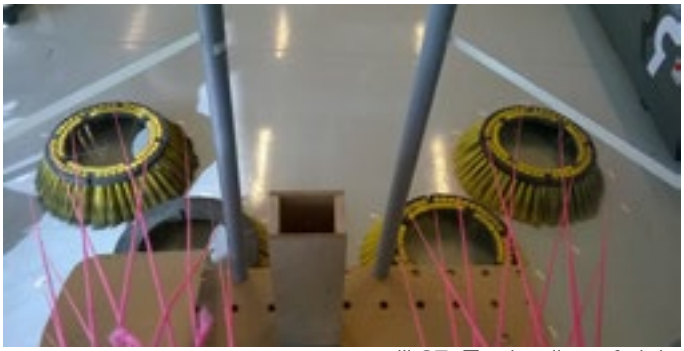
Even though the identity of the vehicle has been established, the project team needs to integrate solutions to issues of a more functional nature. One of the primary issues repported by the drivers was limited visibility from the cabin. When sweeping visibility to the brooms and the curb is very important. Further more good overall visibility is wanted when driving through traffic. However the solution should still provide the protective appearance and feel deduced from the originial rhino concept and the Range Rover.

The design team wants to eliminate obstructive elements in the line of sight to both the tools and the curb while preserving the rhino identity ill 92.

To control the process the design team has chosen to say that the windows can only be bend in one direction and not be double curved, as this was the production capability of Timan A/S

MOCKUP TEST

ill 96. Testing line of sight



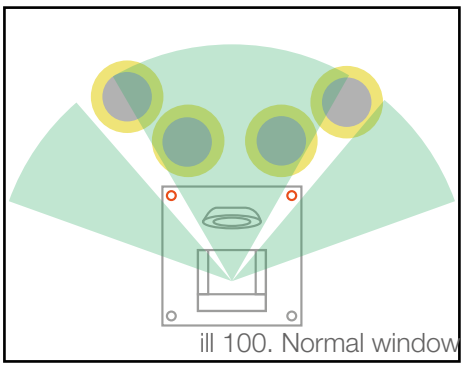
ill 97. Testing line of sight

ill 98. Testing roof angle

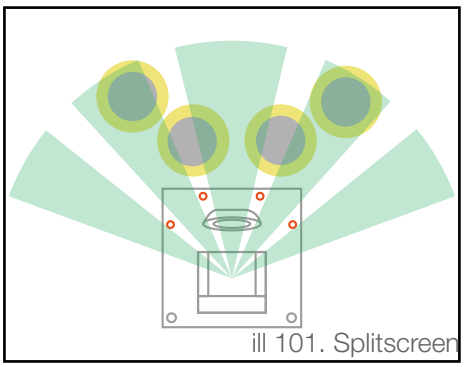
ill 99. Roof angle

Placement of the coloums supporting the roof and the class was an important step in creating good visibility. Through testing using the 1:1 mockup the design team decided to use a split window shown in ill 101. This provided good visibilty to the outer edges of the brooms which is important when trying to follow a curb. The solution shown in ill 102. also provided god visibility however it requried a large window panel that would deviate from the wanted aestetics and be more costly to manufacture, and change if broken.

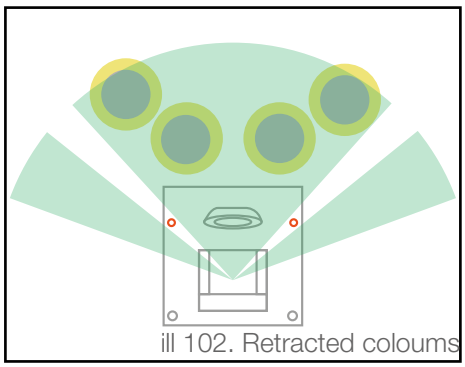
When driving a tool-carrier you not only focus on the tools, but also on the traffic and conditions arround you. Therefore the driver has to be able to see elements such as traffic lights, road signs and the traffic in front of the vehicle.
A valid concern of the drivers was the sloaping roof of the original rhino concept would hinder this visibility. The sloaping roof is an important part of the aesthetics as it gives the vehicle its charging appearence, and using the mockup the team was able to establish how much the roof could be lowered before hindering the line of sight.



ill 100. Normal window



ill 101. Splitscreen

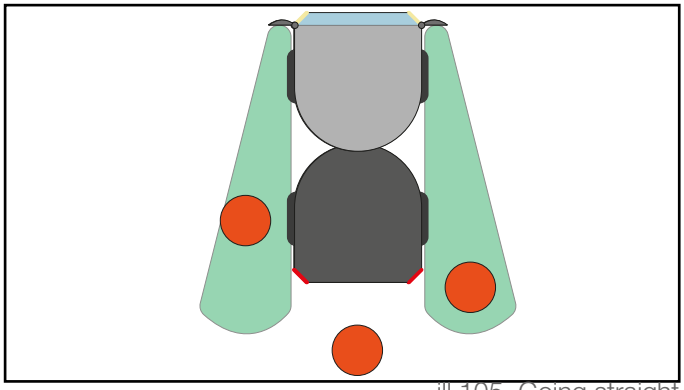


ill 102. Retracted coloums

REARWARDS VISIBILITY

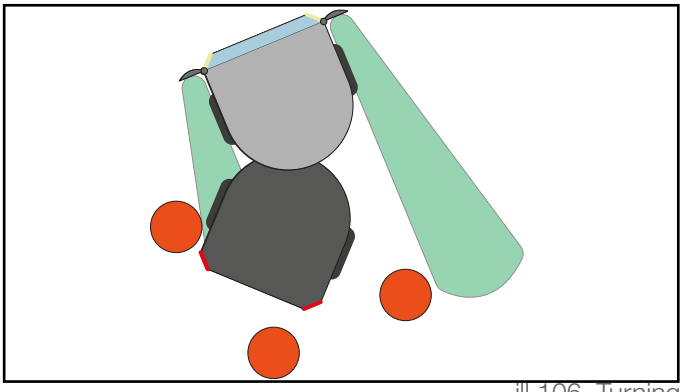
CHALLENGES OF ARTICULATED STEARING

ill 103. Blind spot



ill 105. Going straight

ill 104. Blindspot



ill 106. Turning

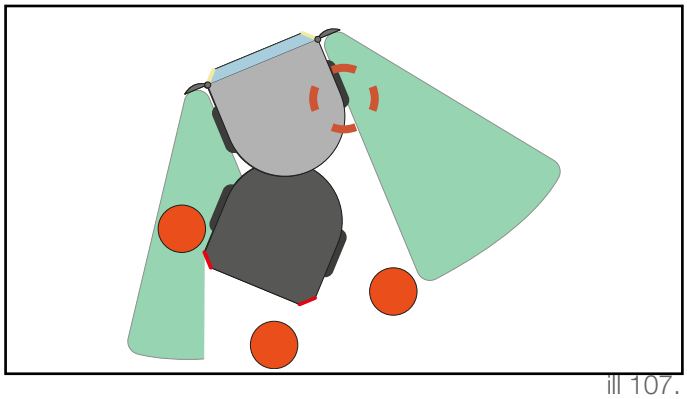
Turning the attention to the rearwards visibility, one of the biggest problems with articulated steering becomes apparant. When driving straight, traditional mirrors works just fine and gives the same visibility as driving a car for instance. However the slightest adjustment of the steering changes the angle of the front relative to the rear of the vehicle and that makes the mirrors pretty much useless.
The one mirror points directly into the side of the vehicle and the other points away from the vehicle leaving several dangerous blindspots for the driver as seen on ill 103 to 106.
Furtermore the wastetank on the back of the vehicle makes the use of rear windows insufficient
This issue alone bears a big responsibility for the drivers insecurity while driving the vehicle. When driving around obsticles such as lamp posts and road signs the driver has virtually no idea what is going on behind him. This has given some very unfortunate situations where drivers has turned in front of cyclist and runners making for a very unpleasant experience.

Therefore this issue is of high priority for the design team. As seen on ill 105. the problem arises with objects directly behind the vehicle, and to the sides of the rear body.
In terms of solutions the design team searched different technologies. The nature of the problem makes a mirror based solution imposible, so the team turned to elctronics. First thought was the use of proximity sensors giving a warning if anythin was located in the blind spots. However a quick talk with the drivers of Aalborg municipality revealed this idea to be insufficient. The problem arised in trusting a sensor to handle something this important. The drivers would prefer to have visual contact with the blindspots. This lead the design team to the use of cameras. Using cameras in combination with a screen as mirrors is becoming more popular in the automotive industri CNBC (2014). A series of concepts was created an analysed for the best solution.

SOLUTION PROPOSALS

WIDE ANGLE MIRRORS

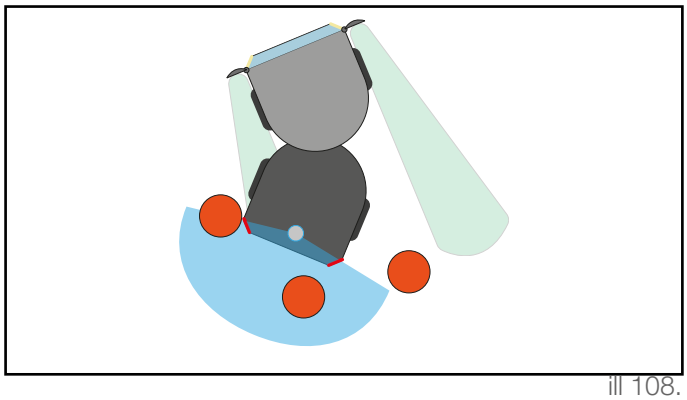
The nature of the vehicle movement make the use of mirrors impossible as there will alway be a blindspot next to the rear on the outside turn as shown on ill 107, due to the front cabin bloking of the view.
If a mirrorbased solution should work, it would require the mirror to be extended unreasonobly far out from the body of the vehicle, making it to wide and worsening the issue of external parts hitting object.



ill 107.

1 CAMERAS

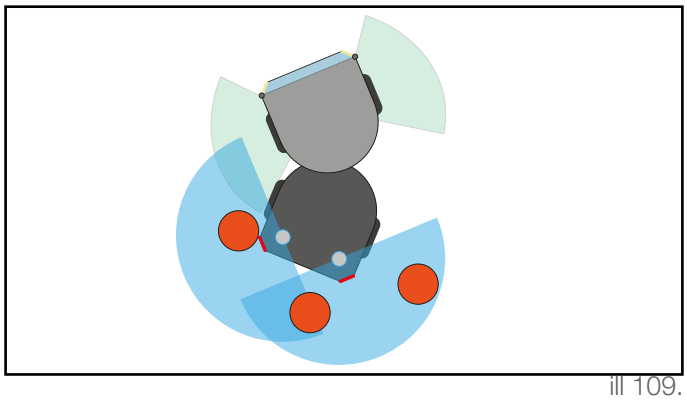
Having just one camera facing the rear isnt sufficient for covering the blindspots of the vehicle
As seen the mirror provide very litte coverage, and it is decided to completely remove them at this point and rely on cameras and visibility from the cabin alone.



ill 108.

2 CAMERAS

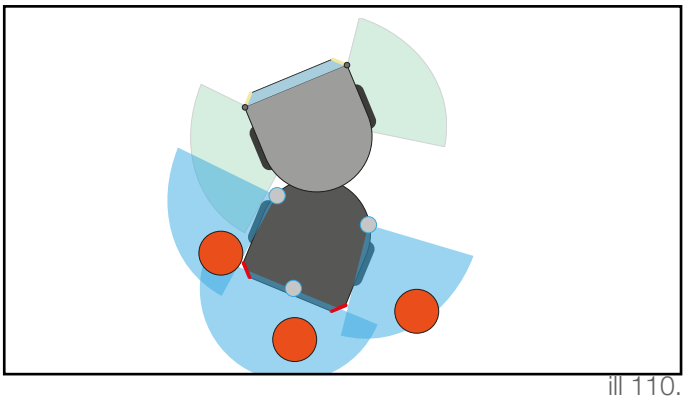
The use of two wide angle cameras mounted on the top of the vehicle looking backwards in a 45 degree angle could be a viable solution. However the combination of the to video feeds to create a view directly backwards would be impractical due to image distortion of wideangle cameras.



ill 109.

3 CAMERAS

The final concept uses 3 cameras in combination. One facing rearwards and two located ahead on the rearpart of the vehicle looking rearwards. This combination provides a good coverage and only leaves a small blindspot. The feed from the cameras are easely displayed using 3 screens. One central functioning as a tradition rearview mirror displaying the camera feed from the back. The two aditional screens function as sideview mirrors and display the feed from the side cameras.



ill 110.

REVERSING USING A CAMERA

ill 111. Reversing through opsticle

ill 112. Using an ipad as reverse screen

ill 113. Mouting of GoPro camera

ill 114. Camera view

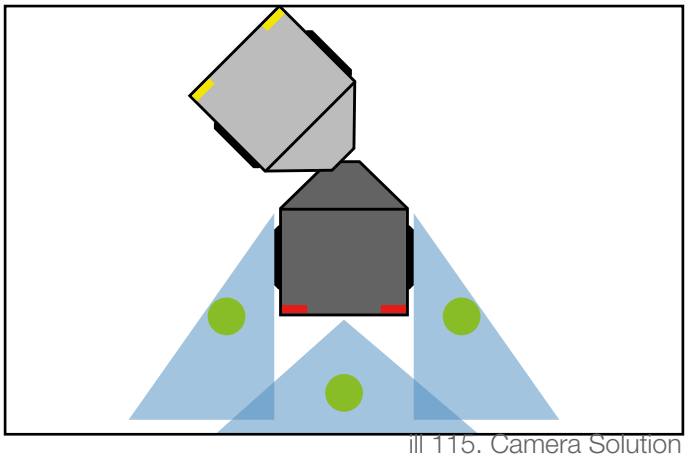
Following the theoretical ideation, the project team utilized the availabilty of a VPM 3400 to test out the deduced camera angles, and bodystorm the experience of reversing using the camera. A GoPro camera was strapped to a simulated waste tank and an ipad showing the GoPro feed functioned as the intended screen. The members of the design team has no prior experience in driving a articulated vehicle and deemed the test to be real world applicable in relation to learning new users the system. Using the ipad as a rearview mirror worked suprisingly well and both members of the design team was able to reverse the vehicle between a narrow opening using only the feed from the ipad. The GoPro was placed at the shown positions in ill 113. However the team found it the easiest when the camera was mounted up high looking down and getting a part of the vehicle in the picture as well. This made it much easier to determine distance from the vehicle to the obsticle. Unfortunately it would be impractical to place the cameras on the wastetank as this unit has to be able to come of when using different tools.

The team then tried lower positions fitting the camera to the engine shields. While not as good as the higher position the view still made it easy to reverse the vehicle and keep a sufficient overview avoiding blind spots.

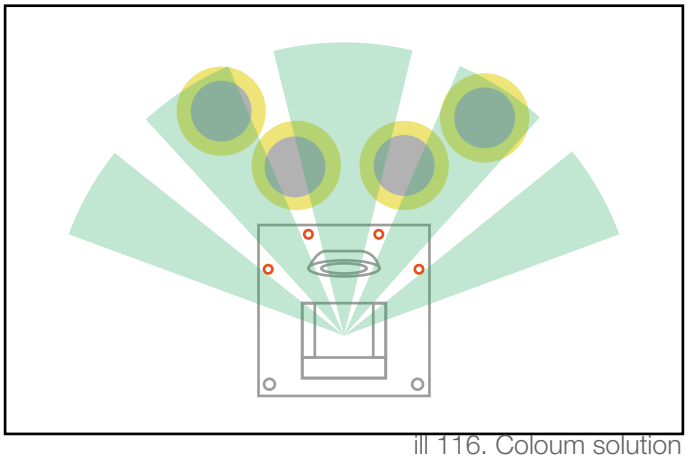
PART CONCLUSION

VISIBILITY REQUERIMENTS

Having had an initial ideation round regarding the integration of good visibility both forwards and rearwards with the wanted vehicle identity, the design team can now set up more tangible requriements for ussage in the detailing phase.



ill 115. Camera Solution



ill 116. Coloum solution

DEDUCED REQUERIMENTS

FORWARD VISIBILITY

- A splitscreen front is wanted for best tool visibility
- The roof lining of the vehicle should not drop lower than 5cm above eyehight of the driver

REARWARD VISIBILITY

- Is created using cameras with accompanieng screens
- Consist of one camera mounted on the rear and two cameras mounted on the sides
- The cameras should be mounted on the lower tail section

DESIGNING THE CABIN

DRIVER INTIMACY

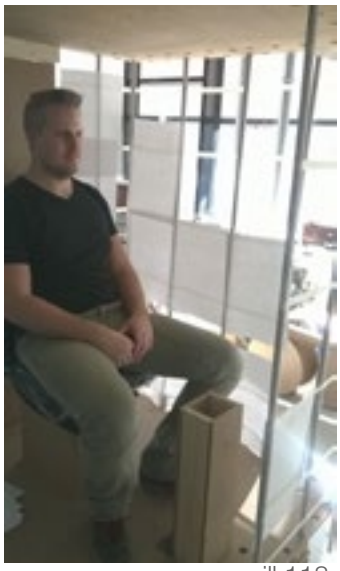
Having established how to solve the issues of visibility, attention turned to the rest of the cabin. Through the aesthetic analysis of the rhino concept and the range rover the design team had deduced that the cabin should provide a protective feel for the driver. In an atempt to determine how the paneling of the cabin could create this feeling, the mockup was configured for a intimacy test. The design team and other students then sat in mockup and used sheets of paper to create their wanted intimacy as shown on ill 117-118.

The conclusion was that the test persons wanted to be shielded from the back, and partially from the sides. This goes well in tune with the general rule that people doesent like to be watched from the back.

Having established these guidelines the design team continued to test how to achieve this covering of the back, and sides without affecting the visibility from the cabin.

In terms of rear cover, the team tried foward sloping cover as seen in ill 119. and rearward sloaping cover as seen in ill 120. Both solution provided acceptable side visibility in eyehight however the rearward sloap covered to much of the buttom and hindered visibility to the curb. The forward sloap did not have this problem and furthermore lined up with the windows emphasizing the forward momentum wanted. In terms of covering the sides, the team needed to prioritize. From the test persons point of view, the sides should be covered pretty extensively. This lead to the concept shown in ill 121. However this solution did not provide the wanted visibilty to the curb.

ill 117.



ill 118.

Knowing the importance of the visibility the team chose to prioritise this. In the sideview curb visibility, and the trafic visibility in eyehight is wanted, therefor the team experimented in using partial sidecovering as shown in ill 122 -123. This solution proved to provide a good blend of visibility and protective feel, and was chosen for further development.

ill 119.

ill 120.

ill 121.

ill 122.

ill 123.

SPACIOUS FEEL

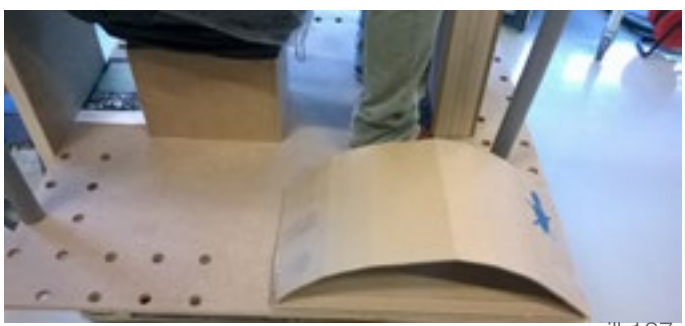
ill 124. Outward tilting sides

ill 125. Inward tilting sides

ill 126. Straight sides

Having focused on the exterior of the vehicle, the team focused on the interior.
Another wanted feature was a spacious feel in the cabin to counteract the "monkey in a cage" experience.
Having locked down the forward tilting front window, the design team looked at the tilt of the sides. The design should express masculinity and stability, and the inward tilted sides shown in ill 125. was deemed to provide this expression. However the spacious feel of the cabin became very cramped with the sides falling in on you. The best spacious feel was provided by tilting the sides outwards as shown in ill 124. But this seemed to make the whole cabin seem unstable, and top heavy.

Having the sides completely vertical proved to provide the best of two world ill. 126. The spacious feel was only minor affected, and the base of the vehicle remained the dominant and most heavy part, fulfilling the wanted masculin and stable expression.
Another big part of the cabin space was the integration of the wheel arch.
As this feature was to be determined later on by its functional nature, the team couldn't lock its position down just yet, but concluded that a position beneath the seat was wanted as it gave more room to the feets and legs thus gave a more roomie feel of the cabin.
This wish was noted for the detailing phase.



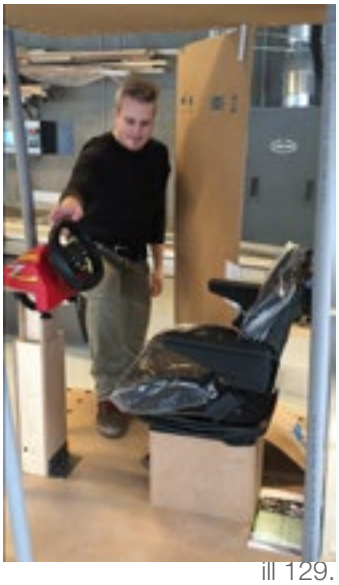
ill 127.

ill 128.

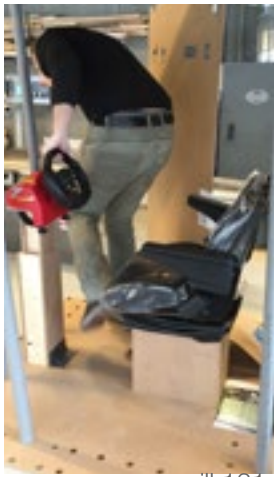
GETTING IN AND OUT

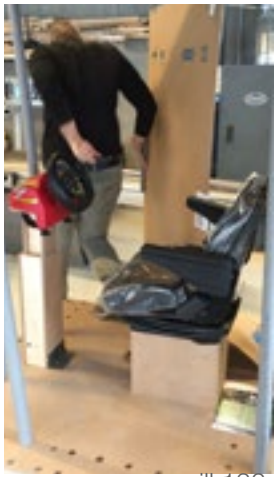
TRADITIONAL VS. SUICIDE DOORS

Not a direct user inspired issue, however still a big part of the vehicle - the getting in and out is analyzed by the design team.
A pleasant and easy entering and exiting of the vehicle is wanted since the driver often get in and out multiple times during a day. Due to the vehicles construction and need of space for a vacuum-hose and a suction head the floor height is a challenging 50cm. This makes for a high step when entering and exiting. The design team quickly concluded that a step was wanted to ease the entering.
However the models that the design team had tried out during the research all had normal doors with entering from the rear as shown in ill 130. The design team found that this oriented the body in a awkward position when entering, and combined with the high floor made for a straining experience. The design team wanted to try utilizing the so called suicide door principle where the doors open from the rear as shown in ill 129. This way of entering oriented the body for a more direct and less awkward entering of the vehicle. Instead of "climbing" in as with the traditional doors, the driver can utilize a swinging motion keeping a hand on the steering whel for support.
The suicide doors also proved superior when exiting the vehicle. The driver is able to climb directly out of the vehicle as shown on ill 131-132. With the traditional door the driver has to get up from the seat climb past the seat and turn the body towards the door opening before climbing out. This involves more steps, takes more time, and makes for a more unpleasant experience ill. 133-135.


ill 129.


ill 130.


ill 131.


ill 132.


ill 133.


ill 134.


ill 135.

PART CONCLUSION

CABIN FEATURES

Analyzing and ideating on the front cabin had provided the team with a more tangible set of requirements for the final shape of the vehicle.
One of the more interesting conclusions was the effects of using a mid section cover. Providing the driver with an increased amount of intimacy without compromising the visibility from the cabin was a very important goal for the design team. Using this small cover had greatly improved this, and also opened up for the posibility for using the part for integrating lighting and door handles due to its position.

DEDUCED REQUERIMENTS

ENTERING/EXITING THE VEHICLE

- Suicide doors hinged at the back of the cabin should be used.
- Steering wheel functions as support when entering and exiting.
- A step should be incoorporated in the design to ease the entering.

CABIN EXTERIOR

- Cabin should have a covered rear.
- The rear cover shall extend onto the sides utilizing a forward leaning angle matching the front window.
- A mid section cover shall extend from the front glass towards the rear and cover the torso of the driver.
- The sides of the vehicle shall be vertical
- If possible the front wheel arch shall be integrated in the seating console to provide more legroom.

INTEGRATING REQUIREMENTS

IDENTITY VS. REALITY

Through the hands on ideation and testing the design team had established the needed requriements to bring the original rhino comcept towards a more finalized concept, Ill 137 shows the first iteration of requirement integration. The overall lines are preserved, however the vehicle is now articulated, and has integrated the mid section cover in the cabin, along with the split front windows. The design team realized that the vehicle was stretched a bit to much as the rhino is a more compact and dense creature. The hump on the back was also impractical to place in the midle of the articulation joint.

Iteration two ill 138 shows a more condenced version of the first iteration. The rear cover has been pulled further forward and tilted to match the front window and the hump has be moved forward onto the front cabin.

The mid section cover however was deemed too short and did not create the proper foward flowing lines. The fenders of the rear wheel was also hugging the wheel too much in relation to the original concept creating a more static appearence.

The third and final iteration ill 139 has kept the condenced appearance but has a longer mid section cover with a more agressive line. This in combination with the now more flowing and elevated rear fender was deemed to fit togehter nicely with the original concept.

The team now believed to have a concept close to ready for taking further to the system and detailing phases. However as the vehicle is very much designed with the users in mind, the team decided to revisit the drivers at the entreprenurial deparment of Aalborg municipality.

ill 136.

ill 137.

ill 138.

ill 139.

HOW AGGRESSIVE?

RETURNING TO THE USER

The design team was in doubt if the final concept was to agressive for the drivers, and prior to presentation the team decided to produce two more neutral concept in order to get a understanding of where in the spectre the rhino expression should lie.
The first descaled concept shown in ill 141 had its window tilted back to vertical, and was given a less agressive colour. Furthermore the team created a less massive wastetank only utilizing contrast colour along the edges.
The second concept in ill 142 was even more descaled by not only tilting the window back but also removing the sloaping roofline.
The same approach was utilised in the waste tank as with the previous concept. A neutral earthly colour was chosen to limit the last part of agressive appearance.

The visit was enitiated with the design team laying out the three concepts without saying anything about which concept actually derived from the rhino concept they previously had chosen.
The reaction was very fast an determined, every present driver immidiately chose the most agressive concept ill 140. Statements as “the other ones are to boring”, “that radiates performance” and “i want to drive that now!” was filling the room.
This gave the design team an indication that the agressive concept not only carried the wanted values and expresions with it from the original rhino concept, but the integration of the functional solutions hadn’t made it too passive.
Even the concern about forwards visibility was reduced as the drivers didnt se a problem in the now more limited sloaping roof.
The only concern from one of the drivers was that the vehicle might look “too good” and attract unwanted attention. When asked if it was him who didnt like to attract attention the answer was no, he was more concerned that the vehicle would be stolen if he had to leave it in the public. This was of course a valid concern, however the design team chose to disregard it and concluded that the concept was ready for detailing and CAD modeling.

ill 140.

ill 141.

ill 142.

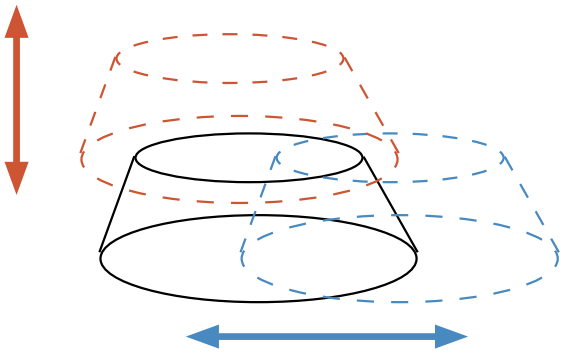
MAPPING OF TOOL INTERACTION

VIDEO SHADOWING

ill 143. Sweeping Jomfru ane gade

ill 144. Sweeping Aalborg East

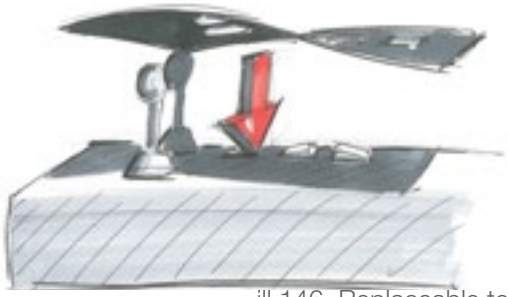
Having looked at the exterior and interior of the vehicle, it was now time to focus attention on the interaction with the vehicle. From the research phase the design team already knew that this was an area in need of improvement, if the value and interaction mission should be succesfull.
The team wanted to make the use of the machine, and in particular the tools easier to understand and manage. In order to do this an understanding of how the vehicles where used, and what functions where use the most, was necessary. The team decided that instead of simply asking the drivers how they did their job, shadowing would be a better alternative. There is a difference between what people say the do, and what they actualy do POULSEN, B., S. (2008).
So a driver from both Aalborg municipality and Himmerland housing society was kind enough and willing to wear a head mounted GoPro camera during their idividual task. The footage provided would then be analyzed by the design team. Footage can be found on supplied USB drive named APPENDIX B.
Going through the footage revealed that the drivers actualy didnt use the tool controls as much as anticipated. Of course the controls where used at the start of the task to enable the brooms and the suction, however during the task very little adjustment of the tools happened. This was the case for both drivers.
When the tool was adjusted it was primarily adjustment of the brooms from side to side, and raising/lowering of the brooms. This proved to the team that the control of the brooms themselves was primary tool interaction, and should accomodate up/down and side to side movement.
Besides this, the actual procedure of starting and stopping



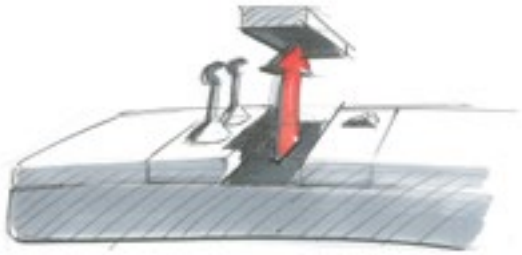
ill 145. Adjustment of the brooms up/down and from side to side prooved to be the most used adjustments

the tools was the second most important interface feature. It was clear from the research face that these exact functions often were controled by unlabled buttons and joysticks and could not be operated if you didn't have prior knowledge as they weren't self explanatory. In some vehicles the buttons and semiotics actualy refered to the vehicle engineering instead of the actual job the switch performed. An example was a switch that both in the vehicle manual, and in the semiotics refered to it reversing the polarity of a 12v plug. The actual job it did was to reverse the spinning direction of the front brooms. It was no wonder that the interface seemed frightening.
The team decided that finding a solution to make control of the tools easier and improve the ease of the startup sequense, should be part of the ideation.

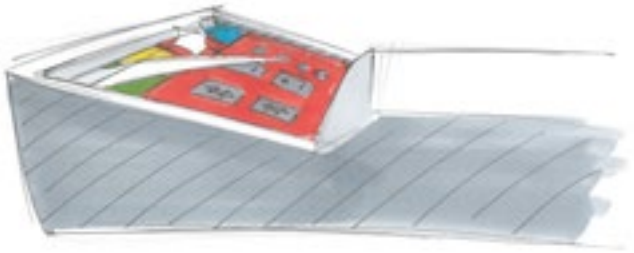
CONCEPT SOLUTIONS



ill 146. Replaceable template



ill 147. Replaceable buttons



ill 148. Touch screen

ill 149. Prioritised buttons

Knowing that the tool interface should be able to control different tools, the need for customization was apparent. Through an ideation round the team came up with the four interaction principles above supporting some way of customization.

The first solution shown i ill 146 was a lowkey solution where the users could replace a button explanation according to the tool used. The solution was deemed viable however tidous to use, and the risk of loosing the different templates in time was apparent. The next solution was a modular interface shown in ill 147. Here the users could change the different buttons acording to the tool in use and personal preference. Even though the solution held potential it was discarted on the same parameters as the first concept. Too tedious to use and would most likely be configured one time, and then stay that way. Having to use time finding and changing buttons as well as tools didn't seem that intuitive.

The third concept shown in ill 149 was the usage of a prioritized button layout. This meaning that the primary function, in our case the city sweeping, would have the best button layout. The secondary tasks would then be included however not as intuitively or well placed as the primary controls. The concept was partly accepted due to the fact that having primary hard buttons offering tactile feedback for the primary tasks didn't only seem as a good idea, it was also requested by the drivers.

However compromising on the control of secondary functions wasn't an option as this was one of the present issues with the existing interfaces. This lead to the fourth and final concept shown in ill 148 - a touchscreen interface. However it should be combined with the hard buttons for the primary fucntions.

This way the screens and function could easily be configured to support the individual tools the best. It could even be configure to change automaticaly if the system could detect which tool was attached, and thereby always show the user the relevant controls, and only those.

DEDUCED REQUERIMENTS

TOOL CONTROLS

- Primary tool control should utilise tangible buttons
- Secondary tool control and vehicle configuration should utilise a touch screen
- Primary tool controls should be within fingers reach when opperating the vehicle
- Secondary configurations should be within arms reach

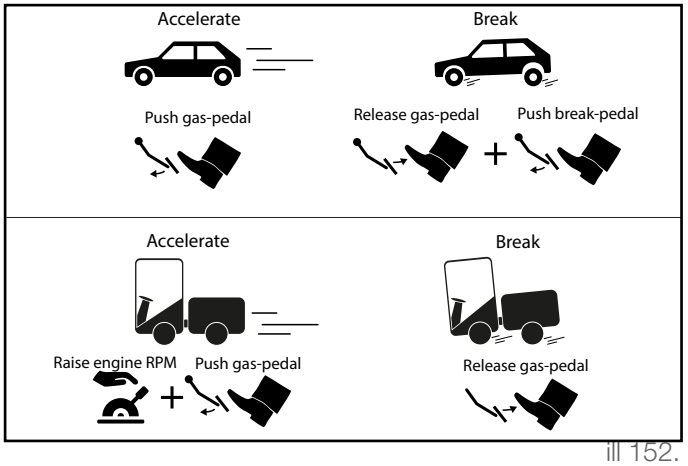
DRIVING A TOOL-CARRIER

BODY STORMING

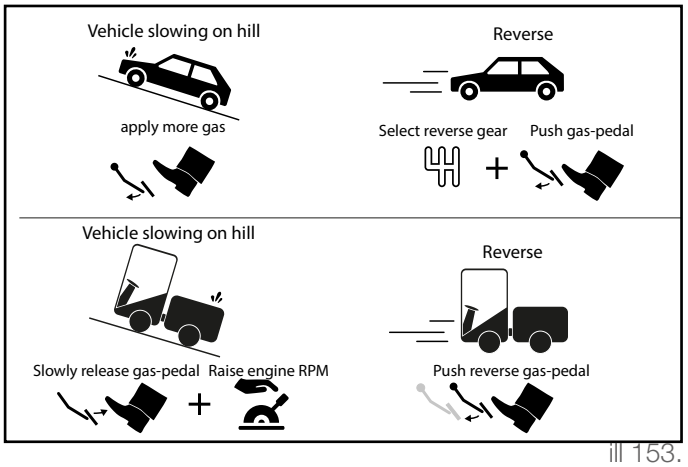
ill 150.

ill 151.

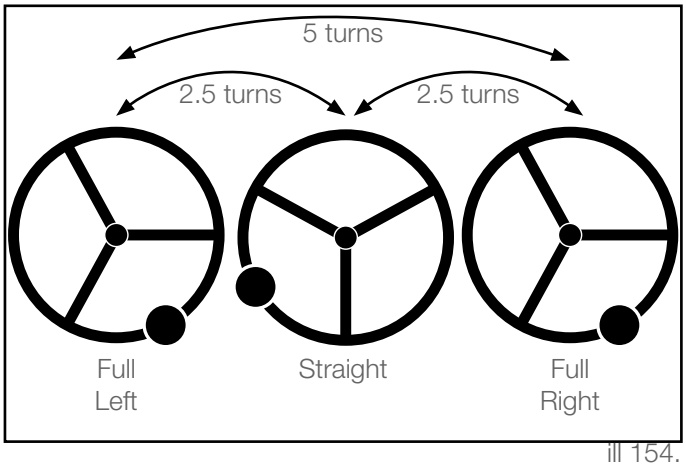
Besides controlling the tools the team wanted to have a look at how to control the vehicle it self. For that purpose Timan A/S was kind enough to supply a VPM 3400 for testing. Driving a tool-carrier requries either a tractor license or a traditional car drivers license. All of the interviewed drivers all had a car drivers licence, and not a tractor driving license. This is a bit problematic as a tool-carier with its hydrostatic drive is more similar to a tractor than a car. The team found some of the same basic functions that were known from the car, acted differently on the tool-carrier. This was related both to forward driving and reversing where the nature of the hydrostatic drive made the vehicle handle differently as seen in ill 152-153.
Furthermore the team discovered that the steering had an enormous range with 2.5 turns from side to side as shown in ill 154. This made it very easy to finetune the path you were driving, however when turning tight corners and turning the vehicle around the steering became very tedious and disconnected you from the vehicle as you had to wrestle around with the steering wheel. Video footage showing this can be found on the suplies USB driver named APPENDIX C. The team decided that both the forward/rearward controls and the steering could be improved and took it further in the ideation.



ill 152.



ill 153.



ill 154.

DRIVING CONTROLS

DIFFERENT CONTROL UNITS

As the current setup of steering wheel and pedals used in most tool-carriers didn't behave and relate directly to controls of a car, the team wanted to challenge the use of these controls. If the control of forward/backwards motion and left/right steering could be combined it could save valuable cabin space, and might even be more intuitive than the traditional steering. The design team chose to set up a test utilizing the software Farming Simulator 2015.
A simulation was set up where the test person would have to harvest a field, the closest to cleaning a street the software could do, using different control units.
A traditional steering wheel with pedals was the first setup. A series of test persons was asked to do the exercise without any prior knowledge to how the controls worked. Most of the test persons was able to establish a familiarity with the controls, both pedals and steering wheel, very quickly. The harvesting task then seemed easy for the test persons.
The next test involved the same task. However now the steeringwheel and pedals was replaced with a joystick. Pushing forward would accelerate the vehicle. Pulling back would slow the vehicle, and side to side movement would steer the vehicle. The task was initiated and it immediately became clear that the test persons struggled with the new control unit. Having forward/backwards movement in the same control unit confused the test persons and resulted in unwanted manouvers.
After some time the test persons became more familiar with the joystick, however the task wasn't solved as efficient as with the steering wheel and pedals.
The conclusion from the test was that the control of movement and steering should be seperated and not controlled by the same unit.
The design team therefore chose to use pedals and steering wheel structure for the further detailing of the vehicle.

ill. 155 - Farming simulator


ill. 156 - Traditional steering


ill. 157 - joystick steering

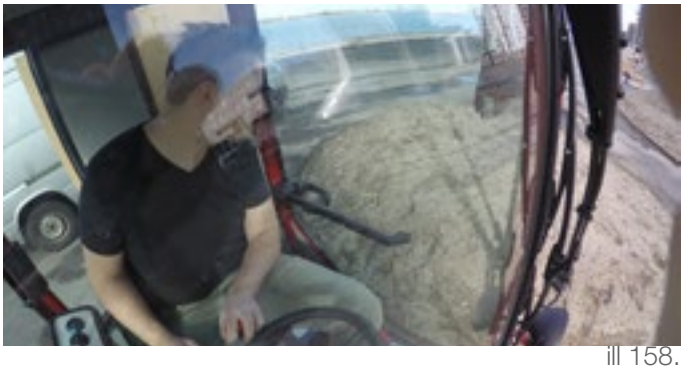
DEDUCED REQUERIMENTS

VEHICLE CONTROLS

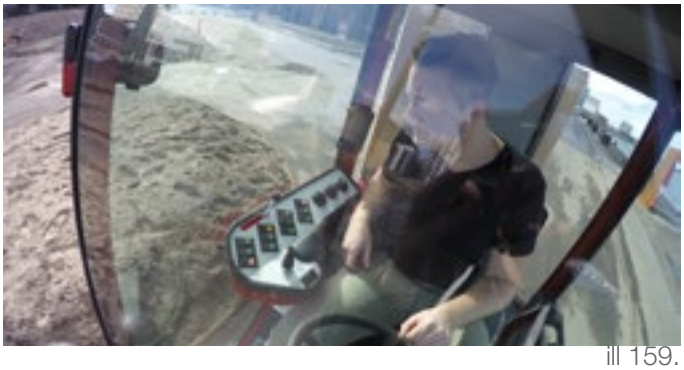
- Forward/backward motion is controled by pedals
- Left/right steering is controled by a wheel structure

ERGONOMIC STUDIES

USING THE VPM 3400 AS A REFERENCE



ill 158.



ill 159.

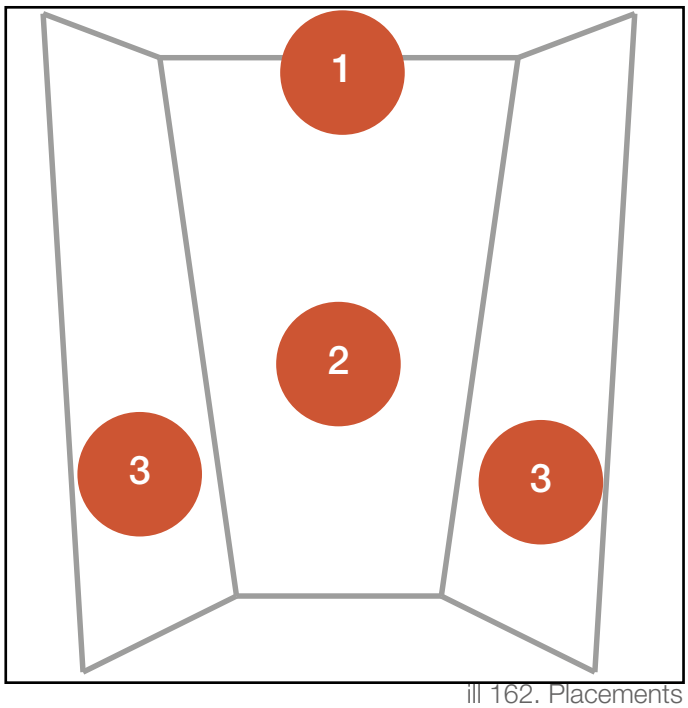
ill 160.

ill 161.

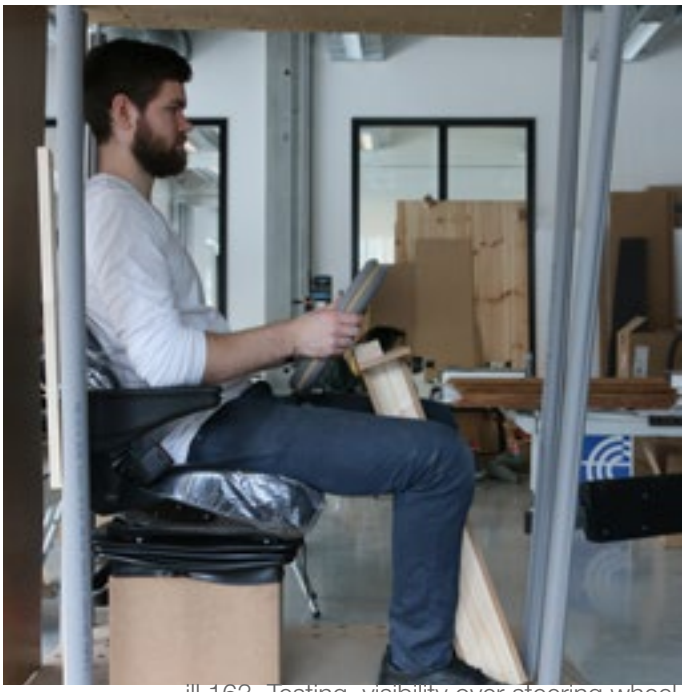
Having established the type of interfaces that should be used for both tool control and vehicle control, the next challenge was the placement of the control surfaces. They shouldnt conflict with view from the cabin, and should still be within reach of the driver.
In order to have a reference a test was set up using the VPM 3400. The test was to follow along a couple of big circles located on the harbour front in Aalborg, simulating a sweeping task. It immidiatly became apparant that the side mounted tool controls of the VPM 3400 actually obstructed view to the side curb when sweeping to the right as shown in ill 159-161. This made it quiet difficult to follow the curb. However the open window to the left allowed good visibility to the curb when sweeping to the left.
This also alerted the design team that the previous approved mid section cover of the cabin couldn't protrude very far into the cabin as it would then obstruct curb visibility.

INTERFACE POSITION

Based on the VPM 3400 test, the design team chose to say that points of interaction should be located away from the sides of the vehicle thereby eliminating position 3 in ill 162. A centered position marked 2 in ill 162. was deemed more viable as long as the driver could look over the controls, and it didn't obstruct visibility through the angled split windows to the brooms.
Position 1, the headlining, was deemed to far away for the controls to be reached with minimum effort. However the position could support the screens intended to fullfill the rearwards visibility issue.



ill 162. Placements


ill 163. Testing visibility over steering wheel

DEDUCED REQUERIMENTS

CONTROL SURFACE POSITION

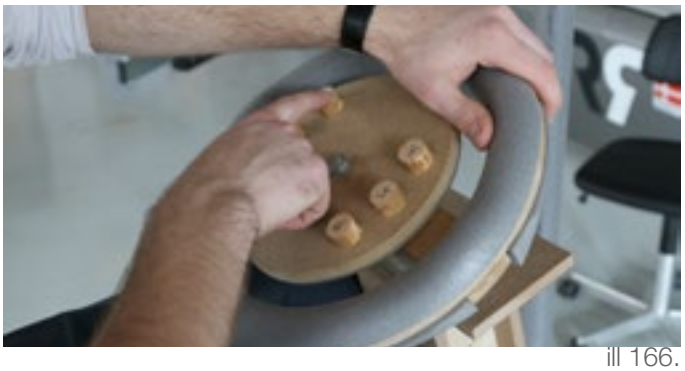
- Both tool controls and vehicle controls should be placed toward the center of the cabin in position 2
- The control surfaces has to be low enough that the driver can easely look over them
- The roof lining should be used for the reverse camera feed.

INTEGRATION

EASY CONTROL ON THE MOVE

ill 164.

ill 165.

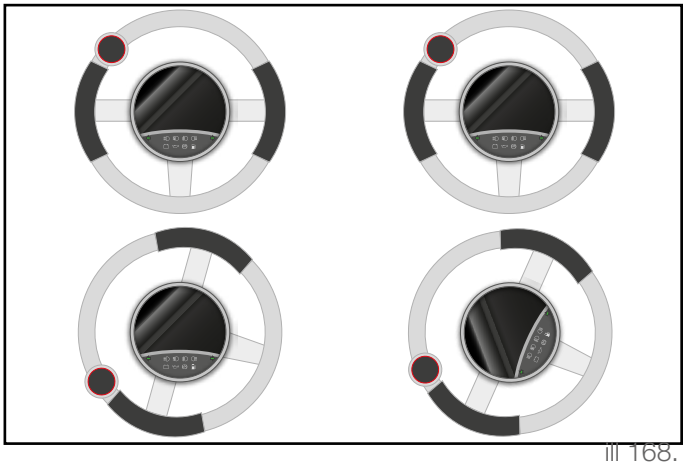


ill 166.

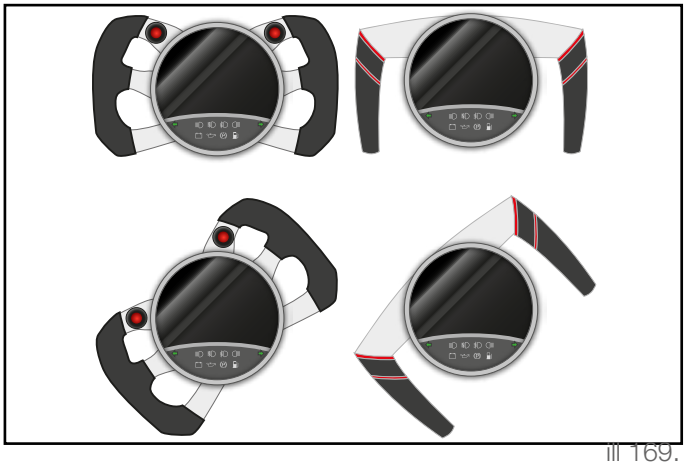
ill 167.

Having established that both the steering and tool control should be located towards the center and operable when driving, the team started to look for inpiration on how to do this. In the automotive world it is common practise to place buttons on the steering wheel for the most used functions. However a dilemma arrises with placing objects on the steering wheel as the wheel naturally turn and then the controls are placed differently. This might not be the biggest problem in a car as one rarely adjusts anything while turning. However the videoshadowing of the drivers revealed that they sometimes adjust the broom mid turn. This might be doeable with controls on the steering wheel, however the design team had decided to use a touch screen for other vehicle and tool opperation. Having this screen turning during driving would become very confusing, and make it extremely difficult to use. The design team looked for inspiration at the car company Citroën. In many years Citroën have used a fixed hub steering wheel in their cars. This has the advantage that the central part of the steering wheel remains stationary while turning the wheel. This would be ideal to use in our case as the touch screen could then be placed central and very much within reach.
A simple test was setup using the mockup where a test person would have to push a numbered button request. One test with the hub fixed and another with the hub following the wheel. It was clear that the fixed hub solution was easiest to opperate.

PROGRESSIVE STEERING



ill 168.



ill 169.

Based uppon the tests regarding the vehicle steering the project team had decided to keep using a tradtional steering wheel as this provided the most reconizable form of steering and would help the users to understand the vehicle faster. The first itteration of the steering wheel with acompaniyng touchscreen is shown in ill 168. The concept is straight forward with the same type of steering wheel as used now coupled with the fixed hub touch screen.
The concept would easely fullfill the current steering requriements, however the tedious experience of this type of steering kept troubeling the design team.
A second iteration was therefore initiated focusing more on the value of the vehicle integrated with the functional requirements of a steering wheel. The thoughts quickly turned to racecars as the charging nature of the rhino concept lay close to that of a sports vehicle. It turned out the race steering actually held a few features that would fit the concept quite well. Race steering wheels are always held with both hands, and cannot be turned more than 180 degrees to either side providing the driver with a very direct and quick steering. This principal seemed to fit very well with the vision for the rhino vehicle. However the project team knew that steering precision was also wanted and when traveling slowly around many obsticles, fast acting steering might not be easy to control. An idea arised at this point to make the steering progressive. The team had established that slow acting steering was great for sweeping but tidious when turning the vehicle around and otherwise orienting the vehicle. If the steering could be configured to offer slow action from straight to a defined amount of degrees, and then increese sensitivity on the last part of the wheel turn, the driver could have both precision and fast acting steeering for turning the vehicle around.
The team could see that when turning the vehicle the drivers weren't going very fast, so the incresed sensitivity would not overwhelm them. This could be done using fly-by-wire principle where the steering digitally steers an electric hydraulic pump instead of driving the pump directly using a steering stem.
The principal was considered doeable and taken further to the detailing phase.
Aesthetically the racing wheels also had an advantage. The oval shape meant that it would be easier for the driver to look over the steering and down towards the road.
These consideration gave birth to the concepts shown on ill 169.
Integration of hardbuttons for tool control was considered possible, however determined to be a part of the detailing phase.

DEDUCED REQUERIMENTS

CONTROL TYPE

- Race steering wheel inspired aesthetics.
- Steering wheel should be oval to create better visibility and emphasize two hand use.
- Steering should apply progressively.
- Steering should utilize fly-by-wire principle
- Steering wheel should not turn more than 180 degrees to either side.
- Fixed hub should hold the touchscreen.
- Hard buttons for primary tool control should be located on the turning part of the steering wheel.

IDEATION SUM-UP

FROM GUIDELINES TO REQUIREMENTS

ill 170.

ill 171.

ill 172.

ill 173.

Coming up on the end of the ideation phase, the design team looks back to initial framing of the project, in particular the design guidelines. The goal with the idiation phase was to establish what kind of principles could be utilized and deduced to requriements helping to fullfill the guidelines. In terms of the exterior of the vehicle, both technically and aesthetically the team was able to identify and integrate solution to the primary issues, with the overall identity of the rhino vehicle.

At this point in the process the rhino concept it defined well enough that the design team wants to take it further in the process, and start to detail the vehicle and establish how exatly the pricipals should be integrated.

INITIAL DESIGN GUIDELINES FROM FRAMING

EXTERIOR
- Sufficient visibility when reversing
- Clear visibility to front tool
- Clear visibility to suction head under cab
- Adjustable control surfaces for users in all sizes
- Reduce external obstructive parts

INTERIOR
Optimized for sweeping jobs
- Ergonomically placed controlls
- Intuitive layout
- Easy control of vehicle and tools
- Easy communication of machine data (e.g. screen)
- (visible warnings lights w/ audio - Timan)

AESTETICH FEATURES
- Horizontal floating lines
- Heavy and rugged appearance
- Front focusing on the trash by tilting forward
- Integration of features such as lighting, antennas etc.
- Use of chamfers and big wheels to inspire masculin feel
- Broad wheel arches with high wheel clearence.

EMOTIONAL VALUE
- Give the feeling of power, comfort and hightech
- Ride the beast
- Radiate performance
- Inspire confidence and reduce insecurity

DEDUCED REQUERIMENTS

FORWARD VISIBILITY
- A splitscreen front is wanted for best tool visibility
- The roof lining of the vehicle should not drop lower than 5cm above eyehight of the driver

REARWARD VISIBILITY
- Is created using cameras with accompanieng screens
- Consist of one camera mounted on the rear and two cameras mounted on the sides
- The cameras should be mounted on the lower tail section

ENTERING/EXITING THE VEHICLE
- Suicide doors hinged at the back of the cabin should be used.
- Steering wheel functions as support when entering and exiting.
- A step should be incoorporated in the design to ease the entering.

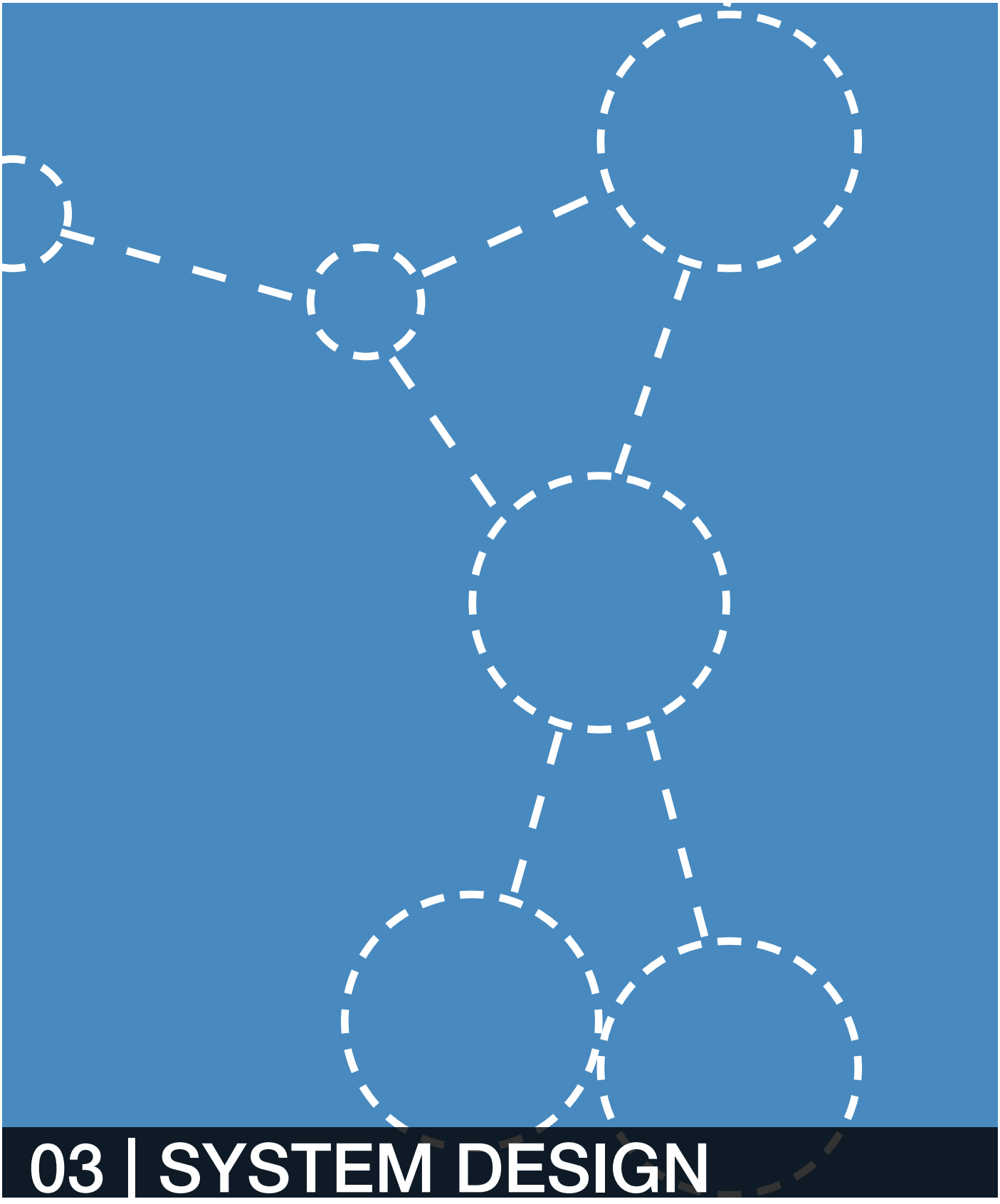
CABIN EXTERIOR
- Cabin should have a covered rear.
- The rear cover shall extend onto the sides utilising a forward leaning angle maching the front window.
- A mid section cover shall extend from the front glass towards the rear and cover the torso of the driver.
- The sides of the vehicle shall be vertical
- If possible the front wheel arch shall be integrated in the seating console to provide more legroom.

TOOL CONTROLS
- Primary tool control should utilise tangible buttons
- Secondary tool control and vehicle configuration should utilise a touch screen
- Primary tool controls should be within fingers reach when opperating the vehicle
- Secondary configurations should be within arms reach

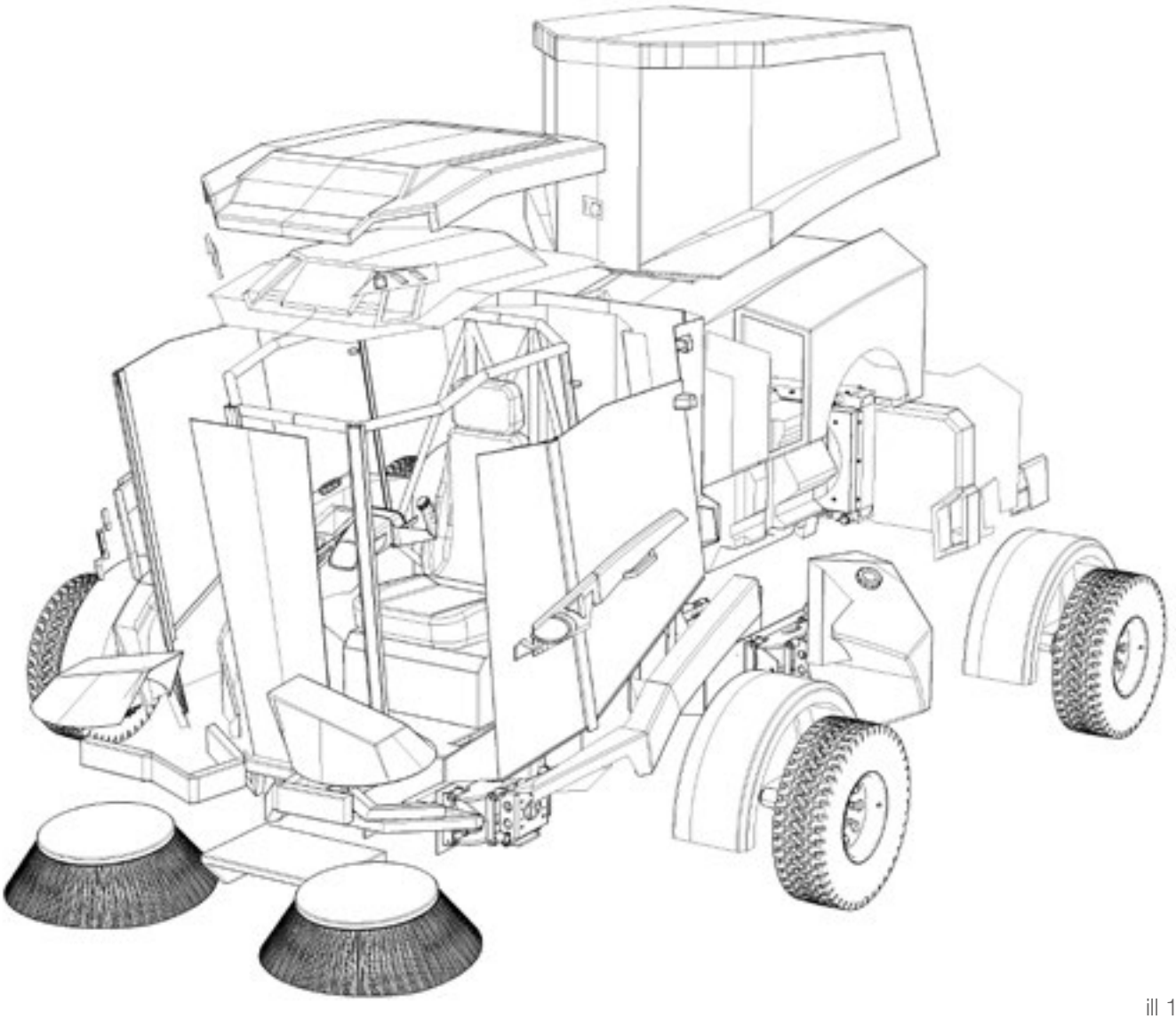
VEHICLE CONTROLS
- Forward/backward motion is controled by pedals
- Left/right steering is controled by a wheel structure

CONTROL SURFACE POSITION
- Both tool controls and vehicle controls should be placed toward the center of the cabin in position 2
- The control surfaces has to be low enough that the driver can easely look over them
- The roof lining is used for the reverse camera feed.

CONTROL TYPE
- Race steering wheel inspired aesthetics.
- Steering wheel should be oval to create better visibility and emphasize two hand use.
- Steering should apply progressively.
- Steering should utilise fly-by-wire principle
- Steering wheel should not turn more than 180 degrees to either side.
- Fixed hub should hold the touchscreen.
- Hard buttons for primary tool control should be located on the turning part of the steering wheel.



03 | SYSTEM DESIGN



ill 174.

THE SYSTEM DESIGN

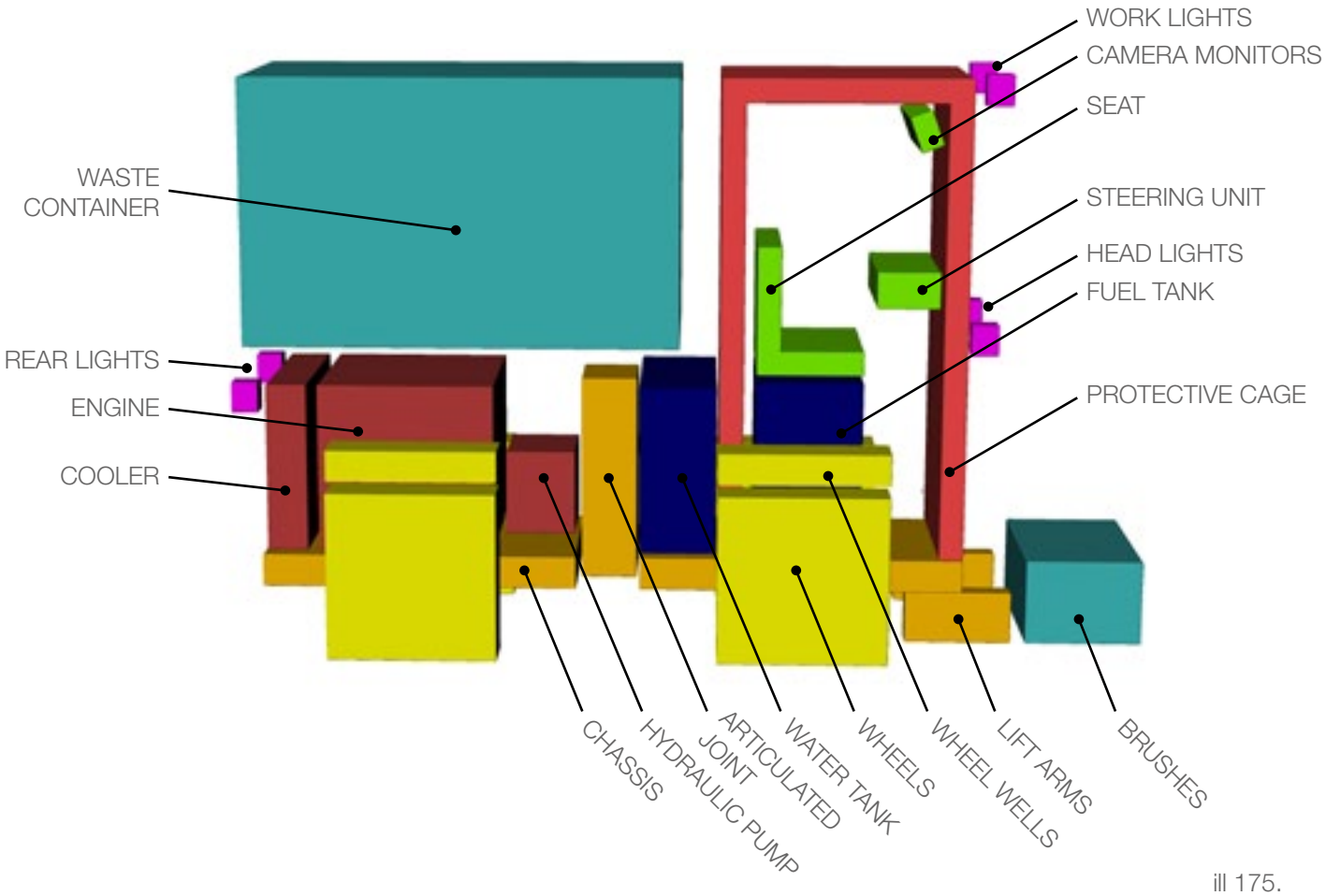
The vehicle concept is dissected in order to account for the relation between the aesthetical and the functional parameters. The current concept consists of a number of volumes and parts with a low degree of details but this chapter searches to make a complete product with feasible structures and relevant interfaces between elements.

In order to ensure the desired emotional expression, the linework and visible surfaces from the concept are largely preserved and the technical and structural elements are adapted accordingly. Some parts, however, will change design due to requirements from neighbouring parts - e.g. will an engine cover need increased ventilation area due to engine placement, cooler size etc.

The chapter will have an overweight of attention to the front part of the vehicle due to a time related delimination and the front is the most complex and the most critical in order to preserve the identity of the vehicle. Large parts of the development process play out as a puzzle where all the many pieces have to match up, and requires many smaller iterations where work is done on several parts simultaneously. It can therefore be hard to display a strictly logical and progressional development but the chapter will explain the main thoughts and ideas throughout the work.

ARCHITECTURE

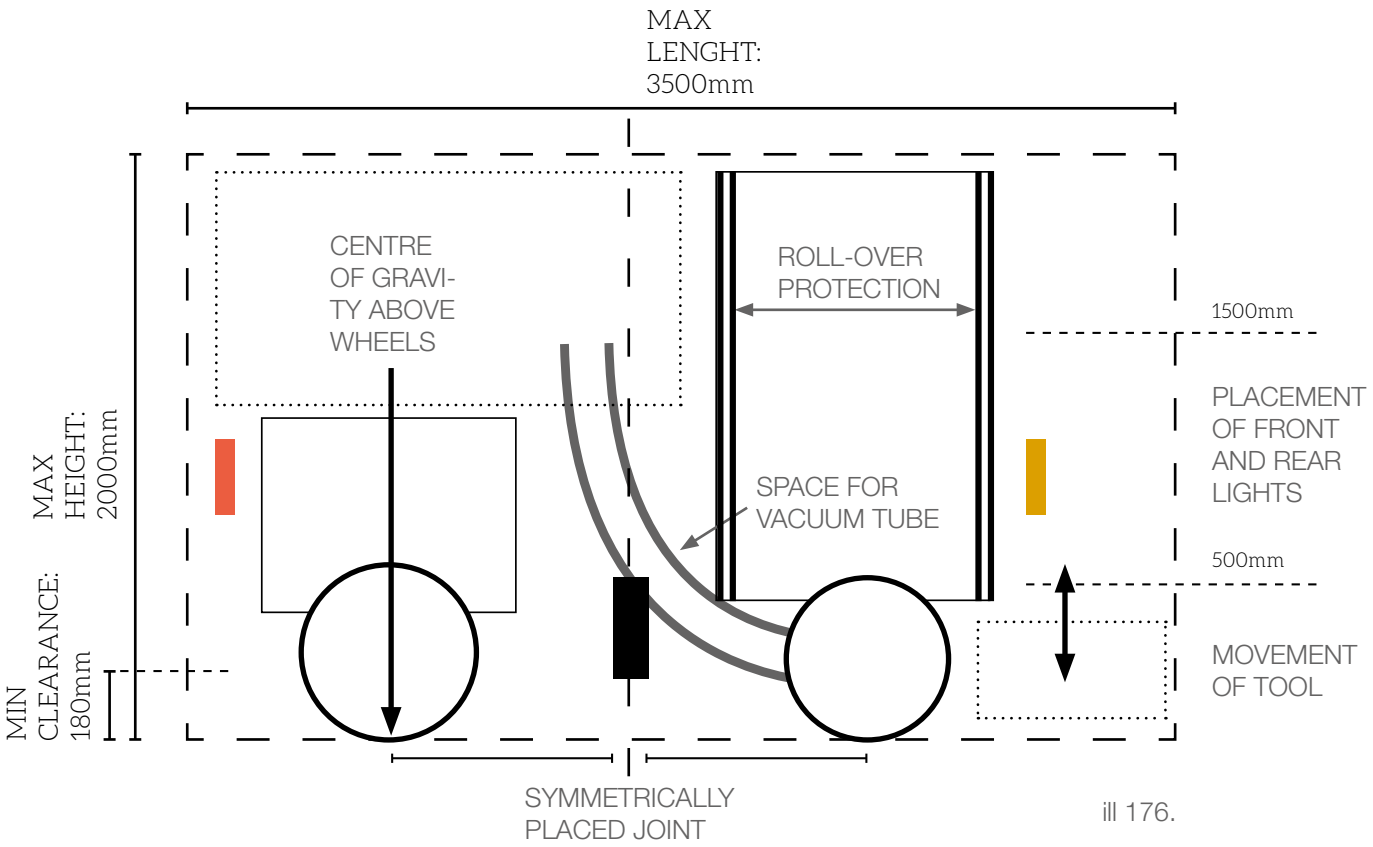
IMPLEMENTED COMPONENTS



ill 175.

A map illustrates the many implemented parts and the overall architecture. The positions aren't exact but illustrates which parts interact and and helps understand which considerations and alternations that needs to be done. The boxy appearances help abstracting from from specific shapes and pay attention to the structure.

TECHNICAL LIMITS



ill 176.

Apart from having a number of parts to fit into the vehicle, a number of technical limits has to be met.

The vehicle has predefined maximum proportions and can thus not exceed a height of 2000mm and length of 3500mm. At the same time a clearance of minimum 180mm should be maintained.

Lights, front and rear, have according to legislation to be positioned in a height from 500-1500mm above ground. The waste container must be detached without removing tail lights.

The articulated joint should be placed centered between wheel bases to ensure driving comfort as front and rear wheels follow the exact same projectory. If your front fits, your rear will as well.

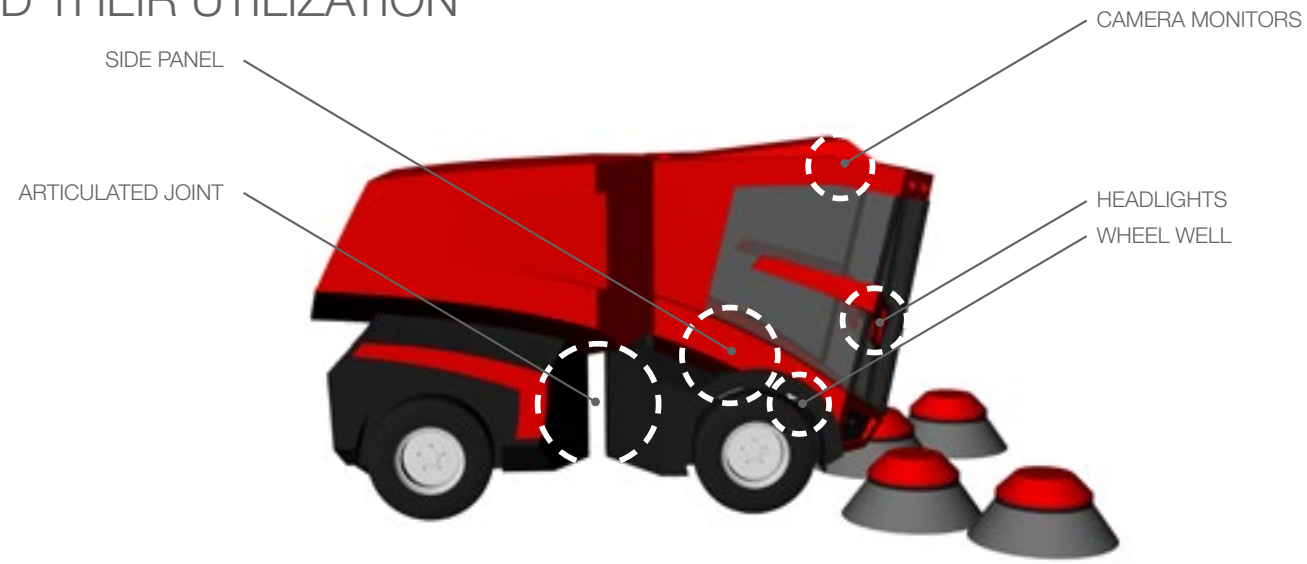
A roll-over protection cage must protect the driver in case of tilting on the side.

Weight must be distributed above wheel bases as far as possible to ensure driving comfort. The vehicle will enable a smoother ride and less tension of the internal structures. This dictates engine and waste container placement.

A vacuum tube must connect the suction head under the cab to the waste container with an as straight projectory as possible in order to increase suction. Meeting with waste container must happen above articulated joint due to twisting.

AVAILABLE VOLUMES

- AND THEIR UTILIZATION



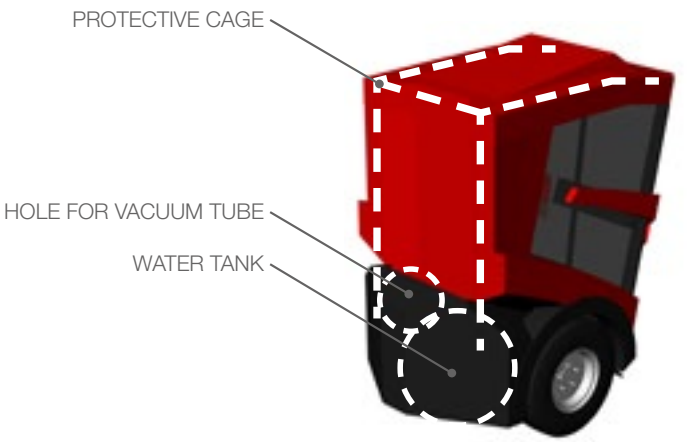
ill 177.

The components from the product architecture is sought implemented into the vehicle concept. Some components such as the articulated joint and headlights have been critical throughout the overall process and is therefore allready integrated in the design, while other components are placed in suitable positions.

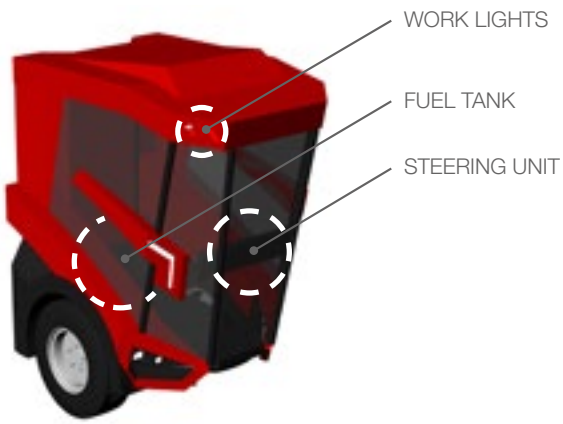
The "neck" of the rhino on top of the drivers cab originates from an emotional starting point but happens to create a perfect place for camera monitors - optimized viewing angle and no sun glare.

The volume behind the drivers cap is suitable for a water tank on each side as they allow for the vacuum tube to go through in the center. The fuel tank fits under the drivers seat and utilizes otherwise unused space.

The protective cage can be implemented in the enclosed rear part of the drivers cab as well as in the roof. It might not be the ideal solution from a structural viewpoint but is considered possible and non-obtrusive to the overall expression of the vehicle.

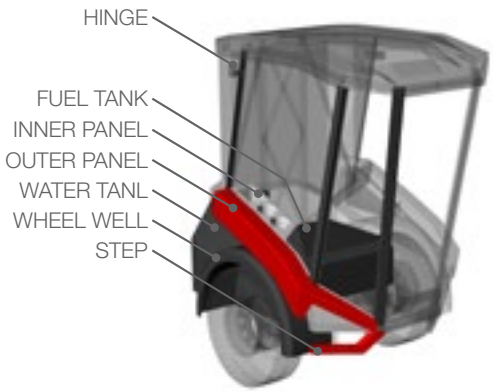


ill 178.

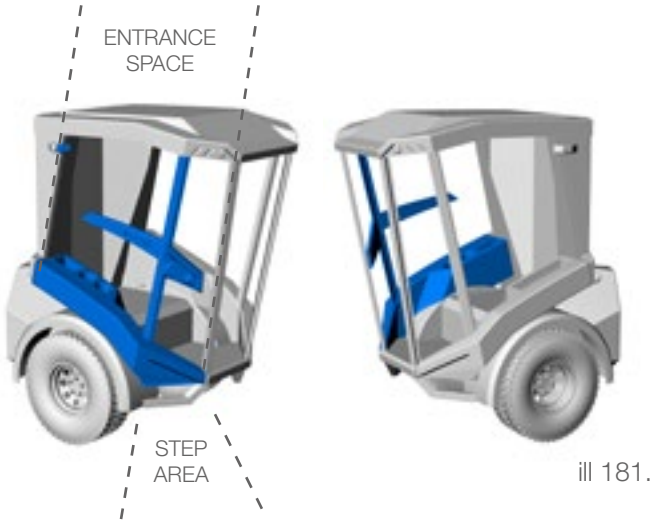


ill 179.

DOOR SYSTEM



ill 180.



ill 181.

To avoid introducing additional pillars or seperation lines in the exterior, the door utilizes the forward leaning side cover as hinge position. This gives the door a slight upward movement and ensures the inside of the open door being dry during rain but requires a spring to assist lifting the heavy door.

The fuel tank and the water tanks are heayve objects and shouldn't move as a part of the door. Neither should the step. Since the side window split the side panel into an inner- and an outer panel, the question is whether they both moves with the door. Excluding the inner panel from the door results in a visual lighter design but leaves a weird space between the two covers to collect dirt. Can the door close if dirt is trapped, and is the end of the window visible?

The door is therefore integrating both panels as well as the headlight and metal profile (blue on ill 181) and allows for a large entrance space and space for an internal structural door frame in the outer panel.

CONSIDERATIONS BEHIND DOOR OPENING

ill 182.

Opening both inner- and outer side panel as well as the wheel well will result in an exposed wheel where dirt might smear off on the driver.

CHOSEN

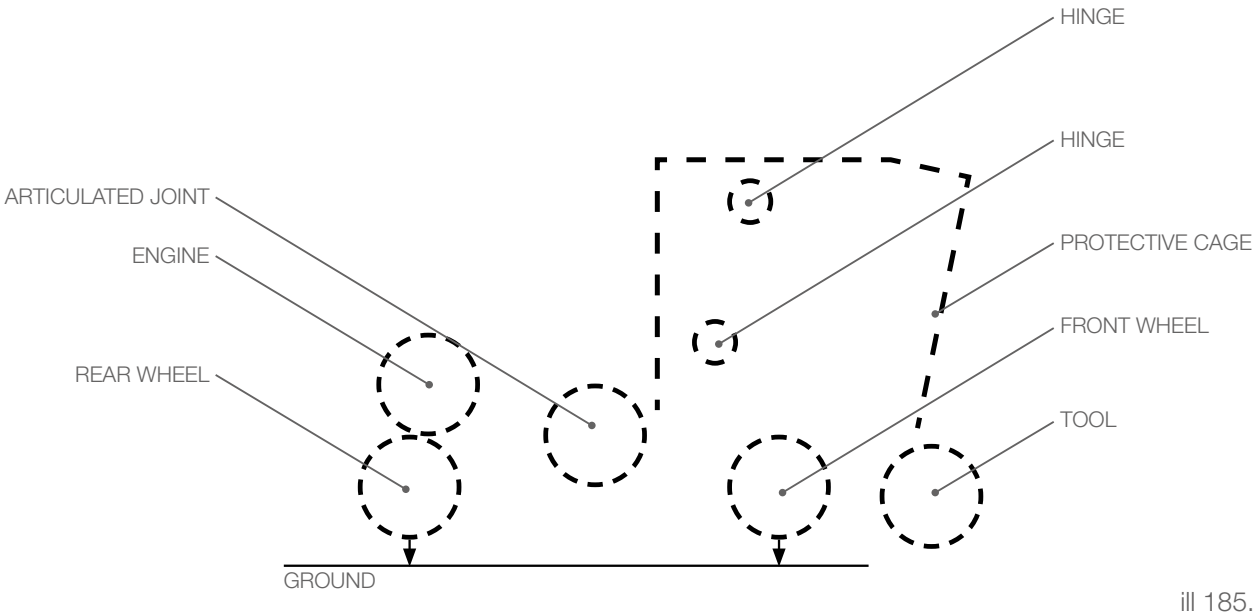
ill 183.

Leaving the wheel well as stationary protects the driver from dirt but allows for a large entrance space.

ill 184.

Leaving both side panels and wheel well results in too narrow of entrance space and lack of door frame.

INTERNAL STRUCTURE



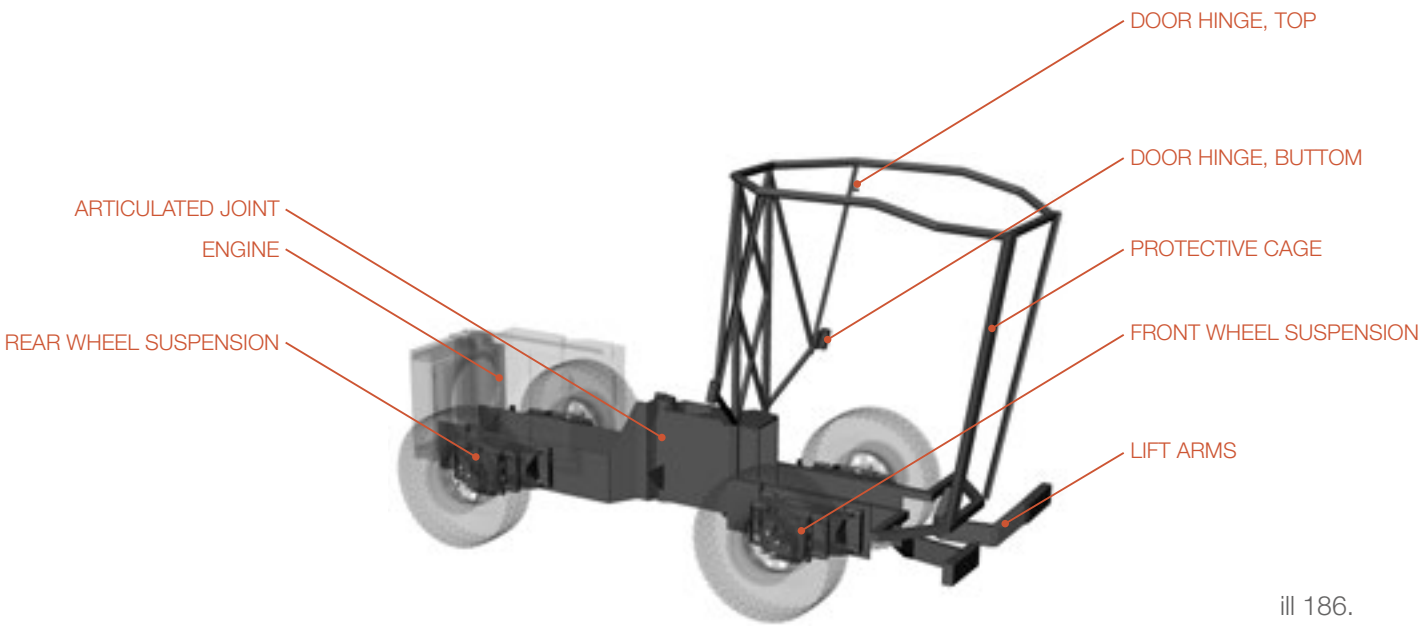
ill 185.

In order to connect the most critical parts, a structural frame is designed. The frame holds the elements in their respective positions and is a key element in keeping the machine together and transfering the weight through the weels and down to the ground - it functions as a backbone.

A vital part of the frame is the articulated joint as it requires high strenght and a direct connection to the wheels.

Individual wheel suspension is attached to the frame and prepares the mounting of wheel motors and wheels.

To ensure optimal strenght, the protective cage is mounted strenght on the structural frame, as well as the lift arms for front tools. Door hinges are integrated onto the protective cage to limit weight.

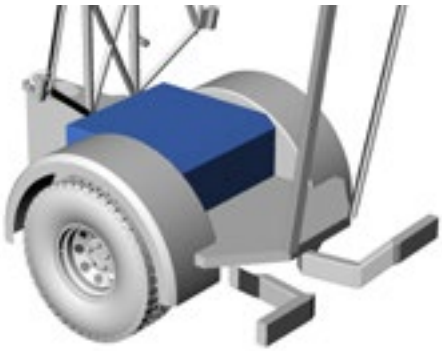


ill 186.

MOUNTING ON THE STRUCTURE

LOWER PARTS

ill 187.



ill 188.

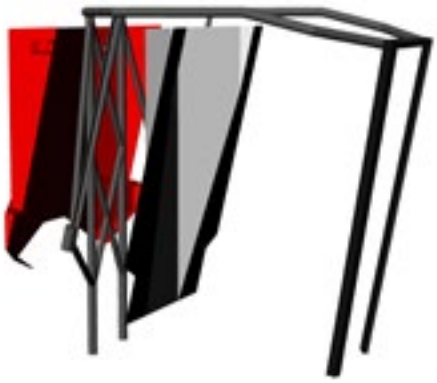
ill 189.

Fuel tank, water tanks and wheel wells are all stationaries and can be mounted straight onto the structural frame. They are all visible parts and especially the watertanks (ill 189) follow a shape deduced by a combination between aethetics from the concept and functionality from the architecture.

The challence was to dissolve the empty volume from the earlier concept idea and create tangible and regular elements that would work for both manufacturing, assembly and the overall architecture of the vehicle.

The parts are touching each other and must therefore be bolted together in order to avoid unwanted gaps or offset surfaces. Space is left for the protective cage, the vacuum tube and parts from the structural frame.

UPPER PARTS



ill 190.

ill 191.

One of the benifits of having the protective cage, is that it functions as a frame for the visible covers behind the driver and in the roof. It also supports the front windshield and holds the doors.

The rear- and roof covers are designed as sandwich constructions where an outer- and inner cover hides the structural element. Alternatively a solution with visible structural elements could be considered but such a solution wouldn't align with the design guidelines from the initial framing requireing a sense of comfort. The feeling would be more raw and drawing associations to trimmed racing cars - not a comfortable workplace to spend 8 hours.

The roof lining has integrated monitors for the rear cameras and is therefore required in order to hide wires and mounting pieces.

DESIGN REFINEMENT

FRONT

The front end of the vehicle represents the face of the beast and must therefore posses the expressions of aggressiveness and brutality. A number of iterations explored to which degree the vehicle should mimic animalistic features such as eyes, mouth and forehead, and the challenge was to give it personality without ending up with a caricated robot-looking creature.

The earlier research of vehicles helped to give some guidelines for the design and some features were adopted more directly. The step for the drivers cab has a completely different functionality than the automotive air intakes but mimics the expression in order to maintain wellknown charateristics and create associations to other vehicles.

The "mouth", or trash intake, has a central role in the expression as well as functionality, and much of the refinement focus of this aspect. But not only was the expression a vital part of the refinement, but the technical requirements of moving brushes were integrated into the solution as well. The final front expresses "consumption" as well as integrating foot step and moving tool mounts into the design.

ill 192.

ill 193.

ill 194.

ill 195.

ill 196.

ill 197.

BACK

The back of the vehicle is in this case intended to look like a back. The brutal beast blasts through the streets and when you see it from the back you must be overwhelmed by the feeling of standing in its jetstream.

The vehicle is therefore designed to be of a light expression from the back by using very little color and by using various shells to form the rear body. Even the solid trash container has a light expression from the back as only a thin colored edge extends backward from the dark grey rear lid. The thin shells and the large areas with perforated mesh give the illusion that the vehicle has very little mass in the back, as well as giving strong associations to tailpipes and jet exhausts.

The back isn't designed in this open and light fashion only because of the aesthetic appearance but the engine needs a large cooling surface and a high airflow through the cooler so the chosen iteration seems to accomodate both issues with a high degree of effeciency.

ill 198.

ill 199.

ill 200.

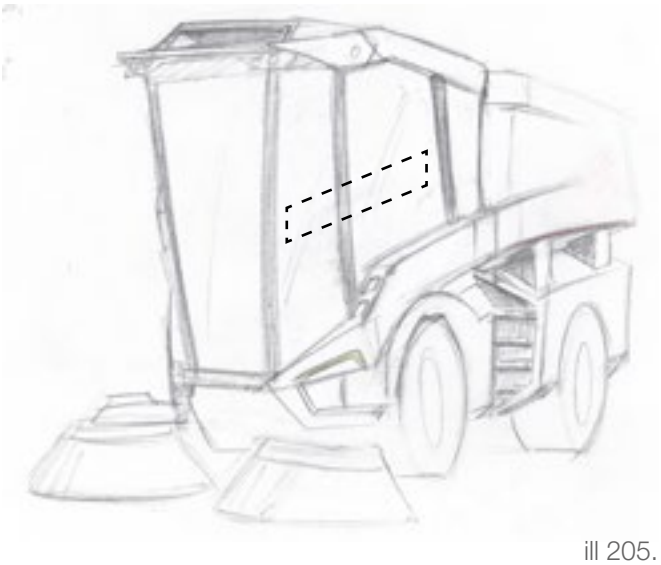
ill 201.

ill 202.

ill 203.

HEADLIGHTS

ill 204.



ill 205.

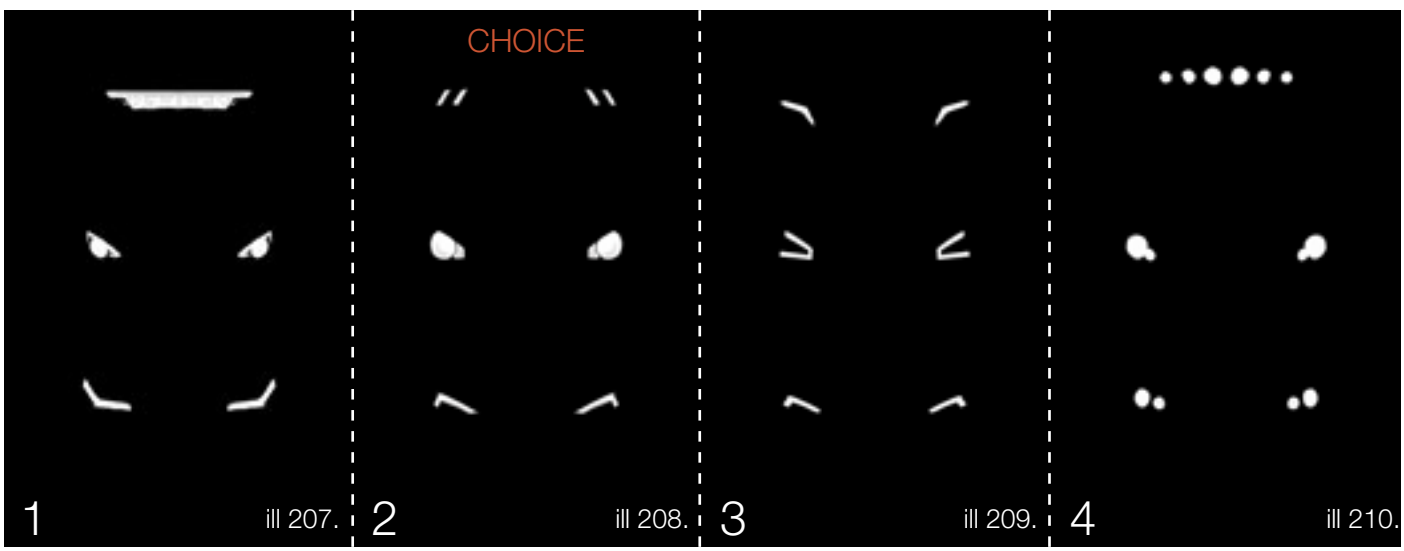
ill 206.

Large parts of the work performed with the urban maintenance vehicle are done in times with little daylight. The light design is therefore crucial in order to maintain an aggressive and evil appearance around the clock.

Some iterations utilized nothing but LED strips for both positioning lighting as well as orientational lighting but the vehicle lost too much character (3) and technical requirements of adjustable headlights with a certain strength weren't met.

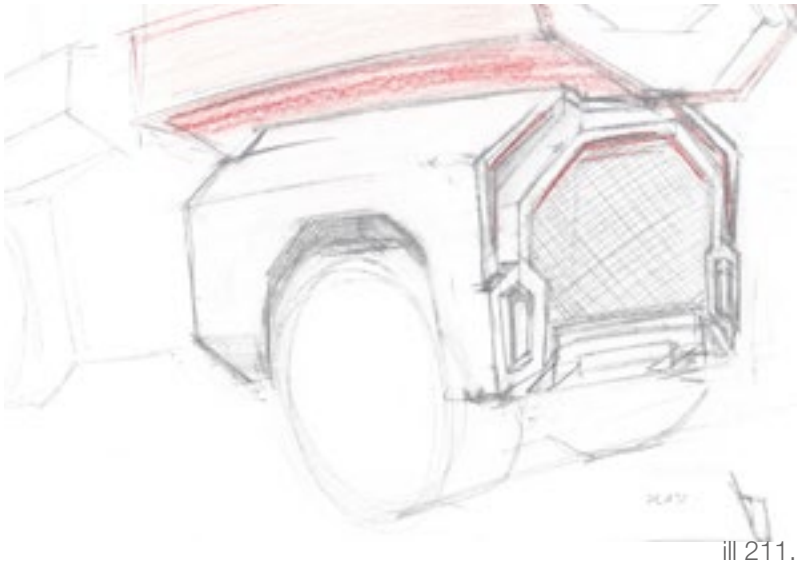
Other design ideas utilized round lights to a high degree (4). The round lights offer the possibility of internal parabolic reflectors and fulfills therefore the technical requirements satisfactorily. It lost, however, too much of the aggresiveness and gave associations to semi trucks and other working vehicles.

Design idea 2 offered a healthy balance between automotive design with LED strips for positioning lighting and round parabolic headlights for orientational lighting. These headlights offered enough identity to vehicle without being exaggerated eyes.



ill 207. ill 208. ill 209. ill 210.

TAILLIGHTS



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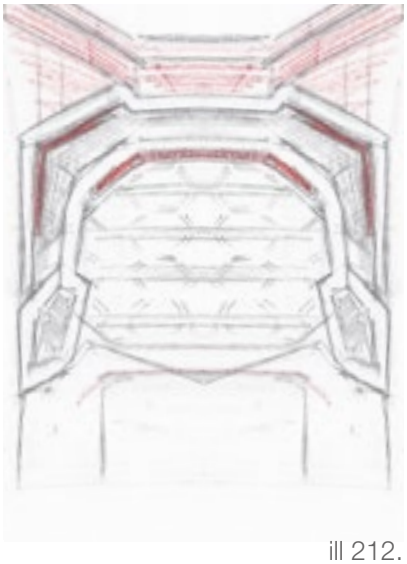
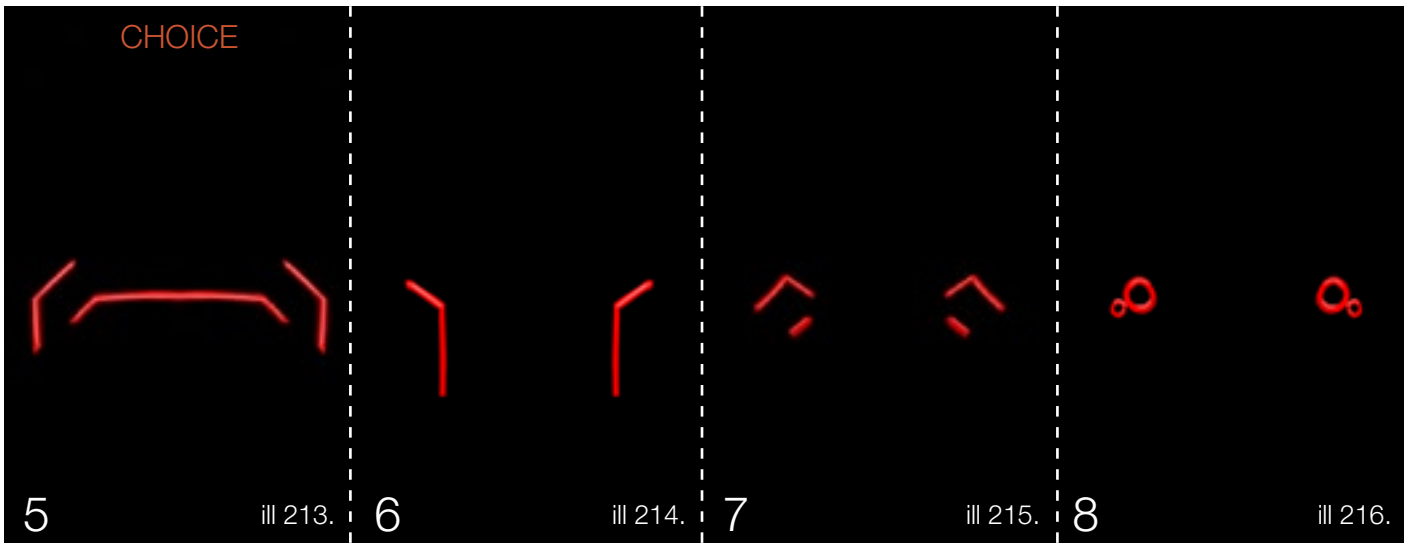


ill 212.

The vision of creating a visual light and open rear end functions as the main design guideline for the taillights. Due to the varying need for the mounted waste container, the taillights must be positioned in the lower body of the vehicle. Since there are no requirements for adjustable lights on the rear, it allows for working with LED lights only. This is chosen to accent the shell design and support the design in a way that you can almost tell the shape of the rear end by looking at only the light (5). The LED strips follow the contour of the covers and are offset into the vehicle which ensures that the actual lamp doesn't take focus during day time but only the emitted light.

In the automotive world you often see vehicles with angry looking taillights but that was not desired for the Rhino 7400. The rear end needs to be without identity and thereby accenting the focus on the front end and the head of the beast.



ill 213. ill 214. ill 215. ill 216.

FINAL DESIGN

ill 217.

Throughout the final CAD modelling, the many details have been touched up upon until the vehicle has ended up with this presented design. The vehicle has the desired expression and has a feasible product architecture with supporting parts and structural elements, and is now ready for detailing with focus on production methods and costs.

ill 218.

ill 219.

OVERALL ASSEMBLY SCHEME

RHINO 7400 ASSEMBLY LINE

SUSPENSION
FRAME

LIFT ARMS
WHEEL MOTORS
CAGE

WHEELS
ELECTRONICS
HYDRAULIC HOSES
HYDRAULIC PUMP
ENGINE

WHEEL WELLS
ENGINE COVER
WINDSHIELD

ill 220.

The vehicle is assembled with starting point in the whole structural frame in order to ensure sufficient strenght thoughout the process. An alternative could be to assemble the front part and rear part individually in order to enable a higher number of technicians to work on the vehicle simultaneously. It would, however complicate the overall build since the electrical and hydraulic lines have to connect the two parts.

Alternatively the production would have several lines set up independantly and thereby allow for an increased number of technicians. Assuming an annual production number of 200 units and a assembly time of a week, it would require approximately 4 assembly lines.

Parts like engine, protective cage, structural frame and doors are preassembled according to in order to decrease the time handling the overall vehicle and thereby decreasing the bottleneck of people work on top of each other. Despite various assembly lines, a variety of technicians must have access. This being e.g. electricians, welders, mechanics etc.

The colored panels are essential parts of the vehicle and therefore has to be installed throughout the overall assembly - not as a final element. It is therefore decided early in the process which color to build and a later switch would require expertise and be time consuming.

ELECTRONICS
GASTANK
STEP
ENGINE GRILL
OUTER REAR COVER
OUTER ROOF

WORK/STROBE LIGHTS
INNER REAR COVER
INNER ROOF

SEAT
CONTROL INTERFACE
ELECTRONICS

HEADLIGHTS
DOORS

ill 221

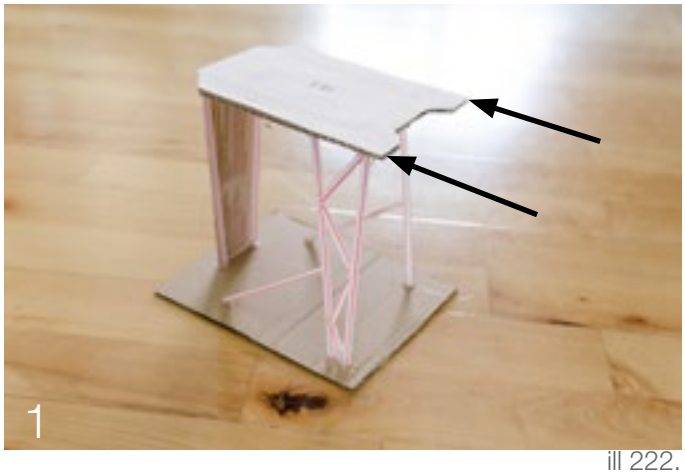
04 | DETAILING

EXEMPLARY DIVES

The detail phase will much like the ideation be separated into two tracks. One regarding the actual vehicle, and another regarding the interface of the vehicle.
Detailing a product of this size is an enourmous task, and therefore the team has chosen to do a few product critical dives. These consist of the roll cage supporting the vehicle and protecting the driver, together with the steering as these are vital points in the concept.
Finally the production of the vacuum molded plastic parts is detailed as these are responsible for giving the vehicle the wanted apperance.

CONSTRUCTION

PROTECTIVE CAGE



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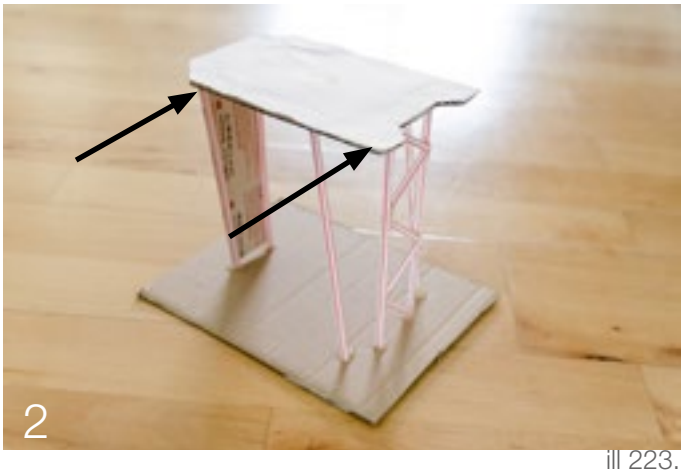

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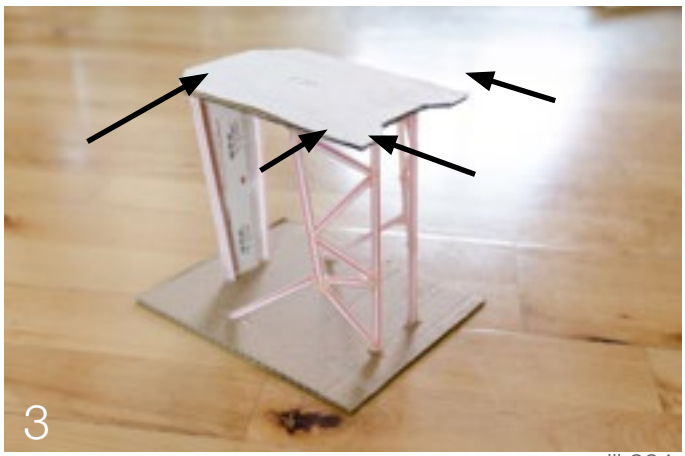

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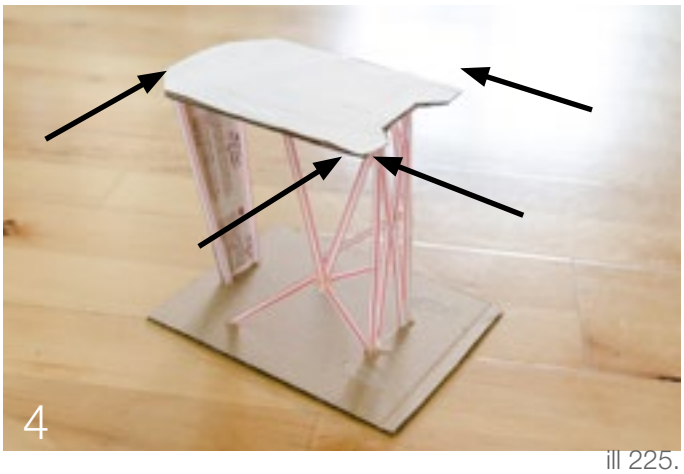


ill 225.

The internal cage functions partly as a structural element to hold plastic covers and doors on place, but also as a protective element. It is considered that the worst, but likely, solo accident that would happen with the machine would be to drive into a deep ditch and thereby tipping on its side. The structure must be able to handle such an accident without putting the driver to danger despite damages on the machine itself.

Simple models illustrates the qualitative strength and weaknesses of different construction principles - the black arrows indicated direction of strength.

Model 1 is stiff in a front-rear direction as it has a disc structure on each side and would serve well in frontal collisions.

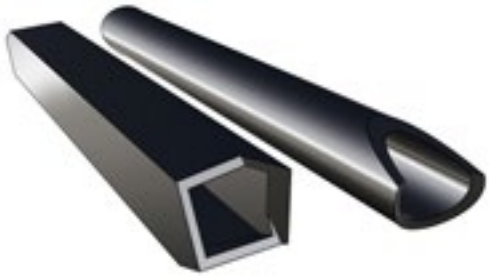
Model 2 is very stiff against forces applied from the side as it has a disc structure both front and back - the glued-in windshield and the pipe construction behind the driver. In a theoretical situation without speed or foreign object this structure would be sufficient to protect from tilting to the side.

Model 3 has diagonal discs and would result in strength from both front and side if the structure could continue all the way to the floor. The outer design of the vehicle, however, doesn't allow for the buttom part of the vertical pipes to continue all the way down (see ill 231 next page) and a slanted support pipe should replace it. Later the door design eliminated that option as well (see ill 230 next page).

Model 4 connects the two diagonal structures with a centered disc structure and has reduced the amount of cross pipes without loosing much strength. This structure is therefore cheaper to produce and reduces weight in the final vehicle.

ill 226.

ill 227.

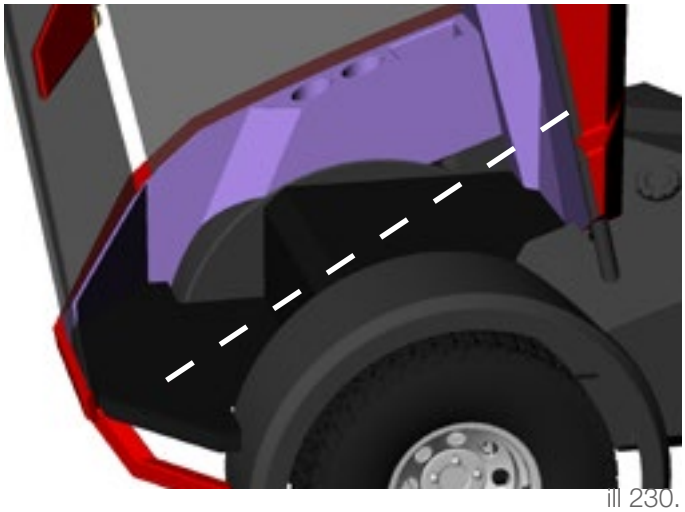


ill 228.

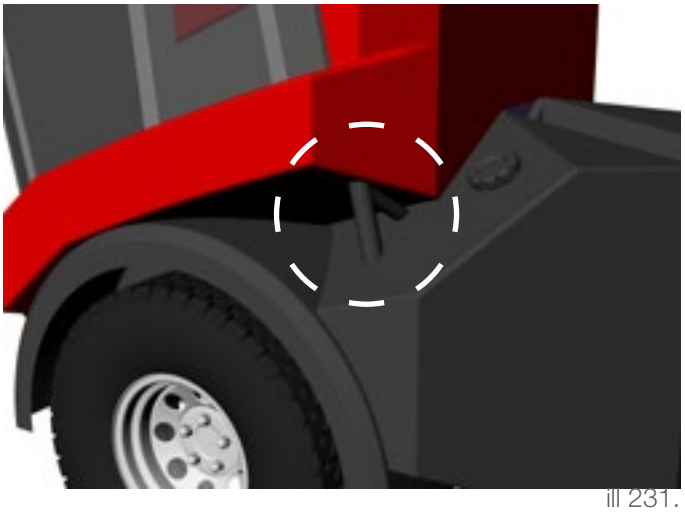
ill 229.

Due to mounting of the plastic covers, the structure was initially thought to be build from square pipe. It proved, however, that the many irregular angles would result in unfortunate cutting angles (see ill 228) and complex welds. Round pipes result in more regular cutting angles and and regular welds.

If possible, bending is the chosen method over welding since a bend requires less manual labour and thereby reduces production price. The circles on ill 229 illustrates bends and instead of being welded from 24 round pipes (plus door and window frame) the cage is welded from 10 bended pipes.



ill 230.



ill 231.

WELDING DETAILS

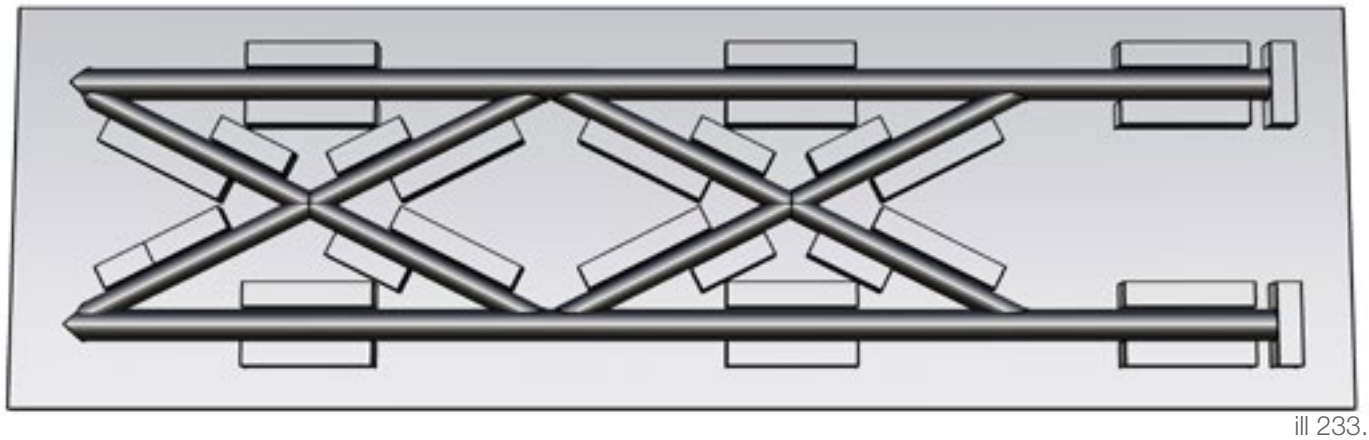
ill 232.

Ill 232 represents some of the iterations in the cage development. Throughout the work the cage design got optimized in order to decrease production costs and unnecessary weight. The pipe went from being a square profile to being circular and the amount of cross pipes were reduced.

The cage structure functions as the skeleton of the whole drivers cab and it is therefore a necessity that it is constructed precisely. Due to the various pipe lengths and cutting angles, all pipes are cut on a CNC pipe cutter after the bending process. The bending process is hard to achieve with high accuracy and the cutting has therefore to be done afterwards.

When welding the structure, a template ensures the correct angles and positions of each pipe element as they are attached. Such a template is quickly produced on basis of the first time consuming prototype and the afterward cage construction can happen with a high pace.

Ill 233 (below) shows a template for a section of the cage and can be created in either plywood or steel. The template is used for tacking up the structure and receives therefore very little heat. The structure is taken out of the template for the full weld.



ill 233.

STRENGTH

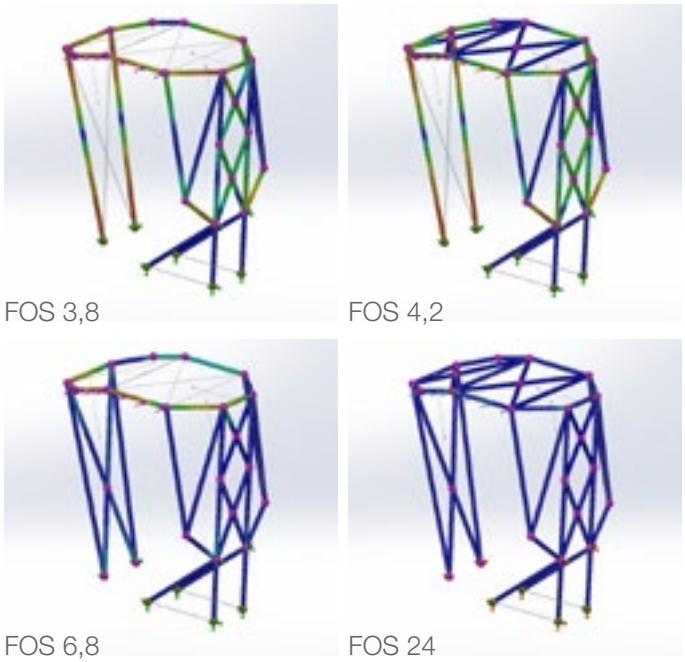
To test the strength of the structure a set of FEM simulations were set up. To ensure a limited amount of variables the structures are only applied force (1000N) straight from the side and the structure is fixed to the ground as if it was welded onto the buttom frame of the vehicle.

Ill 234 (top left) shows a structure without windshield or any extra support in the roof. The simulation shows that the cage will twist due to no stiffness in the front part and the top frame will deform as it receives all the force and has no cross pipes to support.

The structure on Ill234 (top right) has inserted cross pipes in the top frame and has therefore increased strength in that area. It is, however, still prone to twisting as it has no disc structure in the front.

On ill 234 (lower left) cross pipes substitues a glued-in windshield and the structure shows little sign of twisting. If fact the the only weak areas in this structure seem to be to top frame as it deforms when 6800N is applied.

Combining both the glued-in windshield and the cross pipes in the top frame ill 234 (lower right) results in a structure with a factor of safety of 24 and is therefore able to withstand 24.000N before deformation if force is applied straight from the side.



ill 234.

ill 235.

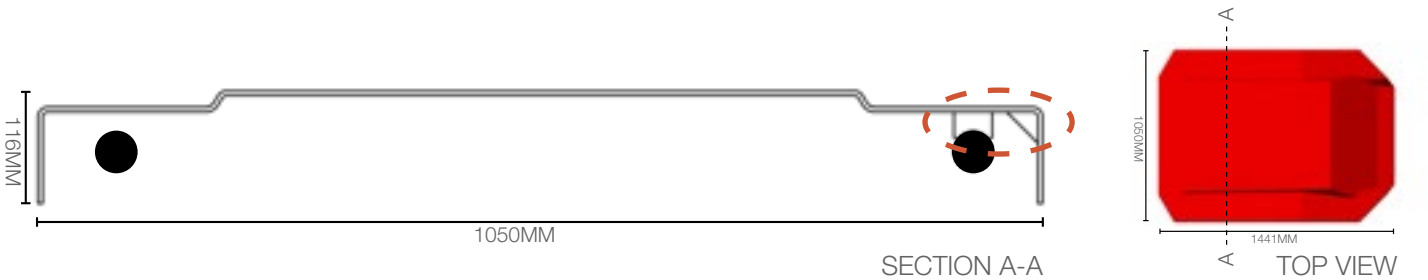
The largest force in a tilting accident will be applied from the side of the structure as it hits the ground. However, hitting a foreign object or tilting while being in any forward motion would result in forces from various direction and create twisting.

The structure without roof reinforcement ill 235 is chosen for the vehicle due to the layout and space requirements on the cab and a final simulation with 1000N from the side and 1000N from the front validates its strength. In such a scenario the structure has a factor of safety of 6,2 and is considered sufficient.

Should it be that the structure is exposed to higher forces deformation will occur to a level according to the applied force. Determining the relation between deformation and injuries of the driver requires more advanced simulations. Even if the structure deforms the driver might still be protected in the center of the structure. This structure is therefore considered to live up to the safety requirements of a protective cage. This conclusion is only being supported by comparing to other vehicles with much simpler “rollover protective structures” - being a simple arch or a pillar in each corner of the cab.

PRODUCTION OF PLASTIC PARTS

INJECTION VS VACUUM



ill 236.

In order to achieve a high enough visual quality of the colored panels, vacuum moulding and injection moulding are considered. Vacuum moulding is possible due to the simplicity of the covers and injection moulding would likewise require relative simple two-part moulds. The sizes of the part are relatively large and not all manufactures have equipment to produce these size items.

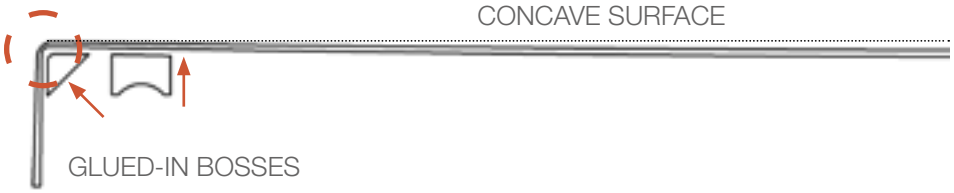
It is estimated that onlya few hundreds Rhino 7400's will be produced annually and it will therefore be hard to profit on the expensive injection moulds. A large part requires a large mould and despite the simplicity, the material price and tooling time increases the startup price. It is therefore chosen to use vacuum moulding for the vehicles colored panels.

Vacuum moulding provides with a different detail level and quality but the parts for Rhino 7400 is designed to encounter that. E.g. will large straight surfaces have a tendency to become concave as the tension around the corners makes the material deform slightly. To encounter this problem the parts are designed sligtly convex so it won't be visible whether or not they are slightly less convex.

The tight corners of the part will have to be filleted and even then the material thickness will vary to some degree. Without the filleting the corners would be unacceptable thin and in danger of breaking.

Vacuum moulded parts require post-processing as any structural bosses have to be glued into position and the final part has to be machined out of the moulded object.

VACUUM MOULDED



INJECTION MOULDED

ill 237.

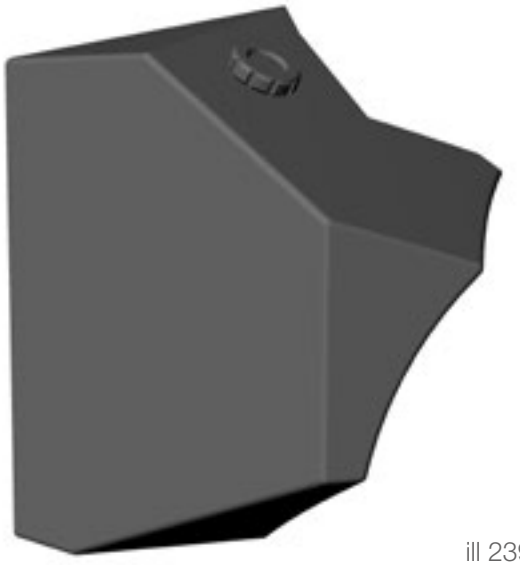
ill 238.

The vacuum mould can be produced in a cheaper plastic/wood composite as it doesn't need to resist high temperatures or high pressure. The vacuum formed parts are designed not to be too tall as the material would have to stretch significantly and cause big differentiation in material thickness.

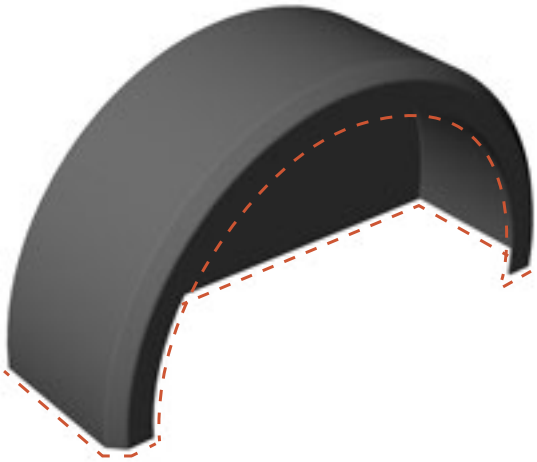
In the moulding process a colored plastic sheet gets heated and pressure pre stretches the material by forming it into a bouble. The mould is then introduced and the vacuum removes the air. Hereby the material will be placed as evenly as possible. Draft angles are a necessity since the plastic shrinks as it cools down.

A CNC milling machine trims the edges and the final part if ready for bosses and then assembly.

ROTOMOLDING



ill 239.



ill 240.

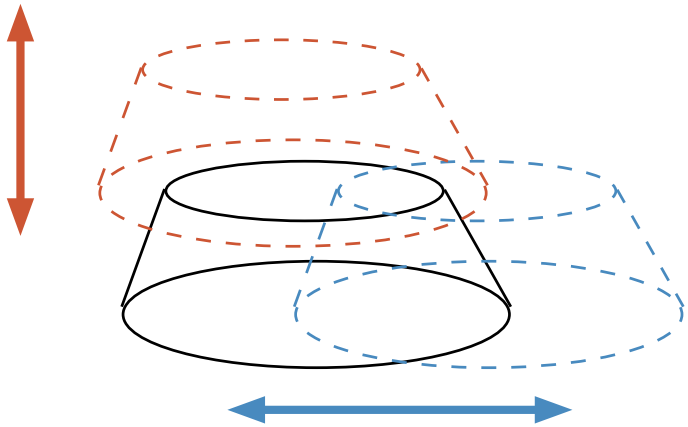
Not all parts are suited for vacuum moulding. Some will have to be enclosed objects for e.g. fuel and water tanks and rotomoulding is therefore chosen. Rotomoulding creates hollow object with a finished outer surface and is therefore perfect for this job despite thickness variations in the material.

The wheel wells are designed to be identical on all four wheels in order to use same mould and reduce production price. Due to the height of the part and the vertical sides, vacuum moulding wouldn't be a good choice. The wheel wells are rotomoulded as well even though the final part isn't enclosed. The rotomoulded part requires post processing in order to obtain the desired shape and the excess material can be granulated and reused for the next parts in order to decrease waste.

STEERING WHEEL DETAILING

PRIMARY TOOL CONTROLS

The controls needed for the primary tool adjustment should support a side to side movement, and an up/down movement. The team quickly established that the side to side movement should be controlled with a horizontal swiping motion using the thumb. That way the driver could rest his thumb and not accidentaly adjust the tool when driving, and then raise the thumb when tool adjustment was needed. This movement could either operate a turning wheel, a slider, or pivot hard button. The design team decided that a wheel should be used with a tangible movement indexation so that the user would feel a tagible feedback when then tool had been adjusted either way.
This resulted in the concept shown i ill 241. However the up/down movement was still missing. The team was initially considering using hardbuttons to control this feature like shown in ill 242 and ill 244. However a concern emerged that these buttons would be too easy to activate by mistake when turning the wheel and resting your thumb.
Another concept, shown in ill 243, operated with the idea of locating the up/down movement away from the steering wheel and onto the fixed center hub. This however would put the controls out of fingers reach when the steering wheel is turned even slighty, and would require the driver to let go with one hand. This conflicted with the requrements deduced during the ideation.
The final concept, shown in ill 245 and ill 246, focused on incooporating the up/down movement within the turningwheel adjusting the side to side movement. The user would then simply push the wheel up/down with the thumb for up/down motion or turn the wheel for side to side movement.
It was clear that this requried the wheel to be springloaded, providing a positive resistance to the up/down motion so the user would be able to feel if the wheel had been pushed up/down when only adjusting the side to side movement. The idea seemed to be doable, however the team had its doubt if such a switch existed.
As it turned out, BMW actually had utilised a very similar switch for controling interface and navigation on their highend motorcycles BMW MOTORRAD (2015).
This reashured the design team that the system could work.



ill 247. Adjustment of the brooms up/down and from side to side proved to be the most used adjustments

ill 241.

ill 242.

ill 243.

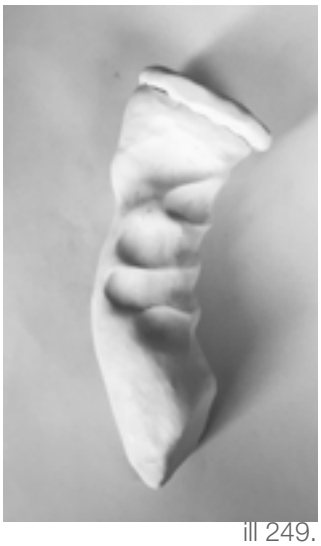
ill 244.

ill 245.

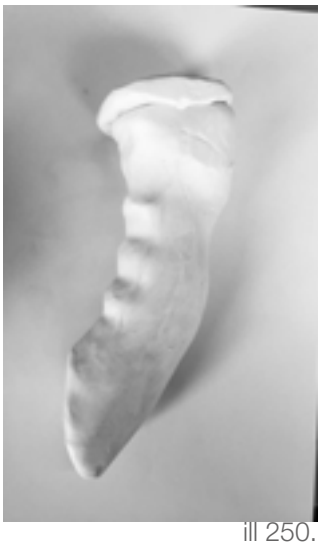
ill 246.

THE HANDLES

ill 248.



ill 249.



ill 250.

An ergonomic study was then created in order to establish the correct size of the handle itself, but also to test out the function of the dual axis wheel. Clay was utilised in combination with organic 3d modelling in order to achieve as comfortable a shape as possible ill 248. Size and finger imprints in the clay was transformed to a 3d model where the idends was faded out a bit in order to acomodate different hand and finger sizes.
Finally the the 3d model was 3d printed as shown in ill 251. This allowed the team to test the final ergonomics of the handle, and get second opinions as well.
The conclusion was that the indends made created a comfortable handle, and the 3d print was repeadidly found in the hands of the test persons "just for fun".
Secondly the operation of the dual axis wheel was tested. The thumb rested comfortably away from the wheel when just holding the handle ill 253. However an easy sideways movement gave a good interface with the wheel ill 252. Side ways as well as up/down movement was easily controlled. This was also the feedback from the test persons.
A final observation was the angle in witch people held the handle. As seen on ill 252. the handle is actualy held at a slight twisted angle to allow the wrist to stay straight. This observation was taken further to the assembly of the steering. The design team then approoved the handle.

ill 251.

ill 252.

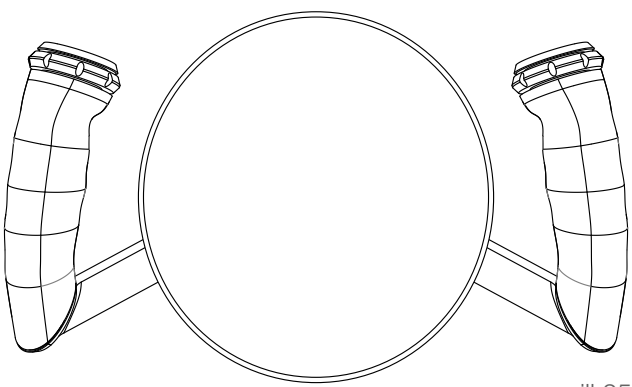
ill 253.

THE CENTER SCREEN

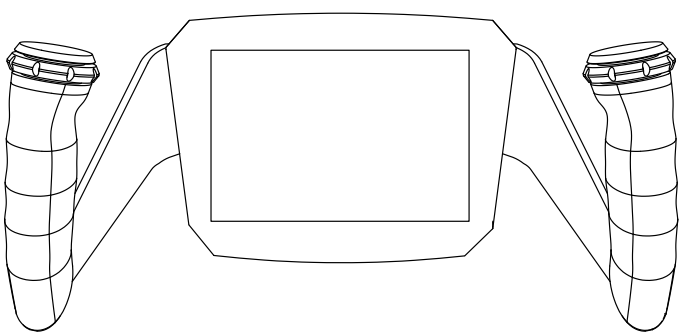
ill 254.

ill 255.

Having established how the handles themselves should look and function, attention turned to the center display. Originally during the ideation, the design team had discovered a new type of touch screen produced by Sharp for automotive use ill 255. This screen could be ordered in any size and shape, and was not confined to the traditional square form. The team thinks that this kind of display would be ideal for the rhino concept, configured in a circular shape to emphazise the circular movement of the steering ill 256. However as this was a very new technology it was deemed out of reach for a company like Timan A/S.
Instead the design team focused attention on using a traditional square touchscreen. The outer casing surrounding the screen was shaped as seen in ill 257 to give space to indicator lights of different functions which should be able to work, even if the screen should fail.
Utilising a touch screen in a hostile environment like a city cleaning vehicle puts huge stres on the material.
It should be able to cope with dirt, moisture and even hits if objects where to be dropped on it, and still function.
Furthermore some users reported wearing gloves in the cabin, so the screen should accept input through a glove.
The technology P-CAP (projected capacitive) ELOTOUCH (2014) seemed to hold the needed features as it could be operated using gloves. The touch sensitiviy could furthermore be projected (hence the name) out into more durable outer layers of the screen, providing the team with the needed durability.



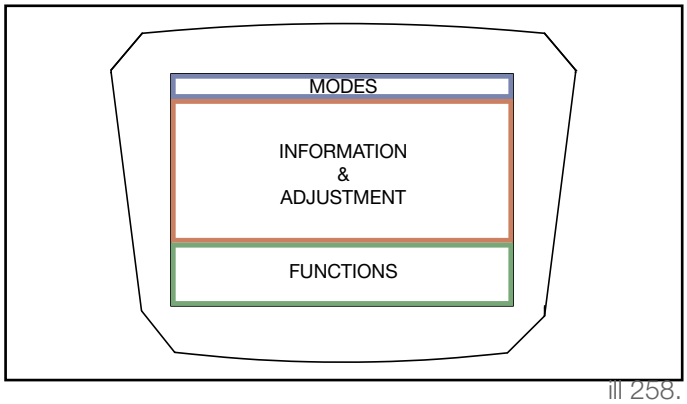
ill 256.



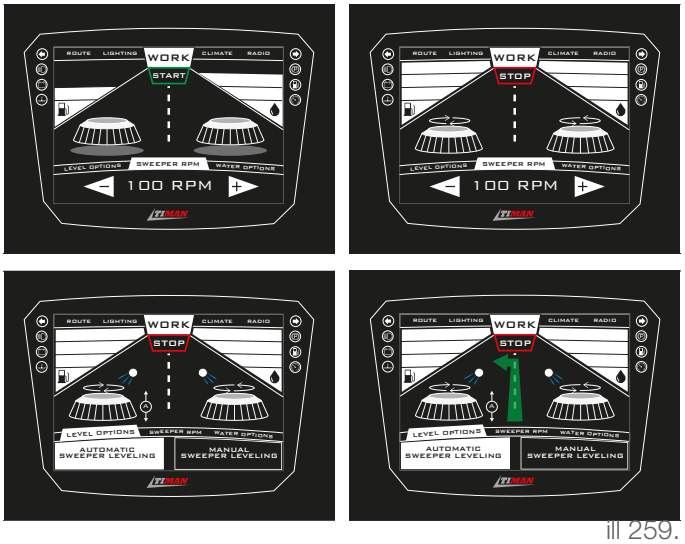
ill 257.

TAB BASED INTERFACE

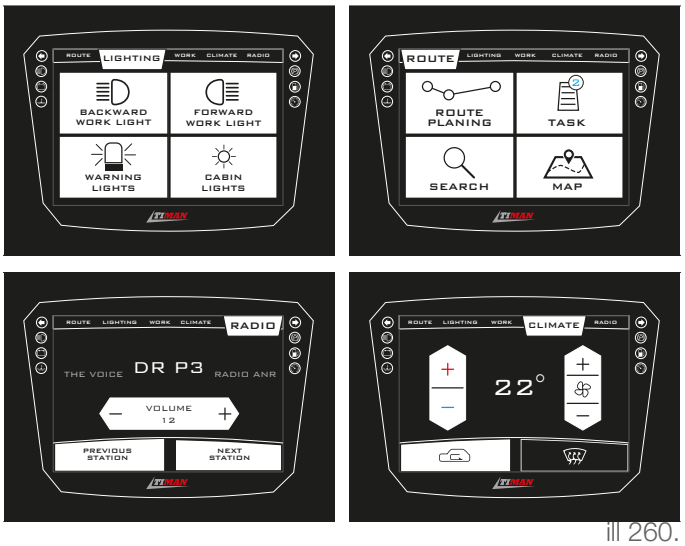
The interface itself should be very basic and easy to use while on the move.
A mode based interface consisting of three interaction levels was developed.
The design team established through analysis of the existing vehicles and driver interviews that the interface should contain modes for: 1. the actual tool control, 2. controlling vehicle lighting, 3. climate adjustments, 4. radio and finally 5. a routeplaning function.
The 5 modes would be placed at the top of the screen as tabs relating to both smartphones and computer interation such as web browsers.
The user can then select the desired mode by pressing the tab.
The mid section of the screen functions as information display space and manipulation allowing the user to adjust mode parameters.
The buttom of the screen and the final layer consist of a function selection within the different modes and is also tab based. Here the user can select the different parameters shown on the main screen area.
Using accurate graphical representation of the tools and icons customized to the actual tool would ensure that the user not only quickly understands the interface and the vehicle but at the same time always knows what's going on with the vehicle.
Furthermore all actions refer to their actual action on the vehicle or the tool, instead of their technial action as it was the case with some existing interfaces.
Early interviews with the users showed that they were very much accustomed to use touch applications ranging from smartphones to GPS devices. This interface structure is heavily inspired from these two devices, and should enable the user to easily interface with the vehicle.
Using very high contrast ratio on the screen with black and white elements should make the screen visible even in direct sunlight.



ill 258.

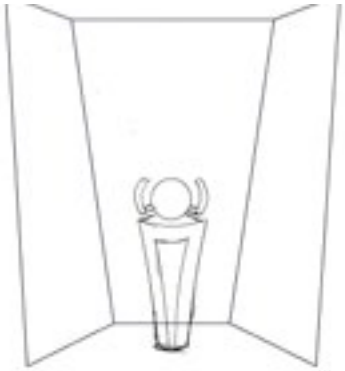


ill 259.



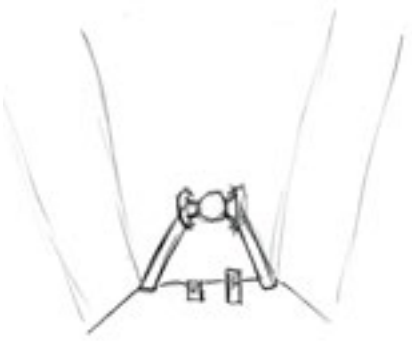
ill 260.

PLACEMENT



ill 261.

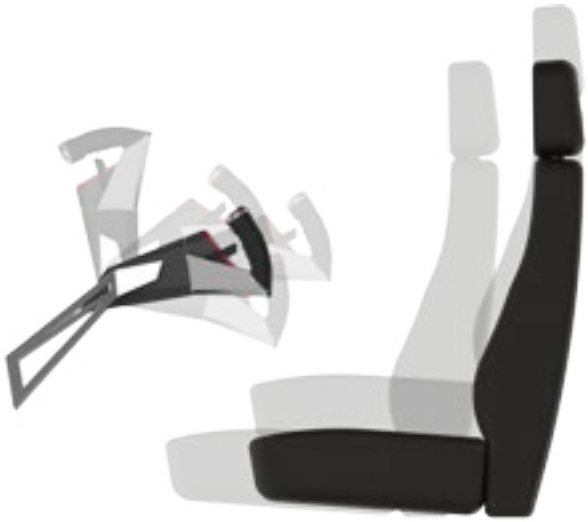
ill 262.



ill 263.

Having established the overall look and fuction of the steeringwheel and touch screen, the last thing needed was the placement. The design team had deduced that all interation should be centered in the vehicle. The existing solution of a steering coloum seen in ill 261 made getting in and out of the vehicle difficult as the driver has to get his/hers legs around the coloum. The use of a coloum also makes more sence when the vehicle has an actual steering steem going to the undercarriage of the vehicle. However the steering of the rhino would utilise the fly-by-wire principle, and this type of steering has no steering stem.
Based on this the team experimented with splitting up the center coloum and make it hug the drivers legs like it's seen in racecars ill 263. This would offer protection and increase the intimate feeling of the driver as his/her legs wouldn't be exposed and visible. However test using the mockup showed that there simply wasn't enough room in the cabin for this approach. It would be imposible to get in and out, and tall people would not be able to have their legs under the structure.
Finally the team took a different approach and sought to utilise existing structure in the cabin. The two front window beams were deamed a viable structure to fasten the steering to as this would provide generous amounts of legroom, and at the same time provide good visibility to the front tools.

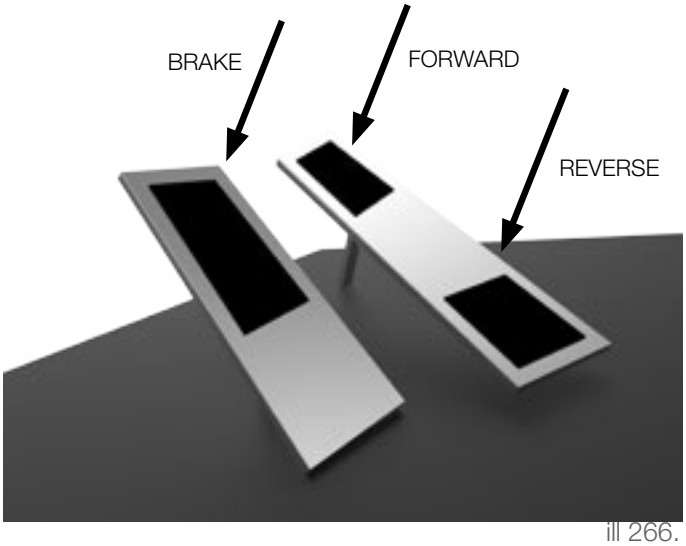
By utilising to support frames the steering assembly would be held in place at an optimal position for the driver ill. 262. The steering and seat should of course be adjustable to fit the different range of driver sizes OPENSHAW, S. and TAYLOR, E. (2006). This could be achieved by making the steering able to tilt and extend or retract in its mount. Furthermore the seat should be able to move back and forth as up and down. ill 264.



ill 264.

FINAL INTERFACE

ill 265.

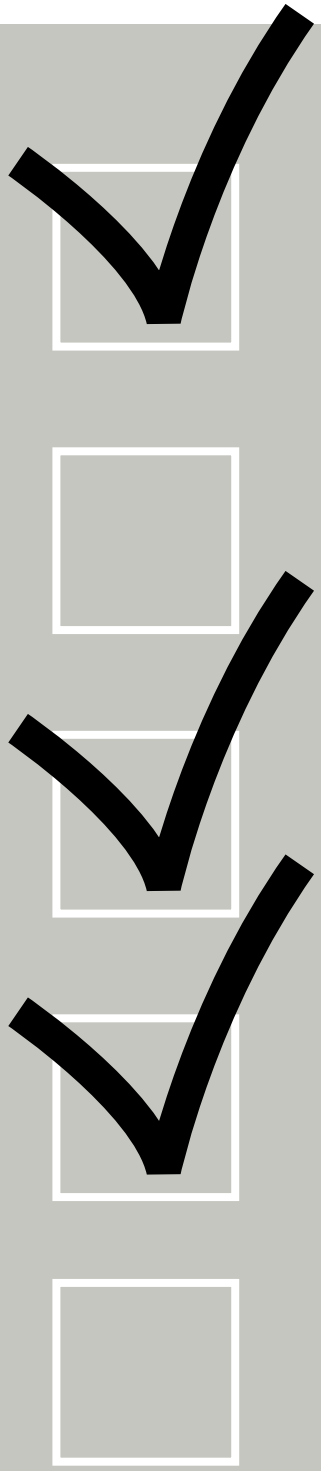


ill 266.

The final interface of the rhino vehicle is, apart from the overall identity of the vehicle, the place where it differs the most from the competition.
The steering offers the user a unique connection with the vehicle not seen before.
In order to validate the final interface concept the design team returned to the drivers of Aalborg municipality.
The overall concept was well received, and the broom controls in particular were deemed a good solution.
The drivers were intriqued by the progressive steering, however they also had their concerns regarding the sudden increase in steering sensitivity when turning.
They weren't rejecting the idea, however further testing was probably needed as the concept is hard to understand theoretically.
The touchscreen was also well received, however they had a slight concern in regards to opperating it with wet and dirty fingers. After explaining that this type of display often was used in heavy industrial settings and could cope with gloves as well, the concerns were minimized.

Even though having tested the handles and position of the steering along with simulated interaction, further testing is needed in order to verify the operation of the progressive steering.

ill 267.



05 | END PHASE

PROJECT EVALUATION

The end phase rounds of the overall project as it evaluates and discusses the final outcome and its prospects. The product is evaluated in order to ensure a strong connection between initial intentions and the finished product and to answer whether or not the product, from a design point-of-view, can be considered a success or not. The process is reflected upon to clarify fundamental elements throughout the project period - elements that to some extend has been surprising. Regardless of a succesful product or not, the overall project can have had a strong process. Finally future prospects of the product's implementation and development is discussed. The discussion clearifies how the product proposal can create value for Timan A/S as a manufacturer and a brief suggestion of what the future for city cleaning might look like.

PERSPECTIVES

IMPLEMENTATION

As the concept design of Rhino 7400 has focused primarily on the front end of the vehicle and the human/machine interaction, a large job lies in designing remaining parts. Engine, with all its add-ons, needs proper mounts and the whole hydraulic system with pump, reservoir, tubes, motors, outlets etc., needs to be designed and integrated into the product architecture. The waste container needs to be designed with focus on the tipping function, efficiency of the turbine, as well as emptying and cleaning. Manual suction hose and pressure washer need implementation in the rear part as well.

The aesthetic appearance of the vehicle would achieve an increased quality by working further with the lines and shapes, by e.g. clay modelling as it would enable the designers to get a very deep understanding of the shapes.

Since Rhino 7400 is conducted as a vehicle concept, some of the solutions might not be matching the visions and ressources from a smaller company like Timan A/S. The concept was purposedly inspired by MAYA (most advanced yet acceptable) in order to present Timan A/S with inspiration to forward strategies. Re-evaluating the Rhino concept into a vehicle fitting Timan A/S would be a necessity before considering any kind of production. The number and gravity of compromises would be up to the management.

Rhino 7400 differentiates significantly from competitors due to a radical expression and a modified interaction. This might be difficult to introduce with success in a conservative market, but research showed that the vehicles are often tested over a period of time before the drivers recommend a vehicle to management. By putting effort into advertisement of Rhino 7400 and giving the drivers a chance to try it out for themselves, it is believed that the well designed interaction and confident expression will be persuasive.

SCALABILITY

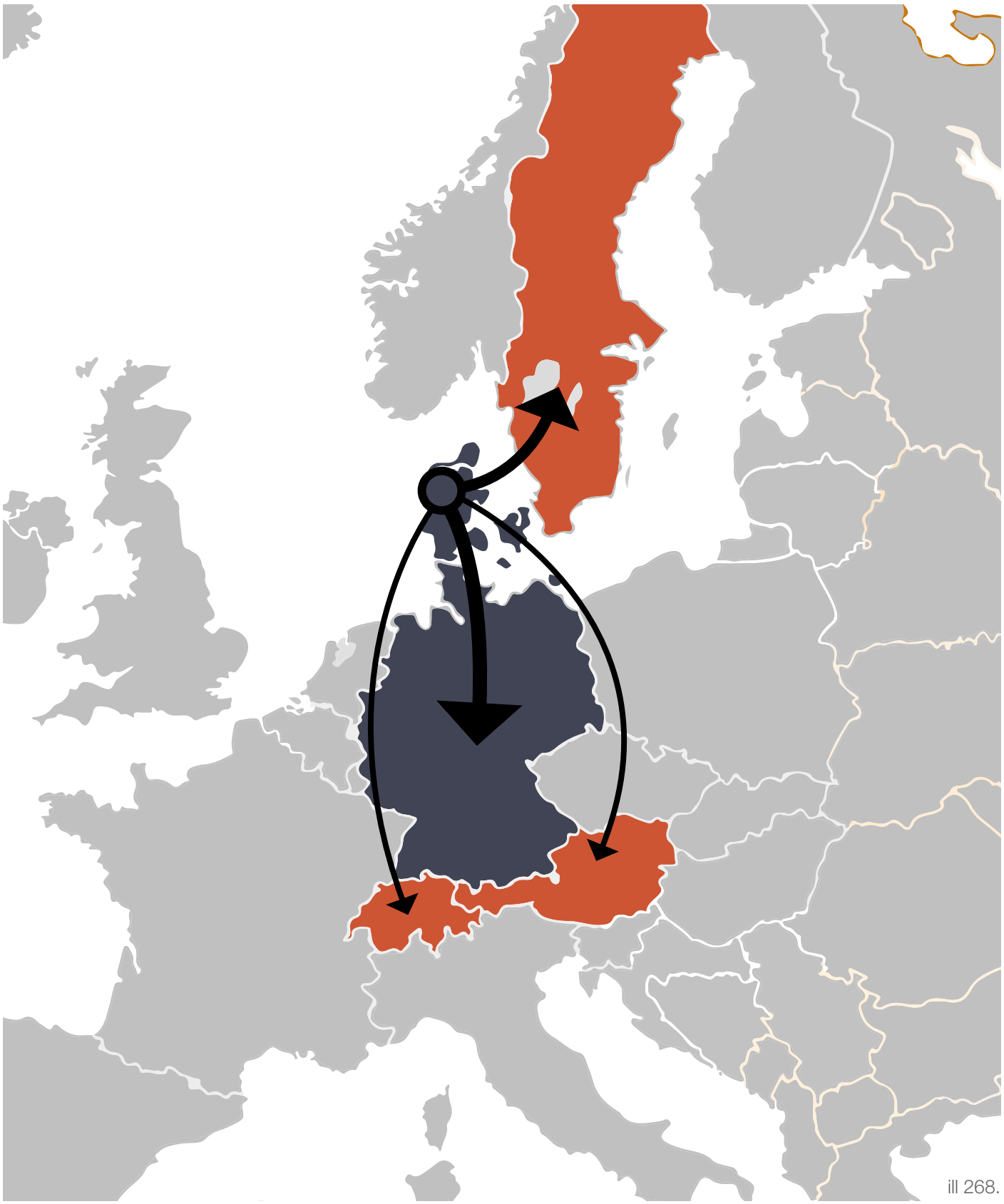
The society displays a trend where cities grow larger and municipalities having increased area to cover - where roads get wider and sidewalks get smoother. It appears as the market for larger and faster urban maintenance vehicles expands and not only nationally but also internationally. Expanding to european markets shows great potential as many have similar conditions as to which the Rhino 7400 is designed for.

Being designed on a structural platform, transitioning the Rhino 7400 would require reduced developmental resources. Configurations like the mini loaded, Tool-trac, and specialized lawn mowers can be considered if they hold suffient market potential.

FUTURE VEHICLES

Another trend in the society is how more and more products become electrical in order to decrease polution and reduce noise. Future versions of the urban maintenance vehicle will most likely be electrical, but a such radical change in the vehicle requires an extensive redesign. The overall value mission and emotional expression might be preserved but the structural changes calls for a new product architecture.

Studies to find out the best possible way to clean the streets might point out that manned sweeping vehicles are not the best solutions and perhaps the future street cleaning relies on drone technology.



ill 268.

PRODUCT EVALUATION

The initial project direction was a redesign of the traditional tool carrier. User research, however, quickly proved that the actual use of the complex tool carriers was far less versatile than anticipated by the manufactories and sales channels, as it appeared that the tool carriers are primarily used for two jobs: sweeping/suction during spring, summer, and fall, and a snow kit during winter. Jobs like mowing lawns, trimming hedges, or digging, are performed with specialized machinery and are therefore able to do a much faster and much better job. Project direction therefore quickly changed focus away from multi-equipment, and onto the specialized suction/sweeping job due to the large usage.

When analyzing existing product on market, a number of technical problems in various dimensions were derived - some due to poor designs while other were a results of a different usage than designed for. Despite the technical issues, it appears that the current products are all offsprings from a form-follows-function mentality and an attempt of competing on the technical area would result in smaller incremental changes. The market for city sweepers is saturated by large dominating players and any change for differentiation should come from an emotional approach. Interviews with the target users, the drivers, revealed a sense of unconfidence as they work through the streets.

A workshop with the target users led to keywords such as "performance" and "power" and became guiding factors in the design process where inspiration was taken from the animal kingdom. The identity of the vehicle originates therefore from the rhinoceros due to its aggressiveness and excessive strength. A rhino can be a persistent and forceful object as it rams through obsticles ans dozes anything off of its path.

With the identity of a rhino, the new urban maintanence vehicle can offer the user a solution to the previously experienced unconfidence. An overall value mission sounds:

"Have your confidence reinvented as you can now face the crowds with the Rhino tool-carrier - a machine designed to push forward, securely and effortlessly, despite any obsticle."

A series of aesthetical sketches and a number of full size experiments helped guiding the ideation of of the preliminary vehicle concept and ensured the desired emotional expression as well as paying attention to driving comfort. Product architecture was determined with focus on the interrelation between the various parts, and final detailing for most relevant parts.

Human/machine interaction has been in focus throughout the process as it accounts for a large part of the vehicles emotional value. The interface takes its inspiration in the racing world and is designed with focus on the intensity and speed of the Rhino 7400. The drivers job is to control the rhino beast and must preserve a firm grip on the steering unit at all times. Primary tool controls are therefore placed within fingers reach and secondary vehicle controls are placed within arms reach.

In addition to matching the identity of the vehicle and being secure, the interface is designed with a high sense of simplicity. The tool controls are devided into right and left and controlled by the respective hand. The vehicle control happens through a projected capacitive touchscreen and enables the user to interact despite gloves or dirty fingers. The interface is tailored to the mounted tool and the driver needs no longer to navigate a number of unlabelled and generic buttons.

With a strong identity and a user friendly interface the driver can confidently drive through the city while performing a good job.

REFLECTION

A PROCESS WITH A TWIST

When looking back and reflecting over the process of creating the Rhino urban maintenance vehicle, a lot of things spring to mind. The initial choice of the project theme was due to a common technical interest from both team members, and the project seemed like a great opportunity to excel within this field. However as the project evolved the team reached the conclusion that in order to create a vehicle that differentiated itself on the market, a more emotional and aesthetic approach would have to be utilized. This threw the project team out on deep waters as this was not the key area of competence, and not what the team had expected when choosing the project. However doing a project with heavy weight on these factors has proved to be a great learning experience.

SCOPE OF THE PROJECT

The project group knew when setting off that the scope of the project was very wide, and the product very complex. It was believed that delimitation wouldn't be a huge problem, and that the team would be able to cope with the assignment. Seen in the hindsight both team members agree that taking on this project has been a mouthful and have resulted in a process that not always have reached the desired depth of detail. It was believed that the delimitation of vehicle parts would be possible, however the complexity of the vehicle meant that everything was connected, and a clean cut delimitation wasn't possible, and in order to create a vehicle that was as complete as possible, detail depth have suffered.This is a learning experience and something the team members will be aware of from now on when having to deal with real world tasks.

WORKING WITH A COMPANY

The choice of working together with a company originated in a need to do a project tethered to the real world, and in order to get an understanding of how working together with a client would be. It was furthermore believed that the company could help the project team to reach a higher level of completion within the project. However throughout the project the interaction with the chosen company has been limited, and reduced to the original assignment provided. This has nothing to do with the company but was more a result of the project team actually taking a step back from the original assignment and through our own research phase traveling along a different tangent than initially anticipated.

USER INSPIRED PROCESS

The user provided insight into the world of city sweeping has been invaluable for the project, and proved to become the cornerstones of many of the decisions and design features of the product.In the mind of the project team this user inspired design has given offset for the emotional design process, being the source to product differentiation in a field of otherwise functional driven design proposals.

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ILLUSTRATIONS

All illustrations, Cad models, and pictures are created by the design team with the exeption of the following:
All sourced has been accessed and verified on 20/05-2015

ill 1, 5 - http://www.timan.dk/dk/vpm-3400.html
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ill 13 - http://www.hako.dk/imageGen.ashx?image=/media/1468309/foto-2.jpg&Constrain=true&pad=true&transparent=false&BgColor=000000&Compression=50&format=jpegill 29 - Tinna
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ill 255 - http://www.wht.by/images/i/15/01/07/wht-222704-281-2.jpg

CONTENT OF APPENDIX

AD:MT

DEPARTMENT OF ARCHITECTURE, DESIGN & MEDIA TECHNOLOGY