
OptiField

'If you get such a field is affordable, it will be in every single stadium within ten years.'

-Ruud van Elk, human movement scientist PSV

Technical University Eindhoven
Industrial Design
B1.2 project: Smart teams on a smart pitch

In collaboration with
InnoSportLab Sport & Beweeg!
Coach: Lenneke de Voogd

Daan Heijsters
Olivier van Duuren
Pleun Heeres
Stijn van Geffen

June 2015

Proloque

Thanks to TU/e, InnoSportLab Sport en Beweeg!, PSV, GreenFields and Koninklijke Ten Cate NV for the assistance during the project. At the first place, special thanks to Lenneke de Voogd and Tim Konings for coaching this project. And special thanks to Ruud van Elk and Luuk van Agt (PSV), René Huizinga (GreenFields) and Bart Wijers (Koninklijke Ten Cate NV) for the collaboration with Movin'.

Table of contents

Introduction

Dear reader,

In this booklet we take you through our design process to our final prototype of our B1.2 project 'Smart Team on a Smart Pitch'. Within this project, we had the special opportunity to cooperate with InnoSportLab Sport & Beweeg!. It was an experience which improved the development of the project and the outcome more than we expected. Thanks to this cooperation we were able to collaborate with several companies, which made our concept better, because it gave us an insight in the real time market. Besides this insight, we were able to make use of the facilities of InnoSportLab and their expertise. We made use of those, during the entire project which evolved with our own desires and input to the final concept we stand for.
The first part of this booklet describes the process of setting our goals and working towards our final concept. The second part gives more details on our final concept.

Project description:

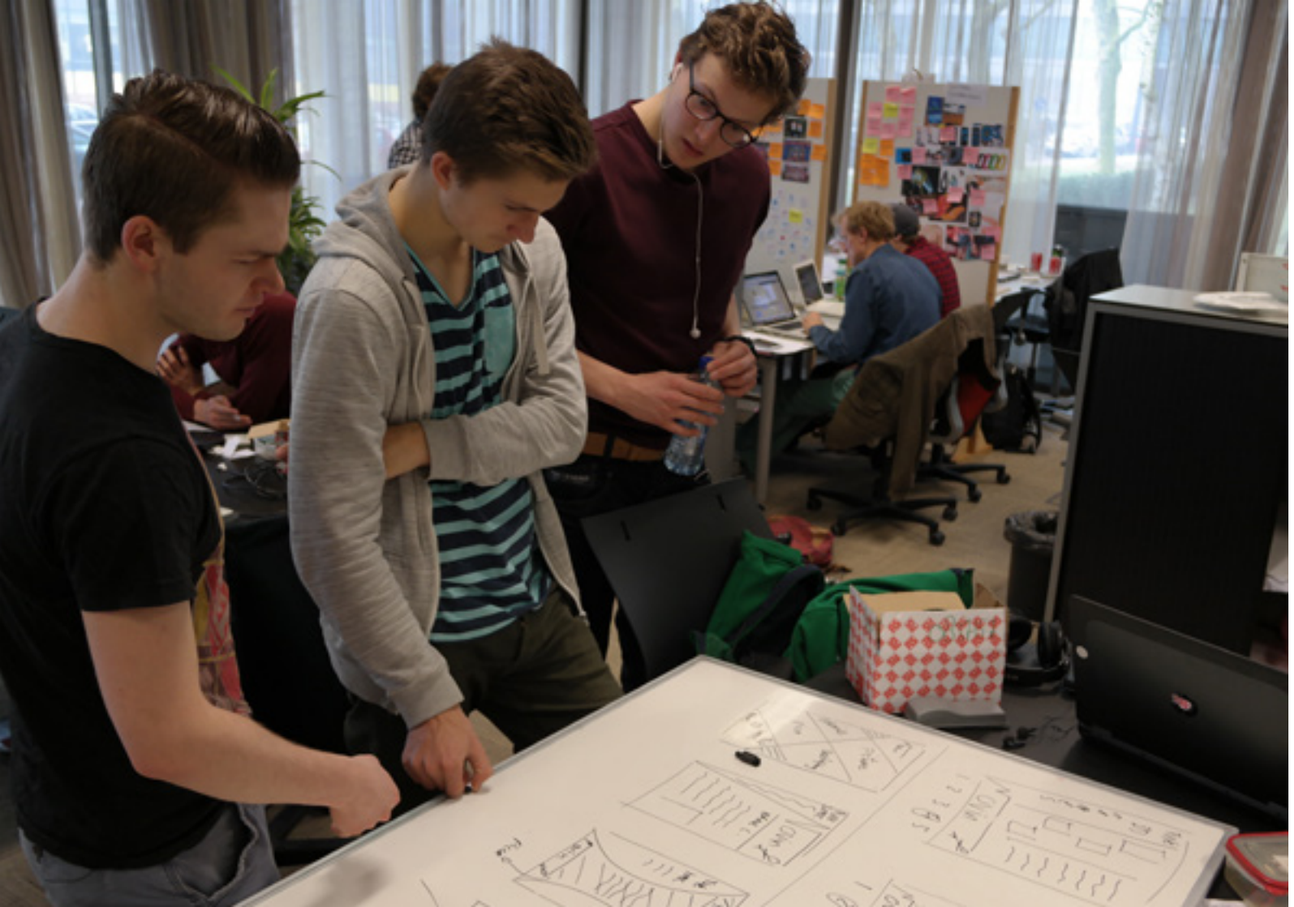
"You will explore the opportunities that arise in connecting sports teams to a smart pitch. With the current influx of technology anything and everything can be measured. The value of measuring is only achieved with rich and insightful feedback systems. In this project the sports pitch will be the main 'canvas' for this feedback. Can you create a dynamic sports pitch and explore what value such a pitch can have for a sports team? Will such a team for instance help in team play, individual performance, or for play?"

Movin'

determining our goals and envisioned project direction

At the beginning of this semester we clarified our goals to set a direction within this project. Our own personal intentions, possibilities at 'InnoSportlab Sport&Beweeg!' and the project description combined, resulted in a shared vision. With the experience we gained from the first semester, we made our goals and direction very clear within a few days.

For this project we wanted to design with attention to multi-functionality and the ability for personalisation in order to improve the sport performances of (semi-)topsport. We wanted to do that by integrating technology in order to create new opportunities for training. At an early stage, it was clear that user centered design was important for us and the development of our concept. We wanted to make a concept which was well considered and a new innovation within sports. We wanted to create a new dimension.



Ideation

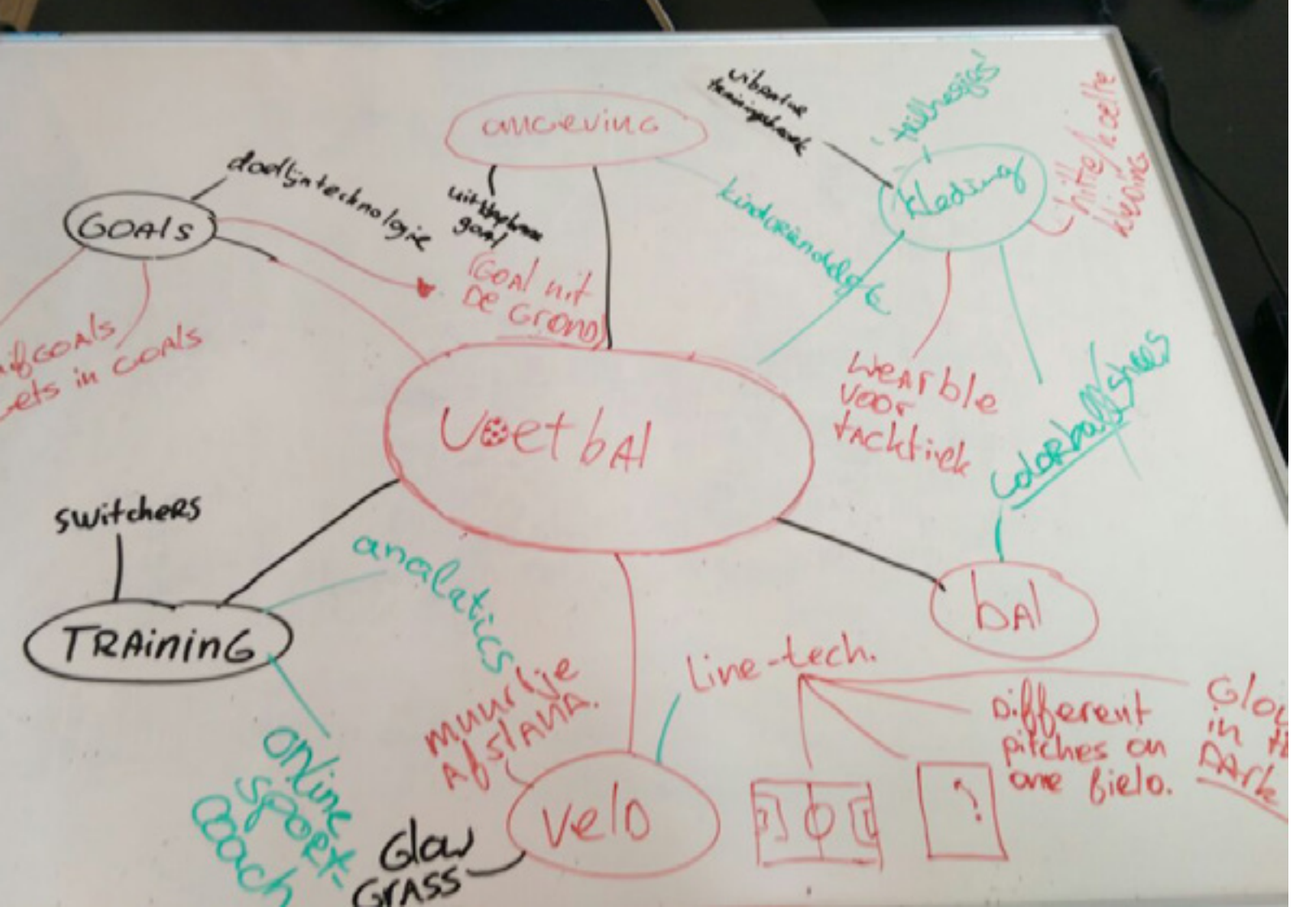
the ideation process from brainstorming to narrowing down to well developed ideas

In this chapter we focus on how we got to our ideas, our way of narrowing down our ideas and how we developed those ideas.

In the first part we take a more detailed look at our way of brainstorming; the techniques that we used and where we focussed on.

For the second part of ideation we give a brief description of the research that has been done.
The third part of our ideation phase was new for us. It was a phase which we liked to do and in which we learned a lot. It was the phase of observing.

Throughout the ideation phase, we made decisions based on the direction we wanted to go. We made a list of requirements which are explained a little in the previous chapter and completely explained in the appendix. With this list we wanted to make sure that all of us were heading the same way during the brainstorms and ideation.



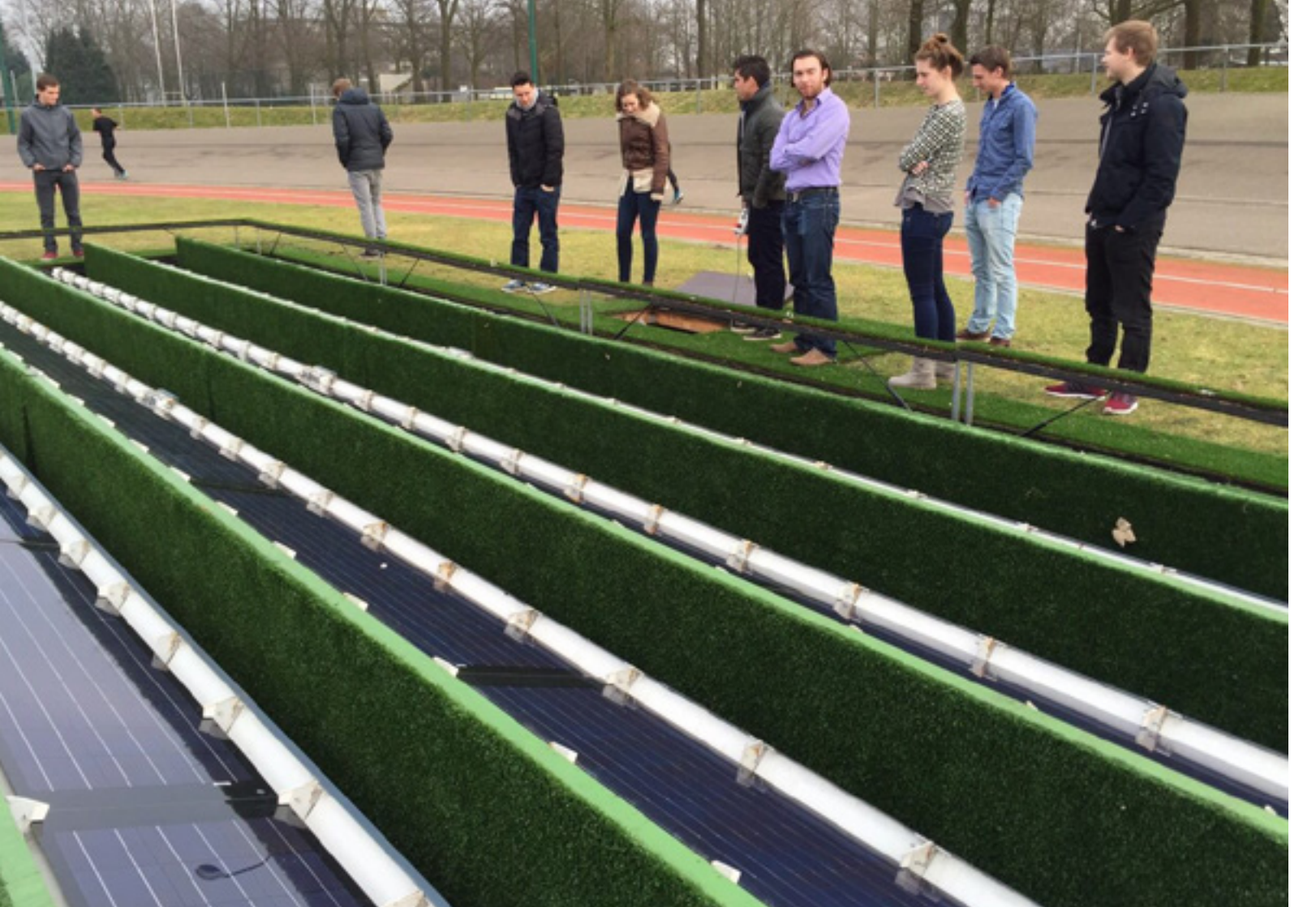
Brainstorming

How we generated ideas

After deciding a direction for the project and setting a list of requirements, we wanted to diverge again. Not necessarily taking a step back, but widen our thoughts again to prevent a tunnel vision. It would be a sin haven't covered and analysed every field of interest before diving into one.

We took a look at every type of sports (ball sports, winter sports, water sports, etc.) and from there on, searched for problems or annoyances that occurred within each specific sport. From here on we brainstormed, to come up with possible solutions for these problems. Also we thought of concepts that were in line with our visions and identities. We did this by searching for existing brainstorm methods and taking these into practise.

Besides brainstorm sessions only executed by ourselves, we did client/coach/co-create brainstorm sessions at the InnosportLab. These sessions were needed, because the experts we brainstormed with had more knowledge about what was possible and already out there. Based on these sessions we could move on in our design process.



Research

the search for what technology is out there allready

In order to design something that is really innovative you have to find out what is already on the market. We did a lot of research, on the internet, on new technologies within sports and set-up a Facebook page where all the students within our project could share their findings. We also made good use of the databases and knowledge available at InnosportLab.

By doing research we came up with a lot of ideas, but also found out that a lot of our ideas already exists. This forced us to think out of the box; how could we be disruptive and unique with our project. This way of thinking was frustrating and fun at the same time and did result in new ideas. In the chapter conceptualization we dive more into four of these ideas.

Observing

going out there, a new way of ideation

As we found out in the previous semester, it is important to keep on moving within the design process. Not getting stuck in a cycle of brainstorming and researching. To get an answer to all the things we brainstormed about, we started with something which was new for the most of us: observing. Really going out there and see for yourself if existing ideas would make sense in practise and generating ideas on the spot by analysing what happens and what is needed.

After mapping our intentions and opportunities for observing, we went to the training sessions of the PSV youth and their first team. As we already noticed by setting goals, making clear what you want will only improve the result you want to achieve. These sessions were insightful, because we could see quite easily that some ideas we had were not so realistic. We didn't generate as much ideas as we hoped based on the observations, but we managed to develop some existing ideas more specific. Overall, it was very inspiring and made us motivated more to start with prototyping in order to take our ideas in practise.

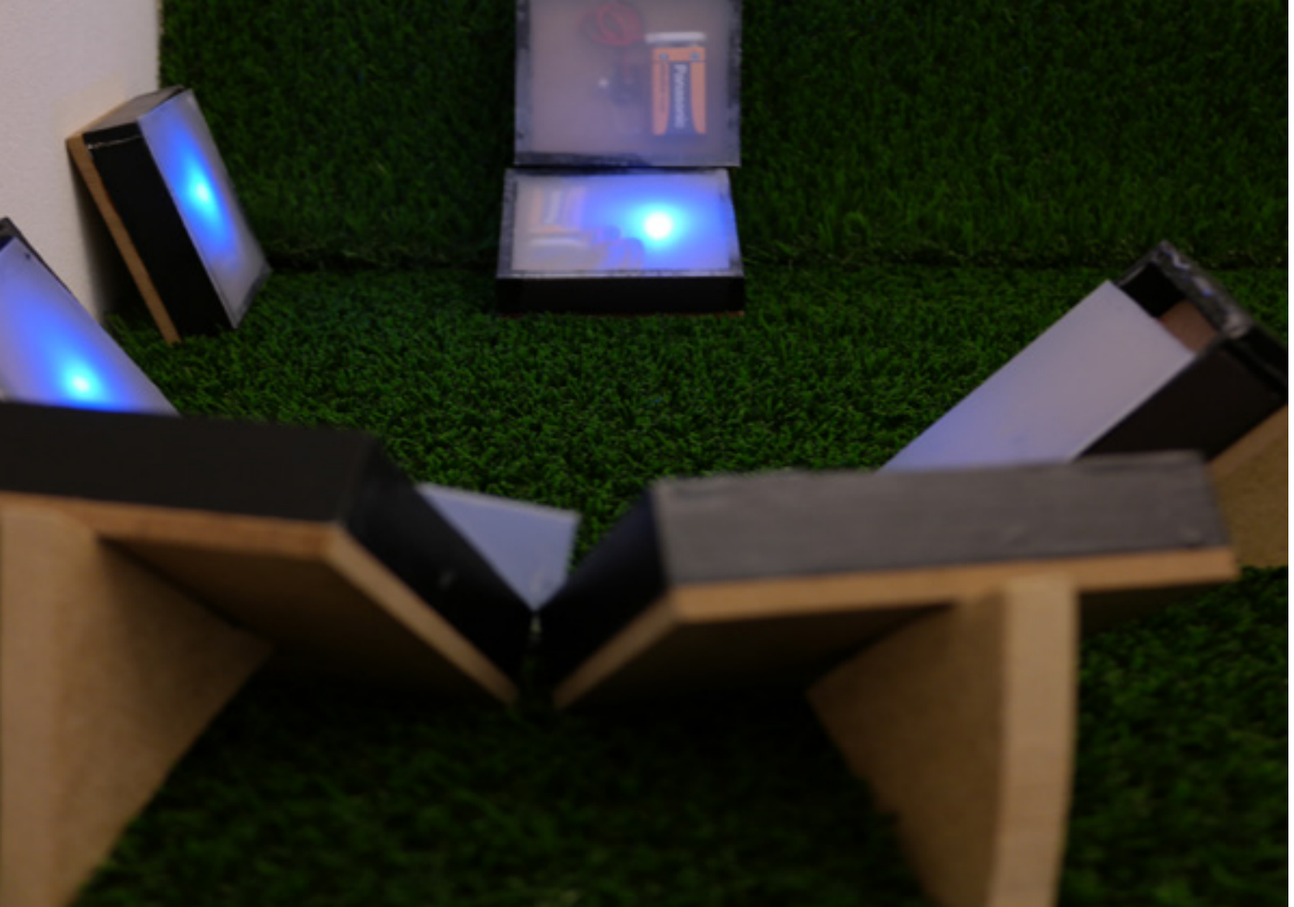
Conceptualisation

working out four ideas to well developed concepts

In order to maintain momentum in the process we decided to stop widening our scope and start focussing. We had created a long list of ideas with brainstorming and made it more specific with research and observing. We chose to conceptualize four ideas. We chose for this approach because we saw potential in all four ideas and we wanted to find the weaknesses of the ideas by working them all out to concepts.

Our conceptualization can be seen as a short design process cycle. We came to with the ideas. Brought these to the field by observing and talked with trainers and end-users. We didn't want to get stuck in the ideation phase and switched to making prototypes. This prototyping helped us with getting an idea of the feasibility

of the projects.
In the next few pages we give a brief explanation of what the four concepts are about.



TargetTiles

This idea is based on multi-functionality, adjustability and simplicity to organize and use. TargetTiles is a training device that exists of individual components. These individual components can easily be clicked together. The components are pressure sensitive and light-up if they are touched. In this way it is a platform for a broad way of use. For example improving dribbling skills in basketball, accuracy training for tennis and team play exercises in football. The possibilities are endless with TargetTiles.

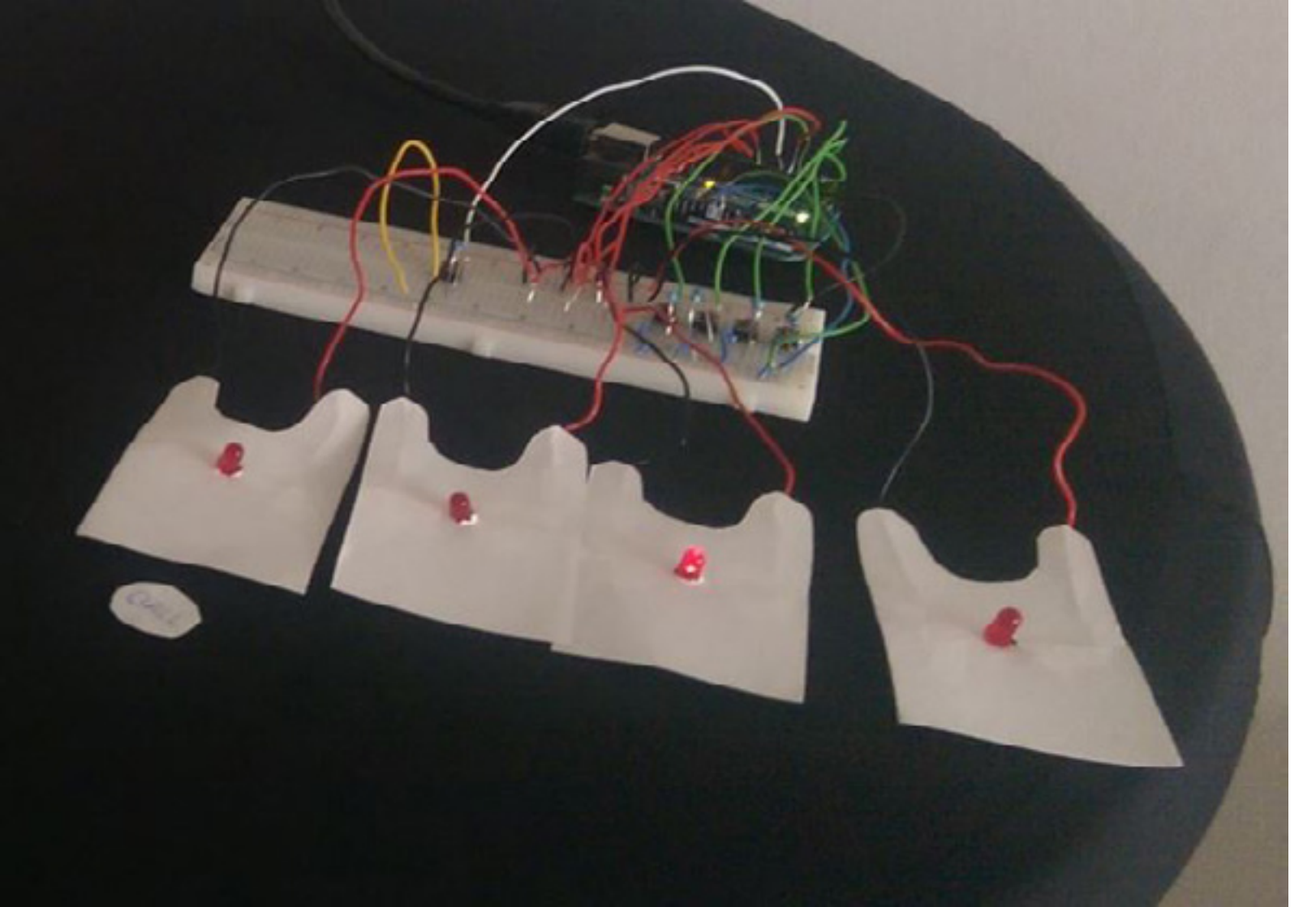
We think that this device is perfect to improve training sessions. Mainly because it a perfect combination of creating the possibility to use this device in different sports and being able to create settings according to your desire. Except for this effort in your improvement as a team it is also possible to use the TargetTiles for individual training sessions if you would like to do so.

Shoet!

Shoet! is a device to make the shoot clear within hockey. With a simple signal of light or vibration, the referee is able to see whether the player made shoot or not.

This device is integrated within the shoe of the player. The shoot is detected with a pressure sensor which sends a signal to the referee. The signal will be received through vision, feeling and/or sound.

The goal of this product is that you can prevent incorrect judgements in really important matches. It's like a helping hand for every referee in the hockey sport. If this product could be integrated in the judgement system of the sport, the intention is to make the product smart. This will prevent shoots played with purpose by the opponent. So the device has to be able of distinguishing deliberate and liberate shoots.



Switchers

These illuminated sport jackets are able to set up a really useful exercise, which offers new trainings opportunities. The goal of the game is to prevent that the jacket fades out. The more you pass, the quicker the fade-out loop will run. This loop continues until you make a mistake or are not able to reach the target in time.

These jackets could be used with own interpretation. That is what we want, open a world of opportunities and give a chance to the user. The future goal is that we want to make it possible to let the user easily add new training games and to create a whole network to this product.

A community where everyone can share his new developed game. Furthermore the intention is to make the unit of light separate, but yet also attachable to the jackets. In this way you can use the product in another situation as well. Offering it as a separate product will also give more market selling opportunities.

SmartField

Could you imagine getting live feedback from a trainer during a training session on the field or set out a training with a click on a button. That is the idea of SmartField, a system containing a field with integrated lighting in the grass, which can be connected to a central computer. This computer is in connection with a smart device. On a program or application the user is able to create everything he or she can imagine.

Trainers and coaches can use their smart-device to draw on the field in real-time for training purposes. This would give unlimited possibilities like training set ups, running lines and goals, both static and dynamic. In this way you could make a training more effective, fun and you create a new dimension to the training.

Presenting

we present to get feedback

This semester we had two organised presentation days. First we had the 'Triple jump'-event at 'InnosportLab Sport en Beweeg!' and one week later the midterm demo-day at the TU/e. The 'Triple jump'-event was an event for a large group of innovators in sport. This event helped us a lot in preparing the demo-day. It was like a repetition. During the mid-term demo day, we got a lot of feedback of students with their faced problems in the design process. The visitors at the InnoSportLab Sport en Beweeg! had a more business orientated view and feedback. So together we had feedback on a few different aspects.

In the following pages we explain a little more on our intentions, way of presenting and what we got out of the two events.

Triple Jump Event

a more business orientated event

Within the first quartile of this semester we got the opportunity to present at the Triple Jump Event. This international event was organised to share knowledge and ideas of sports innovation. Individuals like us had the opportunity to see a large part of international innovative sport cooperation within the European Union. We, as student ambassadors, presented our innovative sport project ideas. At the event we presented our four concepts, by means of presenting our four prototypes and informative posters. During this event a big group of people was visiting our concepts.

These people provided us of feedback that was different than the feedback you normally get at Industrial Design demo days. For example the business interests were much higher, they really thought in business opportunities quicker; are the concepts feasible. This other view on our concepts was really useful. Also it was an extra chance for us to analyse the consumer's interests.

After all, working towards and presenting at this big event was a real boost. It prepared us also for the midterm demo day.

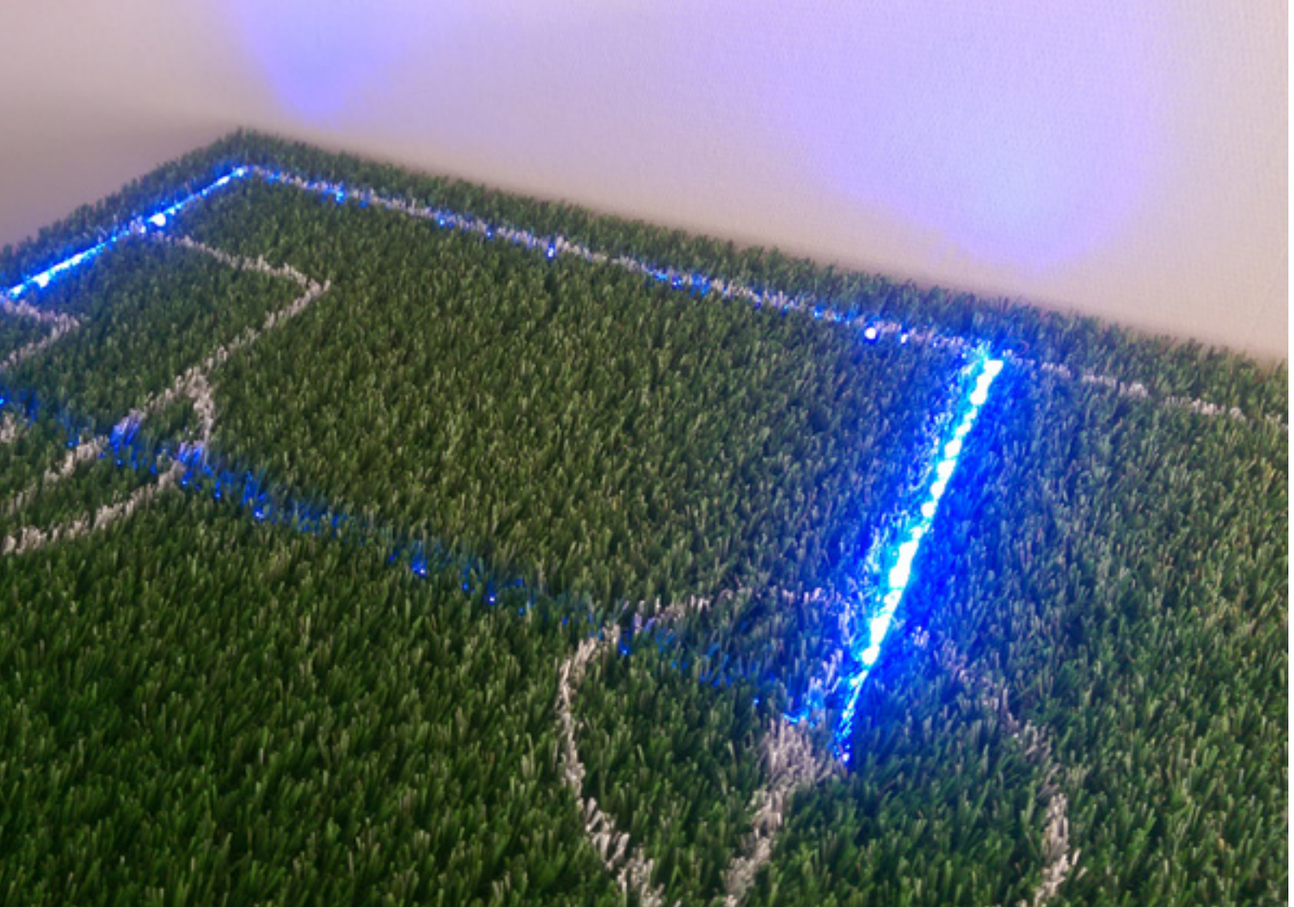
Mid-term Demoday

more focused about feasibility

Halfway our semester we had our midterm demo day at the TU/Eindhoven. The set-up of the demo day was a cross-coaching session. This means presenting for a group of students and coaches and receiving feedback by getting a discussion.

During this session we already excluded two of our concepts. By presenting less concepts you give the opportunity to the audience to choose one over the other and give arguments for their choice. This resulted in insights we sometimes had not thought of yet. Though the feedback was not as much as hoped. The feedback was in a short time period and therefore wasn't of great magnitude. The main focus laid on showstoppers, for us to be proven wrong. Also there wasn't a real shared choice for one concept.

After the demo day, therefore we still needed some time to make a well-considered decision. The process of choosing is covered in the next chapter.



Choosing one concept

the choosing process going from four to one concept

After a few quality evaluating sessions we made decisions about excluding concepts, by use of the list of requirements, our intentions and those of our partners.

First of all, Shoet! was excluded. We noticed that this was a good project, but that it did not match the project description enough. After Shoet! we decided to exclude 'Switchers'. This concept is definitely worth developing, but it did matched too much with already existing products.

Apart from that, we thought our third concept TargetTiles completely covered the goals of 'Switchers'. We did present the TargetTiles and the 'SmartField' at the demo-day. But we stopped with TargetTiles, because there were too many existing technologies according to experts in that area of sport innovation.

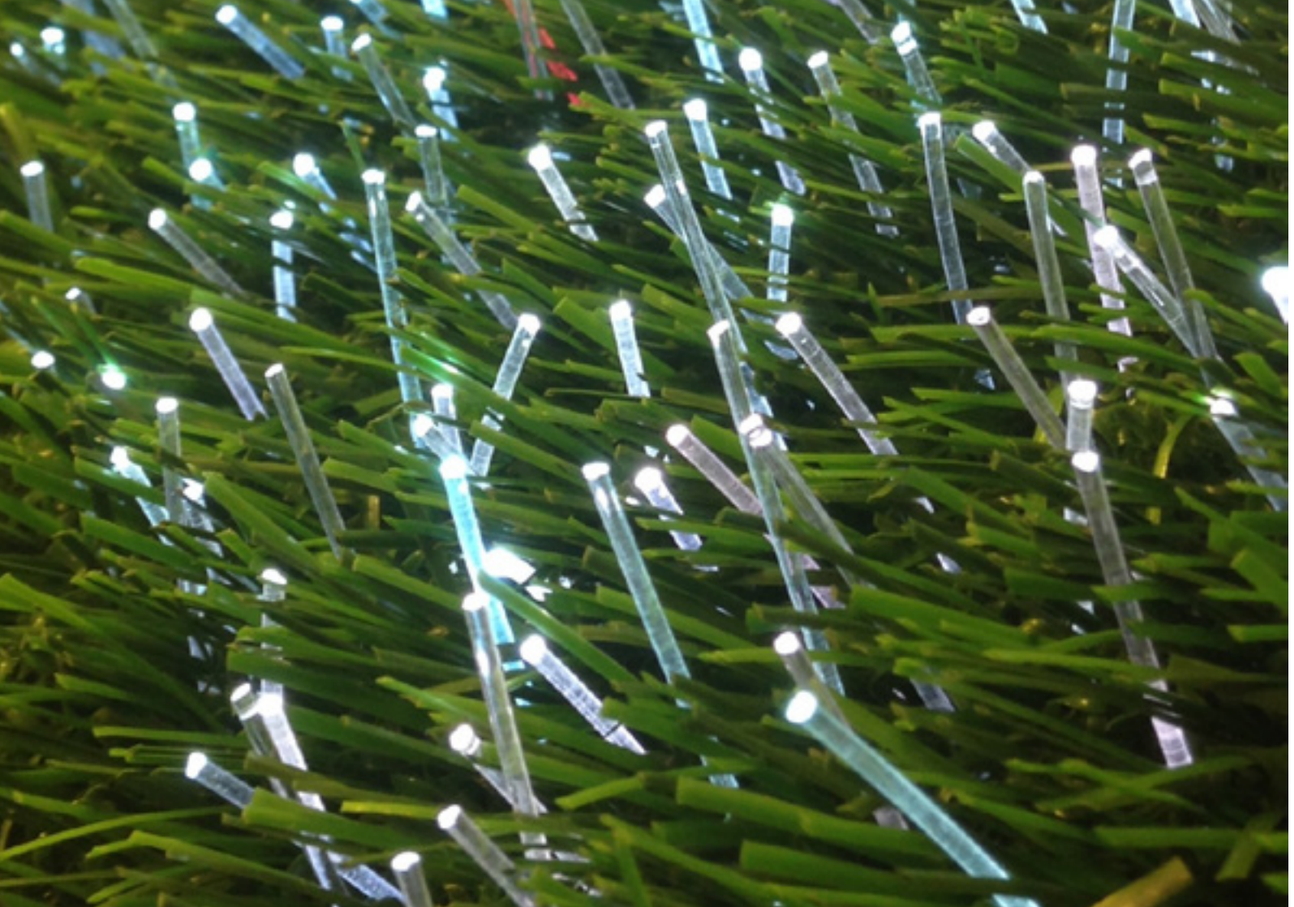
SmartField was new and created a new dimension and new opportunities, that is why we choose SmartField (OptiField) as final concept.

Co-operation

different parties that helped us making a proper decision

First of all, we involved all the feedback of different individual persons. Next to that we also organised meetings with PSV to get feedback in order to make the proper choices and decisions.

This was done by interviewing the main trainer of the youth, human movement scientist and the main exercise physiologist. This meetings gave us wanted aspects for our concepts from experts and from within a top football club. The final decisions we made are partly based on these experiences, but mainly focused on our own preferences.



OptiField

our final concept

This concept is about creating a lot more opportunities in the whole sports world. With this product we want to achieve, the possibility to create your own pitch, your own sports field. We want people to optimise their field. Simply because our prototype did not agree with the expectations you will get about SmartField, we chose another name. With the use of any smart device it is possible to set up training sessions, without using any materials. The training sessions become visual through the grass which glows wherever and whenever you want. With this complete possible illuminated field, a new sport world arises. It can create a new dimension for every field player in every field sport.

Technical research

the research we did in different areas concerning our concept

When we decided to continue working with OptiField, we had to do a lot of technological research. This research is necessary to make this product as feasible and affordable as possible.

So at first, we had to become aware of the different kinds and possibilities of artificial grass. Based on that we wanted, to know if we could integrate our light system. This light system was the second aspect of researching. Maybe even the hardest part of this whole product. So the technological research became really important in our design process.

Artificial grass

the research we did on different kinds of artificial grass

On forehand we knew artificial grass was connected to very specifically demands and requirements, this was confirmed in the meeting with Greenfields and TenCate. We did a lot of research to different sorts of artificial grass so we could imply our system into the grass. We found out that there are a couple of different layers below to the top layer (artificial grass) and how every layer is required for the total package of the field. In the meeting with Greenfields and TenCate it turned out that our layer (the LED grid) could be integrated the best between the top layer of the actual field and the cushioning layer below. However innovation in artificial grass goes very fast so it's likely newer variants of grass and turf will be developed.

For this developments we also did a more detailed 'trendwatch' upon the future and promise of artificial grass. What can be expected and can, for example, the conservative football be convinced to use artificial grass at last.







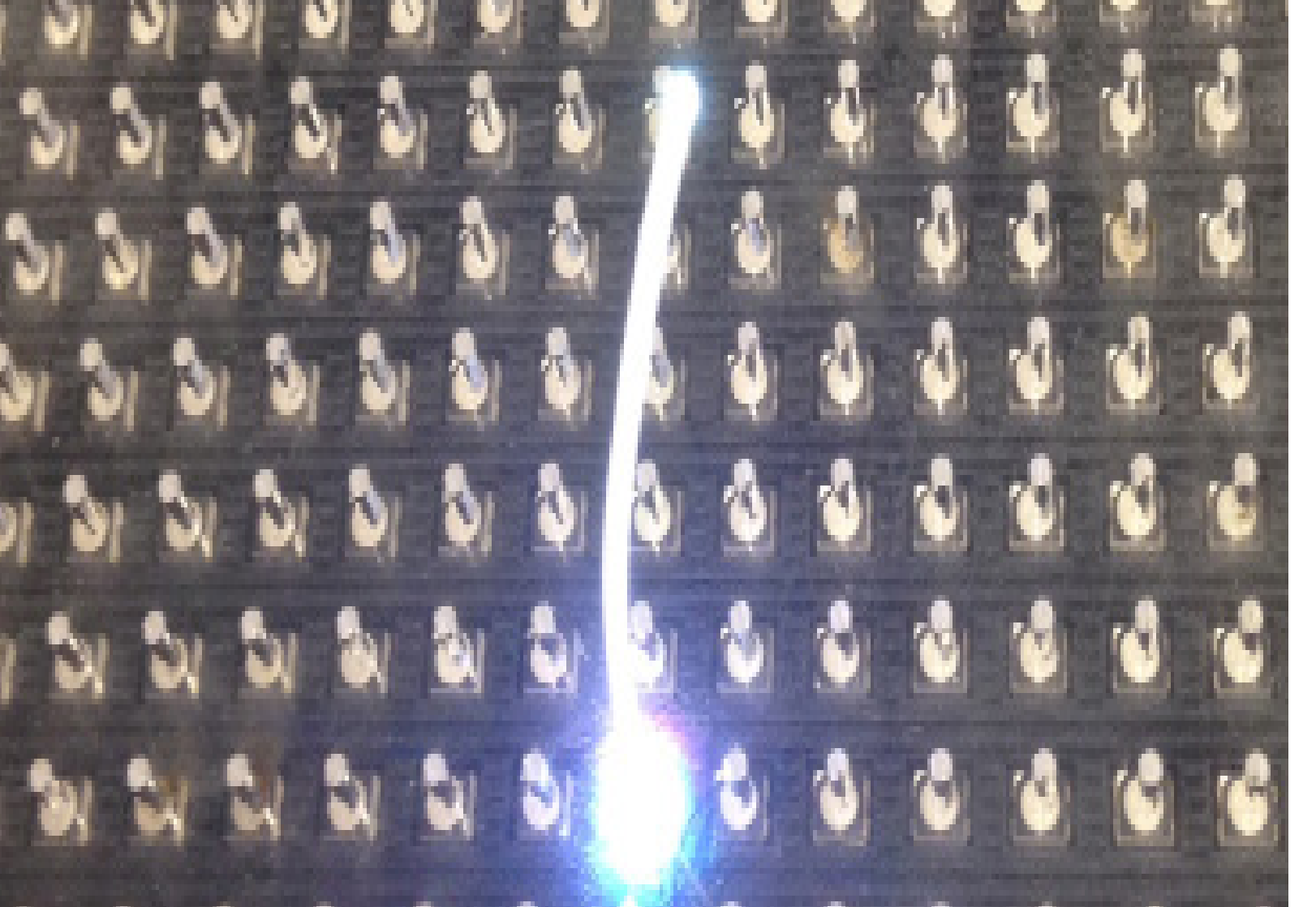

Different light technologies

the research on different techniques to illuminate the grass

As the SmartField concept had been chosen, a concept that acquires illuminating grass, we had to do research on ways of getting this visible feedback to the surface.
We did research on projecting the feedback at first. This way has as positive aspects that it is feasible to make and can be done by us. The downfall of this technique is that you could walk in your own shadow and therefore block the projection. Also projection isn't visible in daylight. Lasers are a light source that could be seen in daylight, but also this technique has too many downsides. Think of blinding players and also blocking the light are issues here.

Our next way of light was LED-strips integrated in the grass field. This could overcome the earlier mentioned downsides. The only obstacle that was important for us is that it doesn't look like grass and could cause more injuries.

Color changing materials caused by change in temperature were techniques that could have all the qualities with keeping grass natural looking, though it had a low feasibility future. This because it is not easy to work with.
So we came to the best way to get light to the surface: optical fibers. They look like grass, give a good light intensity, are integrated in the grass and are feasible for us to work with.



Our technological solution

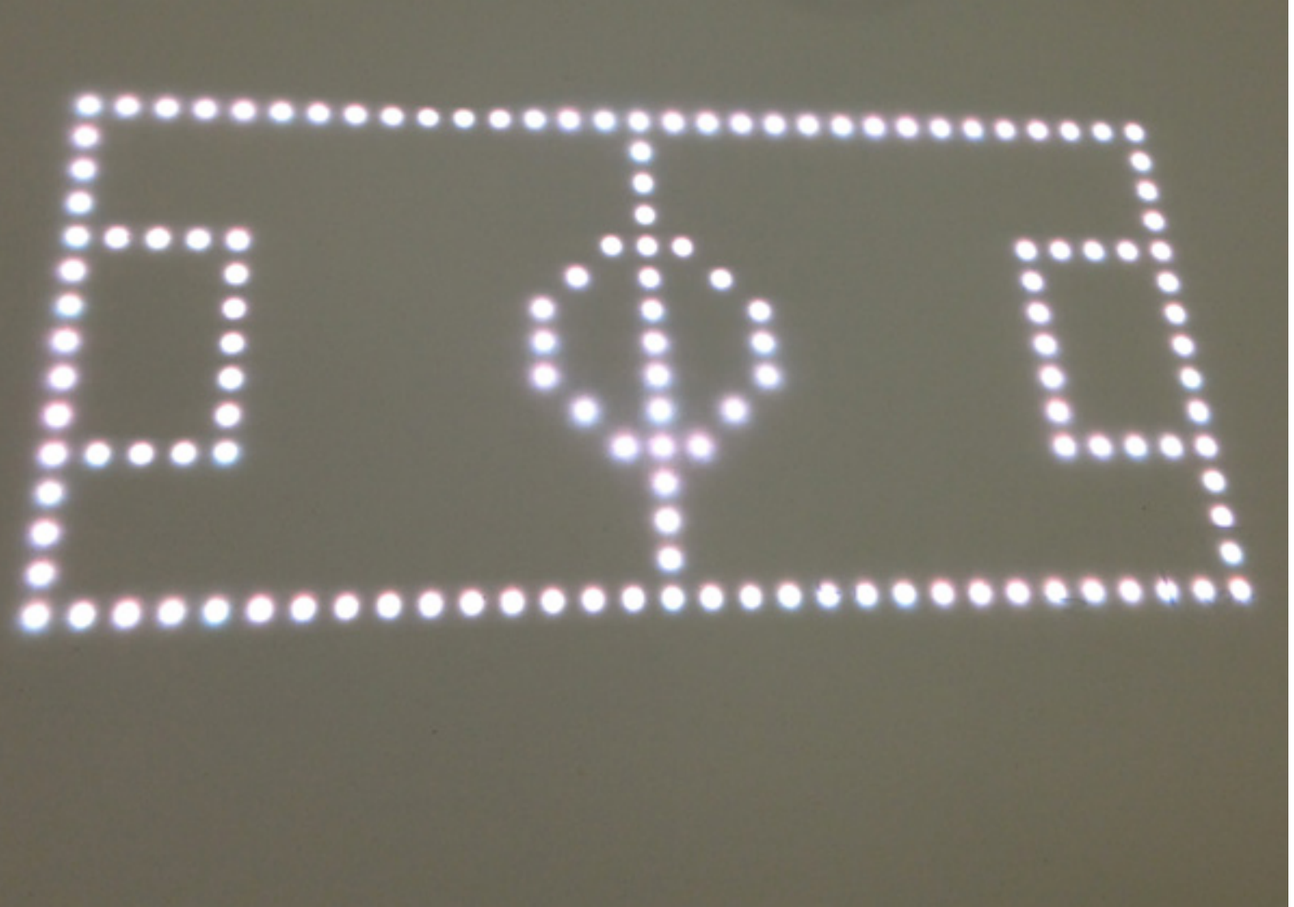
the combination of techniques we use in our concept

After considering we came to the conclusion that optical fibers was potentially the best choice to continue with. With a LED-field beneath the artificial grass we want to send the light through optical fibers, which make it visible on the surface of the grass. If those fibers are as thick as grass itself then the flexibility is equal. Next to that we assumed that if the density of fibers is as large as the white lines painted on the field then it becomes equally visible as current lines.

Prototyping

the process towards our final prototype

Within every design process, it is important to develop and improve your concept. Since we decided to move on with the concept: OptiField, we have been making a couple of samples/ prototypes. Starting with a big field of artificial grass with integrated LED-strips. After the first prototype, we did research to the possibilities of getting the light to the surface and the use of different kinds of light sources. This research resulted in the use of a LED-grid and a piece of artificial grass with integrated optical fibers.

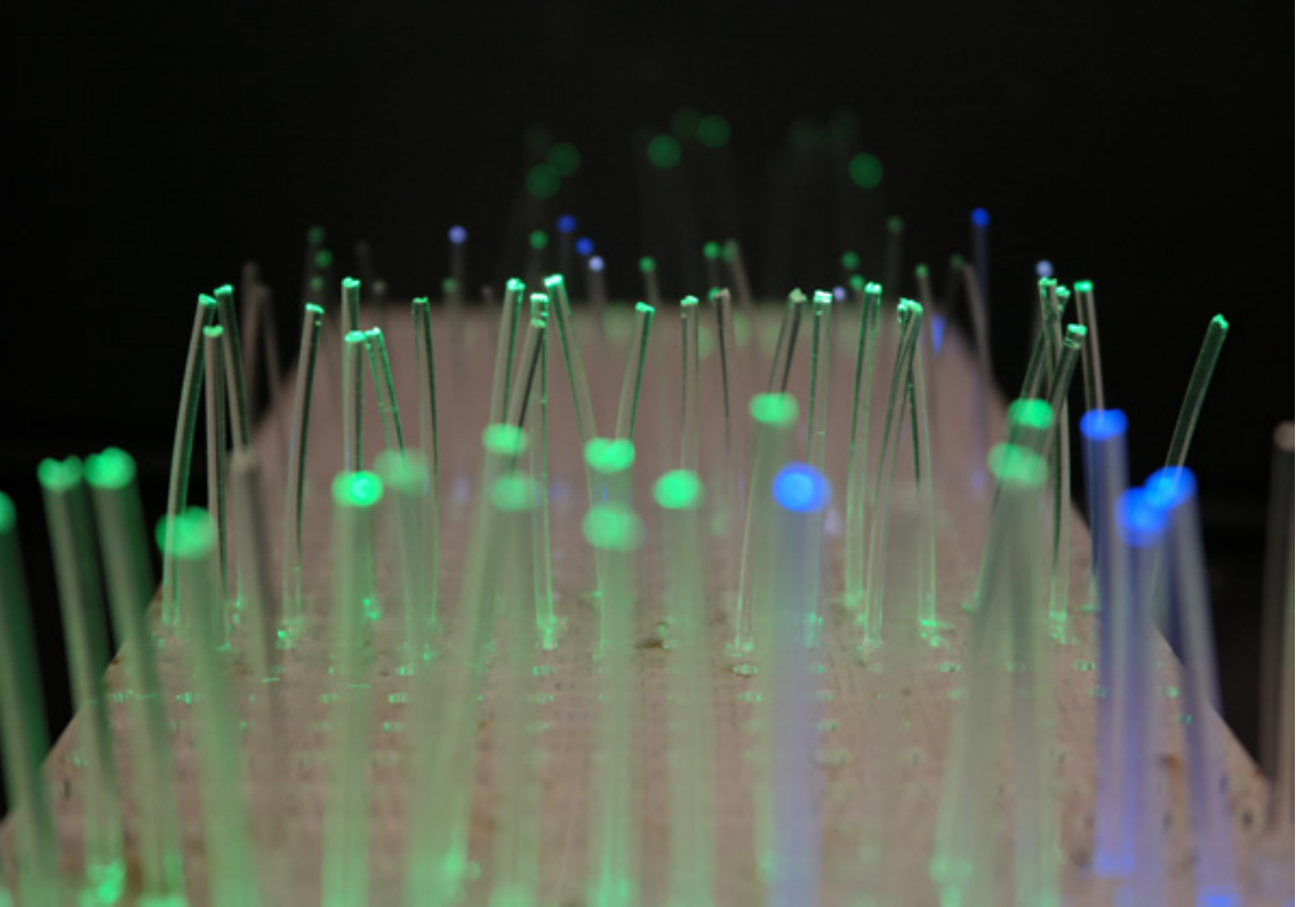


LED-grid

integrating the LED matrix in our prototype

In the first stage we developed an interactive field of nine LED's. All these LED's were individually controlled. Unfortunately, Arduino is not capable of controlling a larger amount of LED's controlled via individual digital pins. So we bought a LED matrix to get the optimal result at a small scale.

This matrix includes 512 RGB's in total. That amount was for our illuminated field enough. In the programming phase we improved it to an interactive display on another laptop wirelessly. After that we converted this laptop display to an android smart device for the extra dimension: touch.



Optical fibers

integrating the best possible optical fibers

After deciding to continue making a field with optical fibers, we tested a certain amount of fibres with different thicknesses, varying from 0,5 mm to 3,0 mm. The light intensity, reached at the top of the fiber, and the flexibility of the fiber, made us decide to make a field with fibers of a thickness of 1,0 mm thick. With these optical fibers the wanted light intensity at the surface wasn't reached. However the possibility of TenCate to make an artificial grass transparent by not adding the green grass pigment during the fabrication might be a solution to this problem.

Application

the supporting application to control the illuminating field

As an addition to our product we deliver a tool to control your own field. This tool could be used in our application. This application is made for the trainers/coaches. These people can find a whole community of other coaches and trainers. So with your own profile you are going to add training sessions and potentially light games as well to improve different techniques and insights. This app is Bluetooth connected with a source near the field, likely placed at one side of the field. The trainer/coach is able to add training exercise offline and send them later on to the field. We expect that the trainers/coaches will add/edit their training sessions before the training sessions actually occur.

Final prototype

how far we reached with building OptiField

We are able to draw free-hand and shapes on a LED grid. This 'draw board' is of course still very small, but it could be called a scale version of OptiField. Next to this physical prototype we made sample of optical fibers with different thicknesses to demonstrate the flexibility of the fiber. This project was a lot about research so we made a lot of analyses and models of the possible outcomes of our concepts. Because our project was a lot about research we made an advice plan as our final product. The Arduino and processing codes to control the LED grid in our final prototype can be found in the appendix.

TenCate & Greenfields

working together with Greenfields & TenCate

Greenfields & Ten Cate, the two companies responsible for the artificial grass fields, supported our concept and offered us help. They were going to make a piece of transparent artificial grass field for us. This to make it possible to transfer light to the tops of fibers.

Next to this sample of transparent grass, they tried to integrate our optical fibers in the process of making an artificial grass field. Unfortunately TenCate didn't manage to complete this sample before final demo day, so we haven't had the opportunity to test it yet.

User testing

confirming a high level of light intensity

An essential aspect of OptiField is light. To be more precise, how do you get light from a light source to the surface? And is the light visible at the surface?

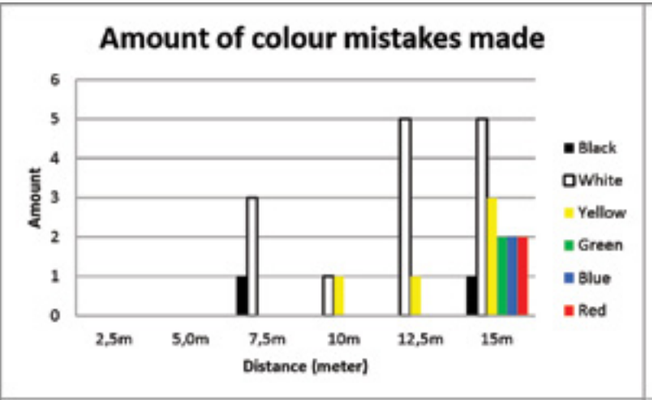
To get an answer to these questions we talked with PSV, Greenfields and Ten Cate to get more insight about the desire of artificial grass and which is mentioned above, what the possibilities are with artificial grass. Besides that we did an actual user test to test how a light source would perform in daylight.

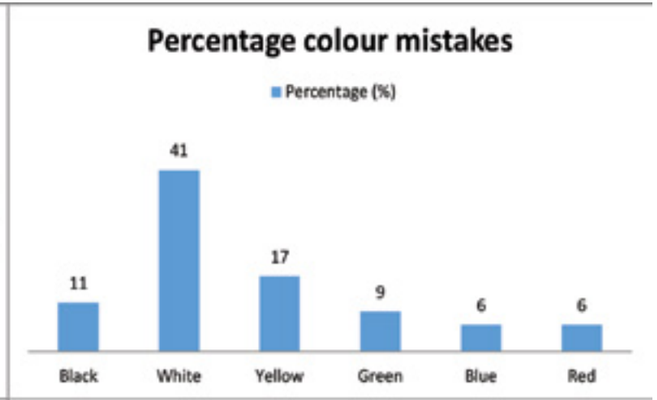
The user test

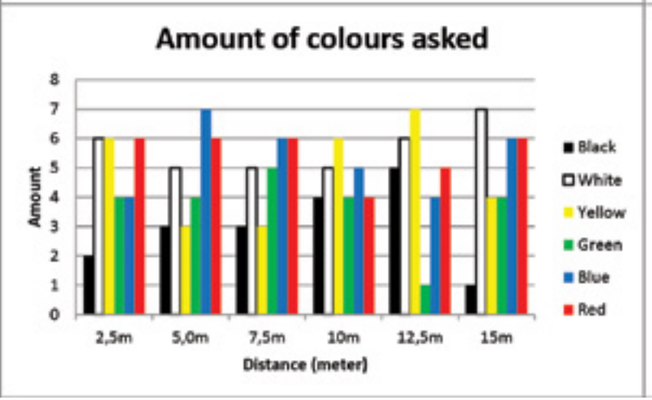
user testing the light intensity

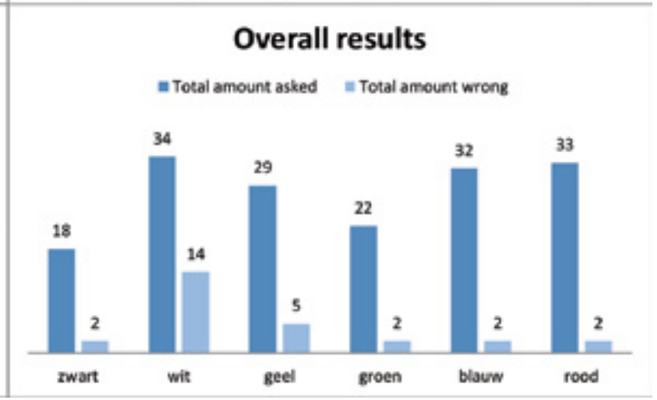
To test if our light source was strong enough, we set up a test. At different distances we wanted to know if it was possible to see the light source. The way we made sure, someone could see the light source, was by asking them to distinguish colours.

The test had been executed by 7 volunteers at InnoSportLab Sport & Beweeg!. Amongst the volunteers there was a variety of people. Female/male, young/old and even colorblind. Before we executed the test we did one test run ourselves. The results of that made us expect that the colors white and yellow were the hardest to see.









Results

the results we got from the user test

The real time results were quite the same as we expected them to be. Though yellow had a lower fault percentage than expected: 11%. It was quite visible in comparison with white, which had a fault percentage of 41. By choosing the colours completely random, not every colour has been tested the same amount. Still we do not expect a lot modifications of results if we had tested every colour the equal amount. The overall results are shown on the pictures to the left. The most important result we found was that the colours green, red and blue were flawless at 12,5 meters.

Future vision

what we think OptiField should become

In the future we believe our concept has to become personal to everyone. Everyone should be able to make their own training. Next to that the preparations should save time in the worked out situation. So it have to be faster than placing pawns and other marking materials which leaves more time for practise. The coach/ trainer is able to give feedback on the field with this smart device.

To accomplish all, we are doing a lot of research to make it possible to meet with all the requirements of FIFA. As extra possibility, the OptiField could be used in the advertisement world, but we want to keep the focus on the sport possibilities.

Our successor

how we think a successor should continue with OptiField

In the future we believe our concept has to become personal to everyone. Everyone should be able to make their own training. Next to that the preparations should save time in the worked out situation. So it have to be faster than placing pawns and other marking materials which leaves more time for practise. The coach/ trainer is able to give feedback on the field with this smart device.

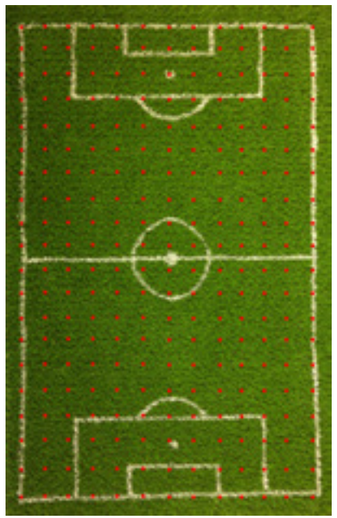
To accomplish all, we are doing a lot of research to make it possible to meet with all the requirements of FIFA. As extra possibility, the OptiField could be used in the advertisement world, but we want to keep the focus on the sport possibilities.

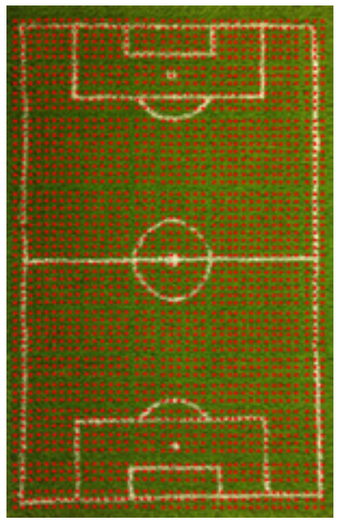
Feasibility research

how far OptiField can be realised with current technologies

We deliver a product which is not ready to launch. The simple reason for this, is that we had no time to work it out to a final product. Therefore we decided to complete our product as far as possible, so it becomes easy and tempting to develop it to the end. We provided a feasibility- and financial analysis part in the next chapters.

Of course there is still a big step to make, but with our report we believe we made a great step in the right direction. The complete feasibility research can be found in the appendix.





Advice plan

the three step plan we suggest an investor

To make it possible for a company to continue with developing OptiField, we created a plan they can use to pick up our concept so far and expand until the final product is realised. The plan is build up in 3 steps going from relatively cheap to more expensive but with a LED grid integrated in the whole field.

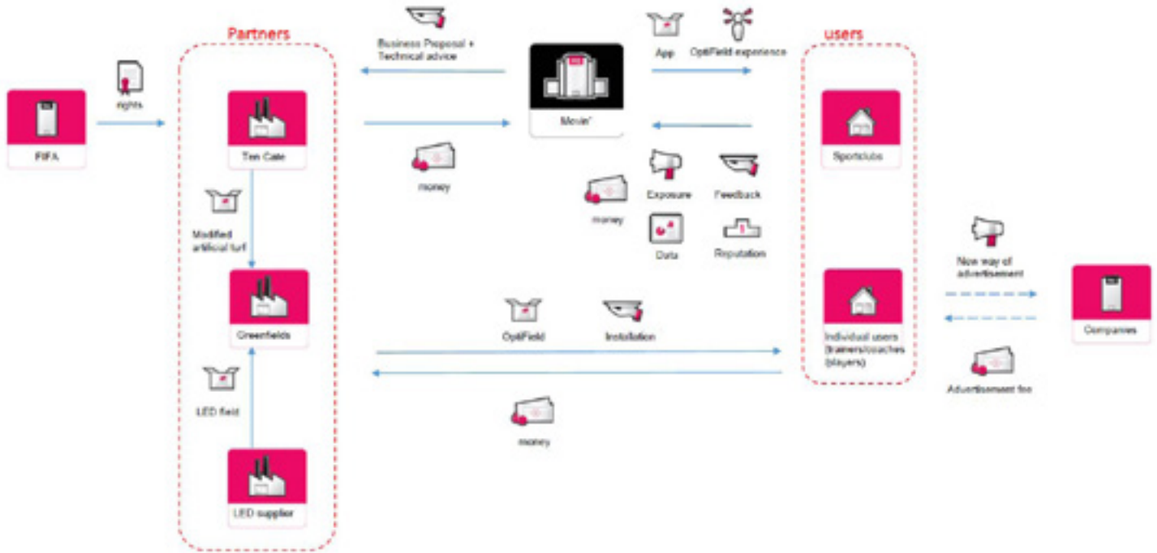
A frontrunner of the final OptiField could be to implement dot of light into the field every 5 meters apart so the user is able to set out smaller fields and straight lines on this grid. The next step would be dots of light one meter apart from each other. The final step would be to integrate light into the entire field. To give an impression of the cost. We made a cost price calculation for each step.

The indication of costs of our added technology is summed up below.

Standard artificial turf: €200.000 - €500.000 (TenCate, Greenfields) in combination with one of the three different versions of the OptiField (considering a 65m x 100m field):

20cm x 20cm dot every 5 meters apart:
Total price = €6.360,2
20cm x 20cm dot every 1 meter apart:
Total price = €111.005,0
Fully illuminated:
Total price = €1.227.423,4

OptiField in business



our prefered position in the market

Movin' your partner in realizing illuminating sports fields, leading through research and development.

For OptiField a healthy business is needed. With aid of the board of innovation we visualized our position in the market. As seen on the left different parties and stakeholders play a role in this model. We want to have a centred position in the market, though we don't want to be responsible for the maintenance, this stays the responsibility of the companies that deliver and install the OptiField. We keep in close contact with the suppliers, so that we stay partners. We deliver the business proposal and the technical advice to these partners.

For the users we deliver the OptiField experience. You can buy the app in an app store. Just like you buy for example the GoPro app for extra usability for your GoPro. Within this app, in a later stadium, it will be possible to buy different training sessions. Think of a training of Barcelona or the speed of Messi. Through the app community our brand gets feedback, data, reputation and exposure.

Next to the business model we discussed our value proposition with the business model canvas, which can be found in the appendix.

Conclusion

different parties that helped us making a proper decision

OptiField, an idea that started in the beginning of the semester and developed into a concept, but not just into a concept. The idea that made each individual of Movin' a better designer. During the project the collaboration within the group improved, mainly because we all wanted to go into the same direction with the same desires. Every one of us could do what he wanted to do. Together we did what was needed for the development of the project. We followed the planning we made in the beginning and halfway the semester, thanks to InnoSportLab. This aspect has been important in the succession of the project and OptiField.

We think it is possible for a company willing to set the first step to realize OptiField. Technological wise it is possible and achievable, so with the right resources, OptiField can be realized and launched onto the market. When it reaches the market, it will change the sports industry with its endless possibilities.

Appendix

List of requirements

- Make a concept in cooperation with InnoSportLab and make use of their possibilities (why: we were lucky to have this opportunity and didn't want to forget about it)

- Being able to user focus (why: it is an project aspect which we think is important to have and to integrate within the project, because it is important to keep the desires of the user in mind.)

- Hands on during the project (why: with visualization you make clear for yourself and for your surroundings what you want to achieve and receive more and most of the time better feedback)

- Be unique, make a new dimension (why: there is a lot of innovation within sports which make it hard to be unique, but it makes you think better about things and makes sure that you have covered all wanted areas.)

- Be innovative in a new way (why: As mentioned, there is a lot of innovation, but we want to go in a new direction. Be innovative by making something new.)

- A concept that is feasible and business centred (why: We want to make a realistic concept with which could be developed after the semester is finished. We want to make a concept that has to include several companies included InnoSportLab.

Arduino code

```
/*
 Serial Event example

 When new serial data arrives, this sketch adds it to a String.
 When a newline is received, the loop prints the string and
 clears it.

 A good test for this is to try it with a GPS receiver that sends out NMEA 0183 sentences.

 Created 9 May 2011
 by Tom Igoe

 This example code is in the public domain.

 http://www.arduino.cc/en/Tutorial/SerialEvent

 */
#include <Adafruit_GFX.h>    // Core graphics library
#include <RGBmatrixPanel.h> // Hardware-specific library
#define CLK 8  // MUST be on PORTB! (Use pin 11 on Mega)
#define LAT A3
#define OE  9
#define A   A0
#define B   A1
#define C   A2
RGBmatrixPanel matrix(A, B, C, CLK, LAT, OE, false);

String inputString = "";         // a string to hold incoming data
boolean stringComplete = false;  // whether the string is complete
int incomingByte = 0;

int x, y;
int r = 7;
int b = 7;
int g = 7;
int s = 0;
int cols, rows;
```

```
void setup() {
  // initialize serial:
  Serial.begin(115200);
  matrix.begin();

  // reserve 200 bytes for the inputString:
  inputString.reserve(200);
  pinMode(13, OUTPUT);

  r = 7;
  b = 7;
  g = 7;
}

void loop() {


  // print the string when a newline arrives:
  //Serial.println(stringComplete);
  if (stringComplete) {


    int spaceposition = inputString.indexOf(' ');


    if (spaceposition >= 0) {
      String currentInt = inputString.substring(0,
spaceposition);
      x = currentInt.toInt();
                              inputString = inputString.
substring(spaceposition + 1);
      int spaceposition = inputString.indexOf(' ');

      if (spaceposition >= 0) {
        String currentInt = inputString.substring(0,
spaceposition);
        y = currentInt.toInt();
                              inputString = inputString.
substring(spaceposition + 1);
        int spaceposition = inputString.indexOf(' ');

        if (spaceposition >= 0) {
          String currentInt = inputString.substring(0,
spaceposition);
          r = currentInt.toInt();
                              inputString = inputString.
substring(spaceposition + 1);
          int spaceposition = inputString.indexOf(' ');

          if (spaceposition >= 0) {
            String currentInt = inputString.substring(0,
spaceposition);
            g = currentInt.toInt();
                              inputString = inputString.
substring(spaceposition + 1);
            int spaceposition = inputString.indexOf(' ');

            if (spaceposition >= 0) {
              String currentInt = inputString.substring(0,
spaceposition);
              b = currentInt.toInt();
                              inputString = inputString.
substring(spaceposition + 1);
              matrix.drawPixel(x, y, matrix.Color333(r,
g, b));
              digitalWrite(13, HIGH);

              s = inputString.toInt();
              Serial.print(x);
              Serial.print('-');
              Serial.println(y);
            }
          }
        }
      }

      //alles uit
      if (s == 1) {
        matrix.fillScreen(matrix.Color333(0, 0, 0));
      }

      //blauw rechthoek
      if (s == 2) {
              matrix.drawRect(0, 0, 15, 10, matrix.
Color333(r, g, b));
      }

      //achtergrondkleur
      if (s == 3) {
        matrix.fillScreen(matrix.Color333(r, g, b));
      }

      // rondo
      if (s == 4) {
        matrix.drawCircle(7, 7, 7, matrix.Color333(r,
g, b));
      }

      // clear the string:
      inputString = "";
      stringComplete = false;
    }
  }
}

/*
  SerialEvent occurs whenever a new data comes
in the hardware serial RX. This routine is run
between each time loop() runs, so using delay
inside loop can delay response. Multiple bytes
of data may be available.
 */
```

```
void serialEvent() {
  while (Serial.available()) {
    // get the new byte:
    char inChar = (char)Serial.read();
    //Serial.print(inChar);
    // add it to the inputString:
    inputString += inChar;
    //    Serial.println(inputString);
    // if the incoming character is a newline, set a
flag
   // so the main loop can do something about it:
    if (inChar == '\n') {

      stringComplete = true;
    }
  }
}
```

Processing code

```
import processing.serial.*;

int videoScale = 58;

// Number of columns and rows in our system
int cols, rows, r, g, b, out;
int s = 0;

Serial port;

void setup() {

 // List all the available serial ports in the output
pane.
   // You will need to choose the port that the
Arduino board is
  // connected to from this list. The first port in
the list is
  // port #0 and the third port in the list is port
#2.
   // if using Processing 2.1 or later, use Serial.
printArray()

  println(Serial.list());

  // Open the port that the Arduino board is
connected to (in this case #0)
   // Make sure to open the port at the same
speed Arduino is using (9600bps)
  port = new Serial(this, Serial.list()[0], 115200);

  size(2640, 930);

  // Initialize columns and rows
  cols = width/videoScale;
  rows = height/videoScale;
  s = 0;

  // Begin loop for columns
  for (int i = 0; i < cols; i++) {
    // Begin loop for rows
    for (int j = 0; j < rows; j++) {

      // Scaling up to draw a rectangle at (x,y)
      int x = i*videoScale;
      int y = j*videoScale;
      fill(255);
      stroke(0);
       // For every column and row, a rectangle is
drawn at an (x,y) location scaled and sized by
videoScale.
      rect(x, y, videoScale, videoScale);
    }
  }

 for (int i = 32; i < cols; i++) {
   // Begin loop for rows
   for (int j = 0; j < rows; j++) {

     // Scaling up to draw a rectangle at (x,y)
     int x = i*videoScale;
     int y = j*videoScale;
     fill(200);
     stroke(0);
      // For every column and row, a rectangle is
drawn at an (x,y) location scaled and sized by
videoScale.
     rect(x, y, videoScale, videoScale);
   }
  }
}

void draw() {

  if (mouseX > 0 && mouseY > 0) {
    cursor(HAND);
  }

  fill(r*36, g*36, b*36);
       ellipse(cols*videoScale + videoScale/2,
rows*videoScale + videoScale/2, 30, 30);
```

```
if (mousePressed == true) {
  //wit
  if ((cols == 32) && (rows == 0)) {
    r = 7;
    b = 7;
    g = 7;
    s = 0;
  }

  //rood
  if ((cols == 32) && (rows == 1)) {
    r = 7;
    b = 0;
    g = 0;
    s = 0;
  }

  //blauw
  if ((cols == 32) && (rows == 2)) {
    r = 0;
    b = 7;
    g = 0;
    s = 0;
  }

  //groen
  if ((cols == 32) && (rows == 3)) {
    r = 0;
    b = 0;
    g = 7;
    s = 0;
  }

  //geel
  if ((cols == 32) && (rows == 4)) {
    r = 7;
    b = 0;
    g = 7;
    s = 0;
    fill(255, 255, 0);
  }

  //gum
  if ((cols == 32) && (rows == 5)) {
    r = 0;
    b = 0;
    g = 0;
    s = 0;
  }

  //alles uit
  if ((cols == 32) && (rows == 15)) {
    r = 0;
    b = 0;
    g = 0;
    s = 1;
  }

    // Begin loop for columns
    for (int i = 0; i <= cols -1; i++) {
      // Begin loop for rows
      for (int j = 0; j <= rows; j++) {

        // Scaling up to draw a rectangle at (x,y)
        int x = i*videoScale;
        int y = j*videoScale;
        fill(255);
        stroke(0);
          // For every column and row, a rectangle
is drawn at an (x,y) location scaled and sized by
videoScale.
        rect(x, y, videoScale, videoScale);
      }
    }
  }

    //een vierkant
    if ((cols == 32) && (rows == 6)) {
      s = 2;

      fill(255);
          rect(cols*videoScale-15  +  videoScale/2,
rows*videoScale-15  + videoScale/2, 30, 30);
    }

    //achtergrond
    if ((cols == 32) && (rows == 8)) {
      s = 3;

      fill(255);
          rect(cols*videoScale-25  +  videoScale/2,
rows*videoScale-25  + videoScale/2, 50, 50);
    }

    //rondo
    if ((cols == 32) && (rows == 7)) {
      s = 4;

      fill(255);
          ellipse(cols*videoScale  +  videoScale/2,
rows*videoScale + videoScale/2, 10, 10);
    }

    if ((cols == 32) && (rows > 8)) {
          rect(cols*videoScale-28  +  videoScale/2,
rows*videoScale-28  + videoScale/2, 56, 56);
      fill(255);
      r=0;
      g=0;
      b=0;
    }
```

```
  cols = mouseX/videoScale;
  rows = mouseY/videoScale;

  port.write(str(cols));
  port.write(' ');
  port.write(str(rows));
  port.write(' ');

  port.write(str(r));
  port.write(' ');
  port.write(str(g));
  port.write(' ');
  port.write(str(b));
  port.write(' ');
  port.write(str(s));
  port.write('\n');
  println(cols);
  println(rows);
  println(r);
  println(g);
  println(b);
  println(s);
  s = 0;
 }
}
```

Feasibility research OptiField

How do we reach success with this product?

Pleun Heeres
Daan Heijsters
Olivier van Duuren
Stijn van Geffen

Introduction

At the end of our project we cannot deliver a final prototype/product. That is the reason that we deliver an advice plan for our stakeholders/ potential entrepreneurs. In this advice plan we include feasibility analyses to clear all uncertainties and to give the reason to invest in this new product. Based on such analyses it is easier to make decisions. The goal of this advice plan was to show the different steps to be made in developing this product.

Realization

Showstopper
In the world of professional sports new innovations are difficult to launch on the market, for example because of traditional norms and values. In our situation there are some obstacles but still opportunities, because all good innovations can bring along risks. Without taking risks we will never innovate. Still it is important to sum up all the stumbling points.
So why is there not yet such a product on the market? There are some relevant aspects in which this product brings along problems. In the current situation, the main problem is that FIFA does not allow any technology in the field. These strict rules have to be edited, because of the many advantages this product has. That is unfortunately still a stumbling point for many entrepreneurs.
Next to that the high tech field has to be applied in artificial grass, which not everyone agrees to play on, because of the high probability of getting injuries. So the field has to be really injury-proof, before football players will play on it and the properties of the artificial turf may not change when the system is integrated.

Motivation

We still believe someone has to take risks and thus we started to do research to clear up all the uncertainties and present a more realistic product. We want to convince everyone of all the advantages of this new technology. It will definitely influence the sport world positively in our opinion.
Why is this new technology relevant for innovation in sport? Why is this so much better than all the current applied technologies in sport and what is an important addition to all the stakeholders?
At first we give our customers the opportunity to create everything they, until now, desired to implement in their trainings. Imagine you can draw all your trainings on your play field. Then it becomes possible to give direct visual feedback with the use of your light controlling. In the sense of creating what you want, our product is very personal and thus customizable. Secondly, it becomes easy to mark out a created play area, in words of a circle of rectangular. Instead of marking points a whole line is visible. So that prevents all possible misunderstandings. It would even become possible to have moving shapes on the field, for example a moving goal.

Demand

'If such an artificial illuminated grass field is affordable, then it will be in every single stadium within ten years.' This was said by human movement scientist Ruud van Elk during our conversation. The meeting with Ruud van Elk and Luc van Agt(physiologist) was organized to get a clear view of the needs of the potential customers. Based on this meeting we assume that this product has a high demand. They mentioned that this technology would be very new. Most of the innovation has a sort of similar goal in another earlier product. For example to improve precision for example. This is a solution in a whole new area of innovation and that was a big plus. Next to that they predict that all the sport clubs active in the Dutch soccer competition(Eredivisie), will eventually all have an artificial grass field. This means that they will all play on artificial grass and accept the consequences to the play style. So when the players all accept to play on an artificial grass field, then the target group is a lot bigger and you will have a lot more potential users. As conclusion PSV noted that this will definitely reach the market. The only requirement was, that the costs have to be responsible enough. Then it will become a guarantee to success, according to the men Luc van Agt and Ruud van Elk.

Steps towards the OptiField

To realise the eventual product small steps can be made towards it. The ideal product would be a field that is able to entirely light up, but to realise this at once isn't realistic so we thought of frontrunners of this ideal that later on can be extended. A frontrunner could be to implement dot of light into the field every 5 meters so the user is able to set out smaller fields and straight lines on this grid. The next step would be dots of light one meter apart from each other, with this density the user would already be able to draw shapes like circles for example. The final step would be to fully integrate light into the entire field. to give an impression these the cost of these different steps are estimated in the cost price calculation.

Cost price calculation

In this calculation we try to involve as much as predictable costs as possible. The values are based on estimations and thus this calculation is not particularly applicable as model, but as rough sketch. Beneath each single calculation we describe the definition of the value.

Standard artificial turf: €200.000 - €500.000 (TenCate, Greenfields) in combination with:
One of the three different versions of the OptiField (considering a 65m x 100m field):

20cm x 20cm 5 meters apart:
Led grids: 13 x 20 = 260. Price= €16.43, 260 x €16.43 = €4271.8
(65m / 5 = 13 (length), 100m / 5 = 20 (width), €16.43 (price per led grid)
Calculating power: 1 chip (€0.02) delivers 750 mA. 1 part needs 320mA so 2 parts per chip. 260 parts/ 2 = 130 chips, €0.02 x 130 = €2.6
(1 arduino (chip) is able to deliver 750mA, this is enough for two grids, the costs of standard chips from china is estimated at €0.02 is this amounts)
Central computer: €2000
Wires: each part 33m, 260 x 33m = 8580. €0.01 x 8580 = €85.8
(width field = 65m, 65/2 = 33m. 33 x 260 units = 8580 x the price of 1m wire.)
Total price = €6360,2

20cm x 20cm 1 meter apart:
Led grids: 65 x 100 = 6500. Price= €16.43, 6500 x €16.43 = €106795.0
(65m / 1 = 65 (length), 100m / 1 = 100 (width), €16.43 (price per ledgrid)
Calculating power: 1 chip (€0.02) delivers 750 mA. 1 part needs 320mA so 2 parts per chip. 6500 parts/ 2 = 3250 chips, €0.02 x 3250 = €65
(1 arduino (chip) is able to deliver 750mA, this is enough for two grids, the costs of chips from china is estimated at €0.02 is this amounts)
Central computer: €2000
Wires: each part 33m, 6500 x 33m = 214500. €0.01 x 214500 = €2145
(width field = 65m, 65/2 = 33m. 33 x 6500 units = 214500 x the price of 1m wire.)
Total price = €111005,0

Fully illuminating:
Led grids: 20 x 24 = 480. Price= €2545, 480 x €2545 = €1221600
(65m /2.7 = 24 (length), 100m / 5.2 = 20 (width), €2545 (price per led grid)
Calculating power: 1 chip (€0.02) delivers 750 mA. 1 part needs 320mA so 2 parts per chip. 162500 parts/ 2 = 81250 chips, €0.02 x 81250 = €1625
(1 arduino (chip) is able to deliver 750mA, this is enough for two grids, the costs of chips from china is estimated at €0.02 is this amounts)
Central computer: €2000
Wires: each part 340 x 1.25m = 425m + 33m = 458m for each part. 480 parts x 458m = 219840m. €0.01 x 219840 = €2198.4
(for each grid 340 parts are needed from the center (2,5m) / 2 = the average is at (1,25m). So 1,25 x - 340 = 425 + 33m (across the field) = 458m x 480 units x the price of 1m wire.)
Total price = €1227423,4

Our development

On the technology aspect we made some big steps in the good direction. We are able to draw free-hand and shapes on a led grid. This 'draw board' is of course still very small, but it could be called a scale version of OptiField. We tested the light intensity and we found that our light source was good enough. However there wasn't turf on it during this test, so it is still an uncertainty if it will be bright enough with the transparent turf installed. The biggest stumbling point we found is the light intensity and the very strict requirements of the artificial turf, so it will still be a big challenge to realise the OptiField.

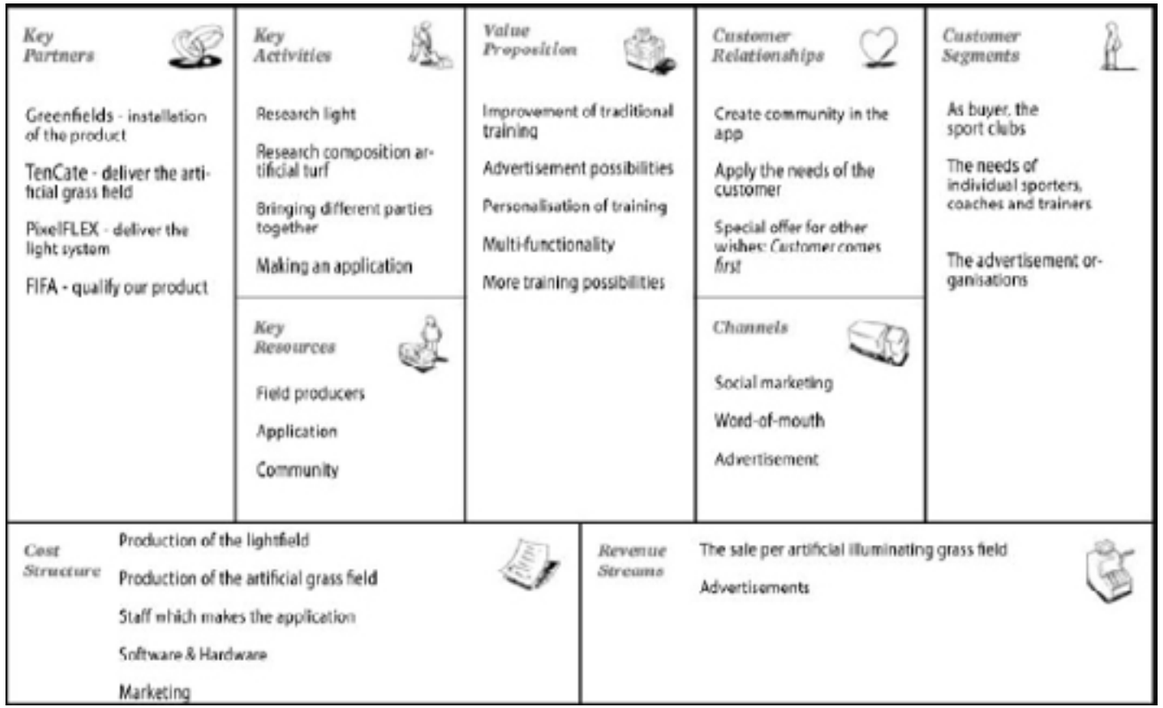
Conclusion

We as students aren't able to complete this product on our own, considering our financial possibilities and the available time, but we think it is possible for a company willing to set the first step. Technological wise it is possible and achievable, so with the right resources OptiField can be realised and launched to the market. When it reaches the market it will change the sports industry with its endless possibilities.

Appendices

Original text Ruud van Elk: 'Als je zo'n veld betaalbaar krijgt, dan ligt het binnen 10 jaar in elk stadion.' – 16-04-2015 at Herdgang, Eindhoven.

Business model canvas



References

This a list of the used resources, we used several websites for troubleshooting and read some books for inspiration.

picture on introduction page: https://www.facebook.com/InnoSportLabSportenBeweeg/photos/a.806176412743093.1073741829.600647353296001/992070034153729/?type=1&theater

picture on research page:
https://www.facebook.com/InnoSportLabSportenBeweeg/photos/a.806176412743093.1073741829.600647353296001/980324938661572/?type=1&theater

project description
http://static.studiegids.tue.nl/uploads/media/S2-1415_Project_Descriptons_Out_of_Control_01.pdf

adafruit LED-grid
https://learn.adafruit.com/32x16-32x32-rgb-led-matrix/overview

Library arduino
https://github.com/adafruit/RGB-matrix-Panel

board of innovation
http://www.boardofinnovation.com/

"I worked with great people this project, which I think resulted in a great concept and major development for us as designers individually. We worked hard but had a great time doing so".

-Daan Heijsters

"Looking back at this project I am really proud of what we accomplished and especially the way of working towards our final concept. Throughout the project we worked hard and professionally together".

-Pleun Heeres

"Unfortunate that we have to stop, because I think this project was really interesting and worth continuing with the four of us".

-Olivier van Duuren

"Movin', a project group that started with brainstorming which resulted in OptiField, just great!"

-Stijn van Geffen

June 2015