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APPENDIX 1: BROCHURE

WOODY

This brochure has been made for the marketing department of Ice-World, this brochure could help Ice-World to attract new customers.
Woody is a boarding system that is made up from four main components:

01 The base
The base is produced from galvanized steel, enables on ice and below ice placement and is easy to (de)assemble during transport and storage.

02 The planks
The five planks are produced from Platowood – an environmentally friendly and durable material.

03 The handrail
The handrail, in Ice-World’s signature colour, is a round 3cm wide rail that provides the skater with plenty of comfort when holding on to the handrail. A ridge on the backside of the handrail ensures extra grip.

04 The support
There are two supports on each side of the panel. The support structures keep the 4 planks in the right place and provide enough stiffness to endure high impact.
KEY ELEMENTS OF THE REDESIGN

SUSTAINABLE
Woody is made from 100% recyclable materials – including galvanized steel for the support and base and Platowood for the planks. Platowood is a special type of wood that is environmentally friendly and especially suited for recycling. Unlike commonly used woods, Platowood is not impregnated with chemicals but it is ‘platonized’. Platowood is made weatherproof and more durable by just using water and heat.

SAFETY
The dimensions of Woody are fully compliant with all relevant international safety standards. The height and dimensions of gaps in Woody prevent accidents from happening.

MORE ICE SURFACE
Woody is constructed to be placed both on top of and underneath the ice. Placing Woody underneath the ice layer increases the surface area of ice - on average Woody can provide an extra 9m² usable area.

LONGER LIFESPAN
Platowood exhibits properties that exceed the properties of ‘normal’ wood. The lifespan of Platowood is improved by approximately 23% compared to the standard impregnated wood (Source: www.platowood.com). Due to an improved construction and optimal measurement of the boarding system, a longer lifespan can be achieved as well.

LOW MAINTENANCE
Platonomizing decreases the level of moisture in the wood, making it more resistance to swelling and shrinking. The improved properties of Platowood will obviate the need for repairing cracks and deformations – making it a very low maintenance material.

TWICE AS MANY SPONSORING OPPORTUNITIES
Woody offers customer twice as much surface area for sponsoring due to a symmetric design. With woody, the customer can easily attach sponsoring to the boarding – both on the inside and outside of the construction.

PERFECT FIT
The system is built to fit the need of every customer. Unlike other boarding systems, the different sized panels of woody can easily create any standard sized ice rink. The entire system consists of multiple components to be able to build a full boarding around the ice rink.

FINISH
The panels are constructed in such a way that hardware is not visible for the users inside the rink - creating a very clean and modern look. The screws on the outside of the boarding are sunken into the material to create a very smooth and clean surface. See image xx.
APPENDIX 2: CALCULATION BOARDING/AIR RATIO

This calculation shows how much air there is present in relation to boarding on 1 palet. This includes only the boarding on top of the palet, the palet is not taken into account.

Volume boarding:
8 boarding sections are normally transported on 1 palet.

Dimensions wooden board:
- Length: 5000 mm
- Width: 40 mm
- Height: 40 mm
- Volume: 19575000 x 4 = 78300000 mm³

Dimensions boarding stand pole:
- Length: 1000 mm
- Width: 40 mm
- Height: 40 mm
- Volume: 1600000 x 3 = 4800000 mm³

Dimensions boarding stand base:
- Length: 400 mm
- Width: 320 mm
- Thickness: 5 mm
- Volume: 6400000 x 3 = 1920000 mm³

Total volume: 85020000 x 8 = 680160000 mm³

Volume area above Palet:
Length palet is 5500 mm.
- Length: 5500 mm
- Width: 1100 mm
- Height: 1027 mm
- Volume: 6213350000 mm³

Ratio:
\[ \frac{(6213350000 - 680160000)}{6213350000} \times 100\% = -89\% \]

APPENDIX 3: HAND CALCULATIONS

A meeting with a material expert at Civil engineering, P.C.J. Hoogenboom. It was advised that simulating the wood with Solidworks was possible, but the stresses present are not represented by the von mises but by sigma one. Besides the simulations in Solidworks, the expert mentioned that hand calculation were also possible in this situation.

Calculation bending stress in steel stand:
- E-modulus: 210 GPa
- Length: 1100 mm
- Surface moment of Inertia: \(2 \times ((bh^3 – (b-2w)(h-2w)^3)/12)\)
  - 30x30x3 = 79704 mm⁴
  - 40x30x3 = 101664 mm⁴
  - 50x30x3 = 123624 mm⁴
  - 50x30x4 = 150464 mm⁴
- Force: 2021 N
- Moment: 2223100 Nmm
- Distance to neutral line = y : 15 mm
- Yield strength : 235 MPa
- \(\Sigma = \frac{M \times y}{I} = \frac{2223100 \times 15}{79704} = 418,38\) MPa

Calculation bending stress in plank:
- E-modulus: 10514 MPa
- Length: 1900 mm
- Surface moment of Inertia: \((bh^3)/12\)
  - 185x27 = 303446,25 mm³
- Force: 2021 N
- Moment: 959975 Nmm
- Distance to neutral line = y : 13,5 mm
- Bending strength : 79 MPa
- \(\Sigma = \frac{M \times y}{I} = \frac{959975 \times 13,5}{303446,25} = 42,70\) MPa

These calculations are shown here and show the plank meets the requirements, but the frame needed for the increased load is 50x30x4. The expert also mentioned the wooden planks not having an influence on the behavior of the frame during impact of the load directly on the frame. So, simulation with only the frame would suffice.

Calculation bending stress in plank:
- Angle = \(\frac{FL^2}{16EI}\) = \(\frac{(2021 \times 1900^2)}{(16 \times 10514 \times 303446,25)} = 0,142\) rad = 8,14 degrees
- \(\sin (8,14) = \frac{A}{20} \rightarrow A = 2,8\) mm is the distance the plank will detach from the frame.
- This means the under maximum load the screws holding the plank to the frame will only be pulled out of the wood by 2,8 mm, preventing the plank from detaching.
The simulations are used to compare to the hand calculations and prove they are correct.

Image 6: Simulation 30x30x3

Image 7: Simulation 30x40x3
## APPENDIX 4: COMPARISON TRANSPARENT VS WOODEN BOARDING

This table shows a comparison between wooden boarding and transparent boarding.

<table>
<thead>
<tr>
<th></th>
<th>Wooden</th>
<th>Transparent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard size (m)</td>
<td>1.98</td>
<td>5</td>
</tr>
<tr>
<td>Transport volume (m³/palet)</td>
<td>7.26</td>
<td>3.81</td>
</tr>
<tr>
<td>Transport amount (sections/palet)</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>Transport amount (m/palet)</td>
<td>15</td>
<td>100</td>
</tr>
<tr>
<td>Cost price (euro/m)</td>
<td>18.17</td>
<td>67.22</td>
</tr>
<tr>
<td>Rental price (euro/m)</td>
<td>40</td>
<td>8</td>
</tr>
<tr>
<td>Weight (kg/m)</td>
<td>9.2</td>
<td>12</td>
</tr>
<tr>
<td>Proposed life span (years)</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Meters/stand</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

- **Wooden**: 1.98 m, 7.26 m³/palet, 40 sections/palet, 15 m/palet, 18.17 euro/m, 40 euro/m, 9.2 kg/m, 5 years, 2 meters/stand.
- **Transparent**: 5 m, 3.81 m³/palet, 50 sections/palet, 100 m/palet, 67.22 euro/m, 8 euro/m, 12 kg/m, 5 years, 2 meters/stand.
Ice-World does not stop where the ice rink ends. Ice-World offers lots of accessories that can be used to improve on the ice experience. When present at the ice rink it cannot be mistaken that ice world is active, because every accessory has in some form or way the color orange incorporated.

- Bobby the seal
- Tommy the reindeer
- Icebyk
- Curling stones
- The base
- Fun slide tube
- Protection
- Ice maintenance
- Cold Fingers

It is not only the colour orange through which Ice-World lets the user know it is their product. Ice-World also does this by putting their name on almost everything. (see fig xx.). The color orange is also solely used on rental ice rinks. Ice world sells blue skating aids for example. This means that when visiting a certain ice rink, it makes it easy to spot which one is an Ice-World rink.

The colour orange can be seen as typical Dutch. In the Netherlands, this is acceptable, but in other countries orange is not always the preferred colour [Guido, Manager R&D, 2018] and when an ice rink is not up to company standards this could also be a disadvantage, because everyone can see who delivered the poor quality.

From certain products like the cold fingers it shows that Ice-World is innovating on how to create the best ice possible and create lots of other activities besides skating.

It must be acknowledged that even though Ice-World has all these products in their portfolio. Ice-World only assembles their own wooden boarding and ice rink piping system.

Conclusions

Ice world did not yet explore the relation between the different product groups. This might be an interesting search area.

Ice world has a clear corporate identity which revolves around the color orange. Looking at the portfolio this becomes quite clear. Besides the color Ice-World places their logo on every product. One of the reasons for this is to prevent theft, but also to have exposure.
APPENDIX 6: VISIT LAREN

The visit in Laren was the first site visit done. This visit showed a lot of problems with the current system and showed the entire process of the boarding installation. This visit was done on 21 November 2018.

Foto description:

1. Wooden boarding that has been unloaded at Laren.
2. The handrail that has been bent through strapping down the sections to the pallet.
3. A boarding stand that has shifted and misaligned through strapping down the sections to the pallet.
4. An overview of how boarding sections deform through current transport method.
5. Placing the first boarding section.
6. A distance piece that is in the way of placing the boarding stand and needs to be moved out of the way with force.
7. A distance piece that is in the way of placing the boarding stand and needs to be moved out of the way with force.
8. Boarding sections that are not yet connected show the amount of deformation that occurs.
9. A staple used to attach sponsoring which was left from previous season.
10. Boarding sections that are not yet connected that does not align properly.
11. Boarding placed around a tree that does not have the right size.
12. Boarding placed around a tree that does not have the right size.
13. An Ice-World employee connecting 2 sections to each other to align the handrail.
14. A corner of the boarding that show how the boarding does not align properly.
15. An Ice-World employee making preparations to cut the boarding to size.
16. The final result of the boarding cut to size.
17. The final result of the boarding cut to size.
18. Repurposed section to a shorter one, where the Ice-World signing now is placed out of centre.
APPENDIX 7: VISIT RAI

This visit was done for a big recreational event in the RAI in Amsterdam. This event uses transparent boarding. This visit gives insight in the problems and process of installing transparent boarding.

Foto description:

1. 2 Ice-World employees attaching an end piece to the boarding.
2. A smaller than standard transparent sections used to make the total boarding fit the required dimensions. The construction used to create a corner.
3. A piece of handrail previously cut at another event.
4. A curve of transparent boarding that does not align with the curve the rink requires.
5. Boarding that is too long and therefore starts bending.
6. Three different corners solved in with a different method.
7. Handrail that is misaligned and shows discoloration.
8. An Ice-World employee cutting a transparent boarding section to size.
APPENDIX 8: VISIT ARNHEM

In Arnhem Ice-World did a pilot test with assembling the entire boarding on site and transporting every part separately.

Foto description:

1. A package of boarding stands.
2. A package of 5m wooden boards.
3. 2 Ice-World employees transporting wooden boards by hand.
4. Ice-World employees using the wooden boards to place the stands at the right distance.
5. Ice-World employees using the wooden boards to place the stands at the right distance.
6. Overview of the main ice rink with most of the boarding stands placed.
7. Some of the first boards that are attached to the stands.
8. Some of the first boards that are attached to the stands.
9. 2 boarding stands interfering with each other in the corner.
10. Corner construction of the boarding.
11. Overview of main ice rink, with wooden boards placed every 5m.
12. Second rink finished half way.
APPENDIX 9: CUSTOMER LIGHTING IMPLEMENTATION

This collage shows images of customer integrating lighting onto and into the boarding and ice rink. This shows a need from the customers for lighting integration into the ice rink. This could be an interesting design direction and business opportunity.
APPENDIX 10: PROFESSIONAL LIGHTING IMPLEMENTATION

This collage shows ice skating events where lighting has a significant influence on the atmosphere of the event. An interesting fact is that there is a lot invested into the illumination around the ice rink, but when you look closely the boarding play not a single role in the entire setup.

Image 12: Collage professional lighting
APPENDIX 11: BOARDING LIGHTING CONCEPT

Ice-World did start with boarding system with integrated lighting but did not continue with the design, as Ice-World presumed that there was no market for it. Research shows otherwise and would be a good investment.

Foto description:

1. LED-strip integrated into transparent handrail.
2. Powersupply of the LED-strip, attached on the backside of the stand.
3. LED-strip integrated into the current orange handrail.
4. A top view of the transparent handrail.
5. An overview of the boarding concept.
6. A close up of the connection and integration of the LED-Boarding
APPENDIX 12: CONCEPT 1

This appendix shows extra images of concept 1. This concept is inspired by the current wooden boarding Ice-World carries.

Image 13: Example setup for corner.

Image 14: Detail of left and right side frame.

Image 15: Base concept 1

Image 17: Detail connection between planks and frame.

Image 16: Right side frame
Image 18: Storage of concept 1 panels.

Image 19: Storage of concept 1 bases.

Image 20: Overview concept 1 on ice rink.

Image 21: Sideview concept 1 on ice rink.

Image 22: Detail of corner connection.
Underneath the ice rink system.

<table>
<thead>
<tr>
<th>Onderdeel</th>
<th>Concept 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paneel 2,04</td>
<td>34</td>
</tr>
<tr>
<td>Paneel 0,59</td>
<td>2</td>
</tr>
<tr>
<td>Paneel 2</td>
<td>2</td>
</tr>
<tr>
<td>Paneel 2</td>
<td>14</td>
</tr>
<tr>
<td>Voet laag</td>
<td>14</td>
</tr>
<tr>
<td>Voet hoog</td>
<td>36</td>
</tr>
<tr>
<td>Hoekvoet</td>
<td>2</td>
</tr>
<tr>
<td>Hoekprofiel</td>
<td>4</td>
</tr>
<tr>
<td>Handrail hoekje</td>
<td>4</td>
</tr>
<tr>
<td>Totaal</td>
<td>112</td>
</tr>
<tr>
<td># Ver. Ond.</td>
<td>9</td>
</tr>
</tbody>
</table>

On top of the ice rink system.

<table>
<thead>
<tr>
<th>Onderdeel</th>
<th>Concept 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paneel 2,04</td>
<td>34</td>
</tr>
<tr>
<td>Paneel 0,59</td>
<td>2</td>
</tr>
<tr>
<td>Paneel 0,82</td>
<td>2</td>
</tr>
<tr>
<td>Paneel 2</td>
<td>14</td>
</tr>
<tr>
<td>Voet</td>
<td>48</td>
</tr>
<tr>
<td>Hoekvoet</td>
<td>4</td>
</tr>
<tr>
<td>Hoekprofiel</td>
<td>4</td>
</tr>
<tr>
<td>Handrail hoekje</td>
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<tr>
<td>Totaal</td>
<td>112</td>
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<tr>
<td># Ver. Ond.</td>
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</tbody>
</table>

These tables show the amount of different parts needed to create an entire boarding on an average ice rink. A comparison is done between a system on top of the ice rink system and underneath the ice rink system.
APPENDIX 13: CONCEPT 2

This appendix shows extra images of concept 2. This concept is inspired by the modular fencing used in architecture.

Image 25: Example setup for corner.

Image 26: Detail of support with stop plate.

Image 27: Corner support.

Image 28: Detail of connection plank to support.

Image 29: Exploded view of concept 2.
Image 30: Storage of concept 2 planks.

Image 31: Storage of concept 2 supports.

Image 32: Overview concept 2 on ice rink.

Image 33: Sideview concept 2 on ice rink.

Image 34: Detail of corner connection.
Underneath the ice rink system.

These tables show the amount of different parts needed to create an entire boarding on an average ice rink. A comparison is done between a system on top of the ice rink system and underneath the ice rink system.

On top of the ice rink system.
This appendix shows extra images of concept 3. This concept is inspired by the transparent boarding of Ice-World with the aneled profiles used to create the water basing integrated into the support.
Underneath the ice rink system.

These tables show the amount of different parts needed to create an entire boarding on an average ice rink. A comparison is done between a system on top of the ice rink system and underneath the ice rink system.

<table>
<thead>
<tr>
<th>Onderdeel</th>
<th>Concept 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paneel 2,04</td>
<td>34</td>
</tr>
<tr>
<td>Paneel 0,58</td>
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</tr>
<tr>
<td>Paneel 1</td>
<td>2</td>
</tr>
<tr>
<td>Paneel 2</td>
<td>14</td>
</tr>
<tr>
<td>Rails 2,04</td>
<td>34</td>
</tr>
<tr>
<td>Rails 0,58</td>
<td>2</td>
</tr>
<tr>
<td>Rails 100</td>
<td>2</td>
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<tr>
<td>Rails 200</td>
<td>14</td>
</tr>
<tr>
<td>Hoekprofiel</td>
<td>4</td>
</tr>
<tr>
<td>Handrail hoekje</td>
<td>4</td>
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<td>Totaal</td>
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<tr>
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On top of the ice rink system.

<table>
<thead>
<tr>
<th>Onderdeel</th>
<th>Concept 3</th>
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<tbody>
<tr>
<td>Paneel 2,04</td>
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<td>Paneel 0,46</td>
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<td>Paneel 0,395</td>
<td>4</td>
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<td>Hoekrails 0,46</td>
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<td>Hoekrails 0,395</td>
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</tr>
<tr>
<td>Totaal</td>
<td>118</td>
</tr>
<tr>
<td># Ver. Ond.</td>
<td>11</td>
</tr>
</tbody>
</table>
APPENDIX 15: ASSEMBLY AND INSTALLATION TIME COMPARISON

This table shows the comparison between the three concepts on assembly and installation time. Concept one and concept three are both panels that are pre-assembled once. Concept two will be assembled and disassembled every year at the ice rink. This comparison was made to research the effects of a pre-assembled system or assembling on site.

Forty-five panels of two-meter have been used for this comparison. The table shows concept two has the lowest assembly time, and concept three has the most economical installation time. For concept one and three, the assembly time is taken into account only the first year, but for concept two, the install time is including ‘assembly time’. For the first year concept, two has the lowest assembly time, which is expected, but for the other years, concept 3 has the lowest overall time. When comparing concept one and two, the table shows that after five years, a pre-assembled concept is preferred.

APPENDIX 16: RANKING THE CRITERION

This table shows how the criteria have been ranked. These methods place every criterion against each other to be able to decide if it is more important or not. When this is done for every criterion, a ranking is a final outcome.

These criteria have been selected in collaboration with Ice-World.
APPENDIX 17: OVERVIEW PROPERTIES POSSIBLE MATERIALS

This table was made to compare the different materials that have been analysed as possible materials for the boarding. The table shows that Platowood is the best choice compared to the other alternatives. Impregnated Vuren is what is currently used.

<table>
<thead>
<tr>
<th>Material</th>
<th>Govaplast</th>
<th>KLP</th>
<th>Duofuse</th>
<th>Platowood</th>
<th>Nobelwood</th>
<th>Imp. Vuren</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-mod (N/mm²)</td>
<td>572</td>
<td>1000</td>
<td>1832</td>
<td>10514</td>
<td>12000</td>
<td>10800</td>
</tr>
<tr>
<td>Bending strenght (Mpa)</td>
<td>15,7</td>
<td>12</td>
<td>16,9</td>
<td>79</td>
<td>18</td>
<td>24</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>960</td>
<td>850</td>
<td>1300</td>
<td>400</td>
<td>580</td>
<td>600</td>
</tr>
<tr>
<td>Cost (€/m)</td>
<td>9,55</td>
<td>9,83</td>
<td>9,1</td>
<td>6,32</td>
<td>14,5</td>
<td>1,88</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Property</th>
<th>Govaplast</th>
<th>KLP</th>
<th>Duofuse</th>
<th>Platowood</th>
<th>Nobelwood</th>
<th>Imp. Vuren</th>
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</thead>
<tbody>
<tr>
<td>Splinter</td>
<td>nee</td>
<td>nee</td>
<td>nee</td>
<td>ja</td>
<td>ja</td>
<td>ja</td>
</tr>
<tr>
<td>Moisture absorption</td>
<td>nee</td>
<td>nee</td>
<td>ja</td>
<td>ja</td>
<td>ja</td>
<td>ja</td>
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<tr>
<td>Recyclability</td>
<td>Ja</td>
<td>Ja</td>
<td>ja</td>
<td>ja</td>
<td>ja</td>
<td>Nee</td>
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<td>Coloring</td>
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<td>nee</td>
<td>ja</td>
<td>ja</td>
<td>ja</td>
<td>ja</td>
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<td>Lifespan</td>
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<td>50</td>
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<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

APPENDIX 18: CONCEPT COST PRICE ESTIMATION AND STORAGE VOLUME

This table shows the cost price estimation of the concepts. It can be concluded that the prices and weights of the concepts are very close to each other.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Prijs (€)</th>
<th>Gewicht (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>20,335</td>
<td>8,134</td>
</tr>
<tr>
<td>1</td>
<td>14,2575</td>
<td>5,703</td>
</tr>
<tr>
<td>4</td>
<td>50,56</td>
<td>13,136</td>
</tr>
<tr>
<td>5</td>
<td>85,1525</td>
<td>26,973</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Concept</th>
<th>Prijs (€)</th>
<th>Gewicht (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>63,2</td>
<td>18,515</td>
</tr>
<tr>
<td>1</td>
<td>22,64</td>
<td>9,056</td>
</tr>
<tr>
<td>85,84</td>
<td>27,571</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Concept</th>
<th>Prijs (€)</th>
<th>Gewicht (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>26,3</td>
<td>4,721</td>
</tr>
<tr>
<td>frame</td>
<td>9,92</td>
<td>6,197</td>
</tr>
<tr>
<td>rails</td>
<td>43,995</td>
<td>17,598</td>
</tr>
<tr>
<td></td>
<td>80,215</td>
<td>28,516</td>
</tr>
</tbody>
</table>

This table shows the storage volume of the different concepts.
APPENDIX 19: CALCULATION
BOARDING LENGTH AND
PANELS NEEDED

<table>
<thead>
<tr>
<th>Boarding length</th>
<th>2.04</th>
<th>1.02</th>
<th>0.815</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.95</td>
<td>4</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>20.15</td>
<td>9</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>30.35</td>
<td>14</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>35.45</td>
<td>16</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>40.55</td>
<td>19</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>45.65</td>
<td>21</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>55.85</td>
<td>26</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>66.05</td>
<td>31</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>106.85</td>
<td>51</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

This table shows examples solutions of the formula that describes the actual length of the ice rink system where boarding can be placed upon. This shows the length is not straightforward, which explains the fact boarding has to be adjusted on site.

Although the maximum length of a ice rink is 55m, the system is capable for use on even longer systems.

APPENDIX 20: ALTERNATIVE CONFIGURATIONS

Image 47: Configuration 195mm x4

Image 48: Configuration 147mm x5

Image 49: Configuration 195mm x5
**APPENDIX 21: SPONSOR FASTENING CHOICE**

<table>
<thead>
<tr>
<th>Concept</th>
<th>Screws</th>
<th>Hooks</th>
<th>Handrail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment cost</td>
<td>D</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dimension visibility</td>
<td>A</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sponsor material freedom</td>
<td>T</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Complexity</td>
<td>U</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vulnerability</td>
<td>M</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Damaging the boarding</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Total +</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total -</td>
<td>-</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Total =</td>
<td>-</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

The table shows the datum method that was used to see what method would fit the boarding best. The outcome is that the screws currently used still have the most benefits and should be used in the redesign as well.

Using hooks is a principle used in the market of field sports like hockey, you often see the surrounding fence covered in sponsoring. The sponsor panels have hooks attached to them that attach to the hand railing of the fence.
## APPENDIX 22: COST CALCULATION BOARDING PANELS

<table>
<thead>
<tr>
<th>Length of Wood</th>
<th>Item</th>
<th>Unit</th>
<th>Price/unit</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2m Platowood</td>
<td>Screws</td>
<td>21</td>
<td>0.04</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>Planks</td>
<td>8</td>
<td>6.32</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>Frames</td>
<td>4.369</td>
<td>2.5</td>
<td>21.845</td>
</tr>
<tr>
<td></td>
<td>Base</td>
<td>6.443</td>
<td>2.5</td>
<td>16,1075</td>
</tr>
<tr>
<td></td>
<td>Handrailing</td>
<td>2</td>
<td>8.75</td>
<td>17.5</td>
</tr>
<tr>
<td></td>
<td>Labor</td>
<td>0.11</td>
<td>17</td>
<td>108.7225</td>
</tr>
<tr>
<td>2m Imp. wood</td>
<td>Screws</td>
<td>21</td>
<td>0.04</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>Planks</td>
<td>8</td>
<td>1.88</td>
<td>15.04</td>
</tr>
<tr>
<td></td>
<td>Frames</td>
<td>4.369</td>
<td>2.5</td>
<td>21,845</td>
</tr>
<tr>
<td></td>
<td>Base</td>
<td>6.443</td>
<td>2.5</td>
<td>16,1075</td>
</tr>
<tr>
<td></td>
<td>Handrailing</td>
<td>2</td>
<td>8.75</td>
<td>17.5</td>
</tr>
<tr>
<td></td>
<td>Labor</td>
<td>0.11</td>
<td>17</td>
<td>73,2025</td>
</tr>
<tr>
<td>2.04m Platowood</td>
<td>Screws</td>
<td>21</td>
<td>0.04</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>Planks</td>
<td>8.16</td>
<td>6.32</td>
<td>51,5712</td>
</tr>
<tr>
<td></td>
<td>Frames</td>
<td>4.369</td>
<td>2.5</td>
<td>21,845</td>
</tr>
<tr>
<td></td>
<td>Base</td>
<td>6.443</td>
<td>2.5</td>
<td>16,1075</td>
</tr>
<tr>
<td></td>
<td>Handrailing</td>
<td>2.04</td>
<td>8.75</td>
<td>17.85</td>
</tr>
<tr>
<td></td>
<td>Labor</td>
<td>0.11</td>
<td>17</td>
<td>110,0837</td>
</tr>
<tr>
<td>2.04m Imp. wood</td>
<td>Screws</td>
<td>21</td>
<td>0.04</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>Planks</td>
<td>8.16</td>
<td>1.88</td>
<td>15,3408</td>
</tr>
<tr>
<td></td>
<td>Frames</td>
<td>4.369</td>
<td>2.5</td>
<td>21,845</td>
</tr>
<tr>
<td></td>
<td>Base</td>
<td>6.443</td>
<td>2.5</td>
<td>16,1075</td>
</tr>
<tr>
<td></td>
<td>Handrailing</td>
<td>0.931</td>
<td>8.75</td>
<td>8,14625</td>
</tr>
<tr>
<td></td>
<td>Labor</td>
<td>0.11</td>
<td>17</td>
<td>64,14955</td>
</tr>
</tbody>
</table>

This overview shows the cost calculation of all the different panels within the boarding system. A comparison has been done between platwood and impregnated wood, the total shows the difference in price.
APPENDIX 23: TECHNICAL DRAWINGS
IDE Master Graduation
Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student’s registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

stoffel IDE TU Delft - E&SA Department /// Graduation project brief & study overview /// 2018-01 v30

STUDENT DATA & MASTER PROGRAMME
Save this form according the format “IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy”. Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1!

family name: van Erven
initials: JA
given name: Jeroen
student number: 4112237
street & no.: Statensingel 40C
zipcode & city: 3039 LN Rotterdam
country: Netherlands
phone: +31 6 23344160
e-mail: javanerven@gmail.com

Your master programme (only select the options that apply to you):
IDE master(s): [ ] IPD [ ] DfI [ ] SPD
2nd non-IDE master:
individual programme: - - (give date of approval)
honours programme: [ ] Honours Programme Master
specialisation / annotation: [ ] Medisign
[ ] Tech. in Sustainable Design
[ ] Entrepreneurship

SUPERVISORY TEAM **
Fill in the required data for the supervisory team members. Please check the instructions on the right!

** chair: S.G. van de Geer
department/section: ID/DA
organisation: Ice-World International
city: Soest
country: Netherlands

** mentor: C.P.J.M. Kroon
department/section: DE/PAD
organisation: -
city: -
country: -

2nd mentor: G. Molenaar
organisation: -

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v.

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.
**Procedural Checks - IDE Master Graduation**

**APPROVAL PROJECT BRIEF**
To be filled in by the chair of the supervisory team.

chair       S.G. van de Geer               date       -       -       signature       _____________________________

**CHECK STUDY PROGRESS**
To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total:       _______     EC
Of which, taking the conditional requirements into account, can be part of the exam programme:       _______     EC
List of electives obtained before the third semester without approval of the BoE:

☐ YES       all 1st year master courses passed
☐ NO       missing 1st year master courses are:

name       _____________________________       date       -       -       signature       _____________________________

**FORMAL APPROVAL GRADUATION PROJECT**
To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks?
- Does the composition of the supervisory team comply with the regulations and fit the assignment?

Content:       ☐ APPROVED       ☐ NOT APPROVED
Procedure:       ☐ APPROVED       ☐ NOT APPROVED

name       _____________________________       date       -       -       signature       _____________________________

IDE TU Delft - E&SA Department /// Graduation project brief & study overview /// 2018-01 v30

Initials & Name       JA van Erven       Student number       4112237
Title of Project       A New Ice Rink Boarding, Creating a Competitive Advantage
A New Ice Rink Boarding, Creating a Competitive Advantage

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

**INTRODUCTION**

This graduation project will be executed for a company called Ice-World. Ice-World International was founded in 1992 by Wim Hoeks and is currently the world market leader in temporary mobile ice rinks. Wim Hoeks started in the swimming pool business but soon found out that the system used for heating the water could be used to freeze it as well. Now Ice-World is able to place ice rinks pretty much anywhere. The headquarters, production facility and warehouse are located in Soest. Ice-World International also has sales offices in Germany and China and an international network of partners. At the headquarters in Soest around 30 employees in different departments make sure everything goes as planned.

Every year Ice-World places around 600 ice rinks all around the globe, about 40 of them are placed in the Netherlands. The average time a rink is used is 30,6 days and has an average surface of 492 m2. The system used by Ice-World to create these rinks is patented and make use of aluminum fold-able tubes. When the system is in place, the boarding of the ice rink is placed on top and after water is added, the boarding anchors within a layer of ice. To get the water to freeze, a chiller and an environmentally friendly cooling agent is used. This cooling agent is called propylene glycol. Ice-World tries its best to be as environmentally friendly as possible. Not only by using the right cooling agent, but also the system uses 40% less energy as systems using rubber to house the glycol. Using the aluminum system also means the water can be frozen faster because of the higher conductive coefficient. Besides the fact Ice-World tries to reduce its ice rink energy consumption, they also compensate the CO2-emission of their ice rinks by planting trees in the mangrove of Myanmar and the use of wind energy.

Ice-World’s biggest market is renting out ice rinks, besides selling them as well. To be able to fulfill the needs of the clients every year, a massive amount of systems is kept in storage. When the time comes to build an ice rink the materials and systems needed to build the rink are taken out of storage and shipped to the expected location. When the systems arrive at the location, a team of builders from Ice-World make sure the rink is built to expectation. In this entire process the key factors are: build time, first time right delivery, transportation and storage volume. These factors all influence the cost of the ice rink not only for the client, but for Ice-World as well. When the season is over, all the systems return to Ice-World and are checked for failing parts. Ice-World tries to re-use as much as possible the next year.

When looking at the product portfolio of Ice-World, it is not only ice rinks they provide. Ice-World makes sure the client has everything he or she needs to provide a full experience for the ice skater. Think of skate, helmets, different types of boarding, fun slides, skating aids and even curling stones. Ice-World even advises on how to make the ice rink into a viable product for its clients.

Nowadays it is not only winter time Ice-World is focused on. To stay ahead of its competitors, Ice-World has developed a product that can be used when there is low demand for ice, but high demand for water. This is when the PlayFountain comes into play. The PlayFountain is a modular playground on which all kinds of games involving water jets can be played.

Ice-World has noticed that there is an increasing competitive environment withing the ice business and does everything it must to stay in front of the rest. As it shows, Ice-World is an innovative company and takes every opportunity to stay ahead. This is also what this graduation is all about. Helping Ice-World explore new possibilities.
PROBLEM DEFINITION **
Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

Ice-World wants to stay ahead of the competition and maintains its position as the market leader. The competition in this market is growing, besides this the patent of the aluminum tube system has almost reached its end. This requires them to constantly develop ice rink accessories, such as ice-skating aids for children, ice bikes and fun parks. Even penetrating related markets with the PlayFountain, the modular water fountain that can be used in the summertime.

As Ice-World wants to ensure and strengthen their competitive advantage. They are interested in the opportunities of innovating the ice rink boarding. Ice-World currently uses different types of boarding: a wooden boarding and a transparent plastic boarding. Where the wooden boarding is used in a more nostalgic setting, the plastic one has a more modern feel to it and already is a bit more optimized. Still both systems have not gone through many changes the last couple of years and have many disadvantages for many different stakeholders involved.

The boarding plays an important role in the overall product performance and appearance of the ice rink, the clients’ decision to choose Ice-World and the costs of storage, transport, assembly and disassembly. In this project, the complete process of the boarding - from production to use, disassembly and storage - will be mapped. Crucial moments and interactions between the boarding and stakeholders will be identified.

For the stakeholders it will mainly revolve on the relationship between Ice-World, its clients and the ice rink builder, with a small emphasis on the skater and visitor. Where Ice-World wants to improve on its market position and stay ahead of the competition. By doing so attracting new clients and keeping the current clients satisfied.

ASSIGNMENT **
State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in “problem definition”. Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... . In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

Create an improved design of (one of) the current boarding system with the help of a Delft design approach, consisting of user research, ideation, prototyping and iteration. The improved boarding system will help Ice-World to ensure its market position and strengthen their competitive advantage.

I will deliver a redesign of (one of) the current boarding systems for the portable ice rinks. An exploration of the complete process of the - from production to use to disassembly and storage- will lead to insights for improvement/innovation and to concept drivers. For the best concept a prototype will be developed. With the working prototype I will illustrate the build-up, use and the break-down of the system. The working prototype will be tested and suggestions for improvement, production and implementation will be reported to Ice-World.

The working model will be the outcome of an analysis of the current problems, stakeholder interviews, ideation, co-creation sessions, conceptualisation, embodiment, and prototype testing. This first working prototype will help to generate insights that can be used as input for recommendations for Ice-World.

A report on the redesign will include accurate cost price calculations, material choice and production method selections, to be able to show the viability of the final product in comparison to the current market.
introduction (continued): space for images

image / figure 1: Ice-World ice rink in Laren, the Netherlands

image / figure 2: Ice-World Fun Slide in Vught, the Netherlands
Through this project I would like to grow as a designer and get a feel of the real world by working for a company. I want to experience how it is to collaborate in a small design team and small design department. I am also curious how it feels to be able to ask anything to anyone in the company and get instant feedback. I already have the experience within a large corporate, because of my internship at KLM, therefore wanted to experience a different kind of working environment.

This assignment is right up my alley as I have a history in ice skating. When I was younger I used to play ice hockey a lot. So when I saw this assignment I could relate to the user and thought that this would come in handy with this assignment. Ice skating is an activity I really like and it would be great to create a better experience in this area. I also liked the fact that it is a hands-on project and to create something that can be implemented in a reasonable amount of time.

What I want to improve/learn during this project:

1. I would like to improve my prototyping skills. - Building a working model that can be tested in a real-world setting.
2. I would like to improve my communication skills as a designer. - How can I communicate my ideas quickly with other (non)designers? Get feedback from people in the organisation?
3. I would like to improve my ability to translate the analysis of the stakeholders into relevant needs and wishes.

I would really like to support Ice-World in the development and implementation of the redesign when the opportunity presents itself.
PLANNING AND APPROACH

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

The project will be divided into three main parts:

1. Field & Stakeholder research
   First it is key to map out the stakeholders and the key processes that they are involved in. Who are the stakeholders, what are their needs in relation to the boarding. As the focus is also on the use phase of the product life-cycle, questionnaires and observations will be conducted with users on site to see what problems they encounter. Expected is that Ice-World, Clients and End-users (rink builders and skaters) will be the main focus of this research.

2. Idea and concept generation
   Based on insights from the research, a list of pain points will be identified and a list of wishes and requirements will be created. Ideas will be generated with the help of brainstorm sessions with employees of Ice-World and possibly clients. Following the initial ideation sessions, concepts will be developed and presented back to the core team at Ice-World. During a prioritization workshop with this core team the most promising concept will be selected.

3. Modeling and testing
   A physical model will be built and tested in a real-world setting. Through user testing, recommendations will be made for implementation and iteration of the design.

My planning is to work part-time on this graduation project - 4 days a week.