Fibo by First Bond Wearables

Design and development of a smart bracelet which helps expectant parents to share the experience of pregnancy

WelfareTech
Collaborative Innovation

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Executive Summary

As part of the “Design Smart Things” performance contract and as part of Welfare Technology’s Network for Innovation, Health and Welfare Technologies, IdemoLab, FORCE Technology has been working with First Bond Wearables to explore partners, technologies and barriers to the creation of a smart bracelet which helps expectant parents to share the experience of pregnancy.

This report has been supported by ISV and our research project "Design Smart Things", and prepared by First Bond Wearables in collaboration with IdemoLab and the ambition with providing this is to help companies who are seeking to develop a smart product with useful information about the process and experiences of First Bond Wearables. As a new startup company who did not specialize in technology, First Bond Wearables needed to get many insights into how the innovation ecosystem in Denmark functions, which funds and incubators they could apply to, and what that process was actually like; the state-of-the-art in technology and how they could integrate this technology into their product; what it is like to seek and collaborate with established companies as partners in a project; how to navigate dependence on a yet-unconfirmed partner product; how to think about and do business development including business and value modelling; and ultimately all the challenges that accompanied this journey.

As such, this report is published as a publicly available document as the outcome of IdemoLab’s work with Welfare Technology’s Network for Innovation, Health and Welfare Technologies. The ambition with the project was to help other companies to learn from the journey of First Bond Wearables and the other companies who took part in the project, and illuminate the potential paths a company can take when creating a new smart health care product.

Introduction

IdemoLab, FORCE Technology worked with with First Bond Wearables, who wants explore and develop "Fibo" - a pregnancy wearable for men (and partners of pregnant women).

The focus of the collaboration, which has been based on IdemoLab’s design thinking based “8-Step” innovation method, has been to explore, find, and engage other partner-companies while utilizing the modelling and in-context testing capabilities of IdemoLab. As with many other startups in this segment, these are what First Bond Wearables identified as the areas, where they had most need for help in.

In this open innovation project, we recruited other companies and institutions, whose involvement featured knowledge-sharing and methods in areas such as anthropological research, industrial design, wearables and medical device developments.

The companies involved will be introduced in detail in a later chapter called *Partners and Meetings*.

Companies who have been part of this process include:

HOLSCHER DESIGN
Design Studio
holscherdesign.com

TACKLE STUDIO
Service Design
tacklestudio.com

VÆKSTHUS HOVEDSTADEN
Consultancy / DigitaliseringsBoost
startvaekst.dk/vhhr.dk/forside/0/2

HAPY MEDICAL
Consultancy / Medical Wearable Devices
hapymedical.com

KEA
Guidance / Network / Wearables Lab
kea.dk

AAU
Part of a PhD about Designing for Meaningfulness in Smart Products
meaningfuldevices.com

Background

First Bond Wearables is a Danish startup which is developing a wearable for expectant parents to use during the last trimester of the pregnancy. Their solution is a smart bracelet called Fibo, which aims to share the experience of pregnancy by providing partners of pregnant women with the opportunity to know when the baby is moving and kicking inside the belly, through real time, haptic feedback on the wrist.

The business model behind Fibo is based on the customers *renting* the device for use during the third trimester of a pregnancy when fetal activity can best be detected.

The concept of Fibo was created by three Jewellery, Technology & Business students at Copenhagen School of Design and Technology (KEA) during a wearable technology class, taught at KEA by IdemoLab. The concept is on the feedback device alone, and the solution as such needs to collaborate with another device and a company focusing on patch solutions for detecting fetal activity. At the time of writing, several companies like this exists, such as Bloomlife (bloomlife.com) and TinyKicks (tinykicks.com).

These patches are placed on the pregnant woman's belly and detect the fetal activity. Originally, Bloomlife and TinyKicks should be coupled with an app, and the concept which Fibo is based on is one wherein Fibo accesses the movement data from the partner company's patch and translates this data to movement in a smart bracelet.

The smart bracelet contains four small beads of different sizes, and is worn on the wrist (see Figure 1 and 2). When the baby kicks, moves, or has hiccups, the beads are activated and the partner can then feel these movements as presses, hits, or prodding against the wrist. In this way, the partner and mother of the child can share the physical experience of the baby's movements from a distance and can establish a deeper tangible and emotional bond from the shared experience (instead of just seeing numbers on an app).

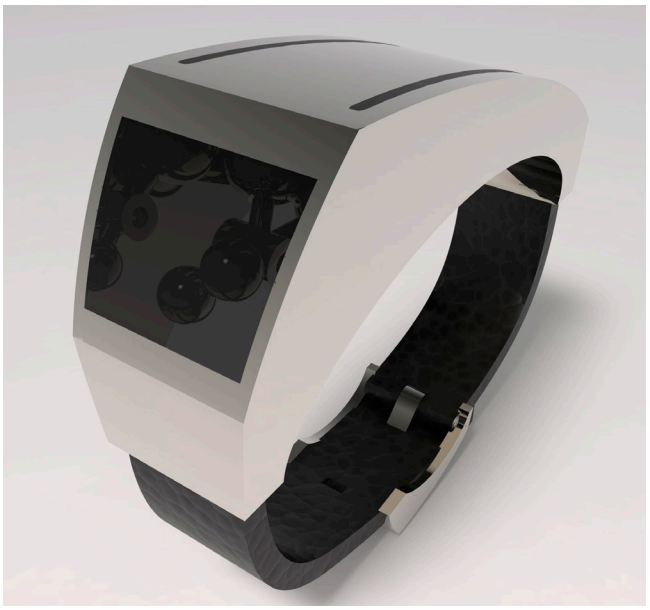


Figure 1: The Fibo smart bracelet.

Figure 2: Showing the rotating beads inside the Fibo smart bracelet.

Technology Requirements

Based on user studies conducted by First Bond Wearables and feedback from expectant parents there are several technical requirements which Fibo must fulfill:

PATCH (MAMA DEVICE)

- Has to detect different fetal activity - kicking/movement/hiccups
- Can detect the fetal activity from the mother's activity (eg. when she walks, sits down etc.)
- Can be used for a whole day
- Can be put on and taken off multiple times
- Smooth design, not distracting the user
- Sensitive - can detect fetal activity without being placed exactly in the area where the activity occurs

BRACELET (PARTNER DEVICE)

- The feedback should be anything other than vibration, sound or light
- The feedback has to happen in real time
- The bracelet should be silent (no buzzing motors or similar)
- No screen (unless it is a built in clock)

OTHER

- Materials suitable for renting (hygiene) as Fibo is a rental device
- Both mama device and Fibo need to be connected to the cloud in order to receive and translate movement data

PCB DESIGN & CONSIDERATIONS

- A device with moving parts requires significant energy. A concern is to optimize energy-consumption, to limit needed battery/recharging cycles
- Taking the above into consideration, the actuation needs to be significant to be distinguishable from other sensations on the skin

Partners and Meetings

In the ecosystem of companies involved with the exploration of Fibo, there is a distinction between those providing the data (the mama device - here, HAPY medical), those providing funding (Væksthus), those providing industrial design (Holscher Design), those providing service design (Tackle Studio) and those providing technological insights and explorations (IdemoLab).

Following is an overview of each company and institution:

Holscher Design

One of Scandinavia's most recognized design studios with more than 25 years of experience. Their role in this project is to develop a design brief for the physical appearance and materials for the Fibo smart bracelet.

Tackle Studio

They conduct user research, gather insights and translate needs into new services and products. In this case Tackle Studio will assist in developing the service design and product journey for First Bond Wearables.

Væksthus

Væksthus Copenhagen offers guidance to startups and businesses with ambitions towards growth and reaching new heights of success. Their program DigitaliseringsBoost allows startups (and collaboration partners) to get up to 33% of funding for hours spent on developing a new product. Væksthus through consulting and their DigitaliseringsBoost program helped First Bond Wearables apply for funding and provide guidance leading to developing a working prototype of Fibo.

HAPY medical

Highly experienced medical wearable designers. They will provide insight and evaluation results for proof-of-concept by using one of their solutions called ePatch to evaluate fetal movement.

KEA

Started the Wearable Technology program where Fibo was first created and is an important part of First Bond Wearables' network. The school has provided space for prototyping and testing at the Wearables Lab (keawearables.com/thelab/), as well as guidance and consulting with experts such as Petra Ahde-Deal, *Docent of Wearables and Aesthetic Technology* at

KEA and Gunnar Näsman, *Development Consultant* at KEA. Gunnar also runs the Mindset Accelerator program which First Bond Wearables was a part of in 2017 (mindsetaccelerator.dk).

AAU

Is a part of a PhD about Designing for Meaningfulness in Smart Products. Fibo has been featured in two published academic articles:

1. Carpenter, V and Overholt, D. (2018) "Designing for interpersonal connections in future technologies: An annotated portfolio of jewellery devices". Proceedings of the 2018 NordDesign conference. Design Society. https://www.designsociety.org/publication/40883/Designing+for+interpersonal+connections+in+future+technologies%3A+An+annotated+portfolio+of+jewelry+devices%C2%A0

2. Carpenter, Vanessa Julia, and Dan Overholt. "Designing For Meaningfulness: A Case Study Of A Pregnancy Wearable For Men." Proceedings of the 2017 ACM Conference Companion Publication on Designing Interactive Systems. ACM, 2017. https://doi.org/10.1145/3064857.3079126

Væksthus's DigitaliseringsBoost

IdemoLab joined meetings and helped to provide technical descriptions of how Fibo might be constructed during the application process. First Bond Wearables was accepted into Væksthus's DigitaliseringsBoost program which requires the collaboration of minimum 3 small or medium sized companies as well as a knowledge institution.

For the program, IdemoLab facilitated a collaboration with Tackle Studio and Holscher Design, companies which fit DigitaliseringsBoost's criteria for participation as well as being beneficial for the development of Fibo. The Welfare Tech Innovation Network for Health and Welfare Technology also joined the initial meeting as it was a natural progression from the funding IdemoLab had received from them for this project to collaborate with the DigitaliseringsBoost program. The people working at Væksthus have been incredibly helpful and informative throughout the entire process.

Through several meetings and workshops with the companies and Vækshus, the goals of the program were identified as well as outlining the involvement of each partner.

The companies met for open workshops and knowledge sharings throughout the project. Based on the process with Fibo, we can summarize the meetings necessary for a startup in this space, to establish an initial groundwork for development:

1. Væksthus meetings
   - Introduction to the DigitaliseringsBoost program with partners - Tackle Studio, Holscher Design and IdemoLab
   - Finalizing the application for DigitaliseringsBoost
   - How to fulfill the milestones for DigitaliseringsBoost with the current financing (Tackle Studio and First Bond Wearables have a problem with how the financing is done)

2. Collaboration meetings
   - Collaboration with Bloomlife, TinyKicks, Cortrium. Exploring possible collaboration partners (mama device)
   - Also how to get the most out of the collaboration with Holscher Design and Tackle Studio
   - Meeting with DigitaliseringsBoost partners to figure out time registration + payment
   - Meeting with HAPY medical - how to collaborate, what can they do for First Bond Wearables. Reading results meeting after 3 weeks of evaluating the patch

3. Technology meetings
   - Meeting with IdemoLab regarding prototypes of the bracelet and regarding connectivity and cloud solutions

4. Workshops
   - Collaboration Plan (with Bloomlife and TinyKicks), Success/Failure Mapping - Full day workshop at FORCE Technology
   - Business Model Canvas and Value Proposition - Full day workshop at FORCE Technology
   - Connectivity planning - half day workshop with IdemoLab

5. Financing meetings
   - InnoFounder pitch. Feedback meeting with Head of Program at InnoFounder
   - Danish Tech Challenge meeting with Program Manager - does it make sense for First Bond Wearables to apply?

Focus Area

Developing a functional prototype where all the factors of the concept (in this case study, the First Bond Wearable) are put together requires the following:

1. State-of-the-art research on suitable products for a mama device which can detect fetal activity and send it to the Fibo bracelet
2. Finding and testing potential interaction technology for the bracelet
3. Creating a connectivity plan for the mama device and partner device to communicate
4. Finding partners and funding to keep the development process going

Project Overview

As with many startups these days, Fibo began as a student project. It quickly developed into a company as startup competitions began to offer First Bond Wearables the opportunity to join their competitions. In becoming a company First Bond Wearables tried to seek a partner for a mama device. However, the ideal provider (Bloomlife, an american company) was too busy to engage with Fibo at the time. Instead, the startup looked for other collaborators and IdemoLab helped connect to two established companies in the space; Holscher and Tackle through Welfare Technology's Network for Innovation, Health and Welfare Technologies.

Together with these new partners, a consortium was formed and it applied to Væksthus' DigitaliseringsBoost program, where they were awarded funding, dependent on if a mama device partner such as Bloomlife could be secured. Unfortunately in the time period we had, both Bloomlife and TinyKicks were unavailable. Fibo began to work with HAPY Medical, another patch development company who does not specialize in prenatal patches. They did, however, provide some valuable insights.
So, in this section the various stages of the project is reported as well as the primary challenges and learnings.

1. State-of-the-art (SOTA)

The concept of Fibo is relying on finding a mama device - a device which can be placed on a pregnant woman's belly and detect fetal activity, such as kicks and movements (and preferably hiccups).

IdemoLab illustrated how a state-of-the-art research on possible devices and technologies for the mama device could be made and, together with First Bond Wearables, reached out to the companies and researchers developing them.

1. Bloomlife - bloomlife.com: A California based company which has developed a patch for measuring contractions. They are the most ideal partner for First Bond Wearables, have a similar business model, a rentable product for expectant mothers, to be used during the last trimester of the pregnancy, and their patch is already on the market. Due to other priorities, Bloomlife was unable to participate in the project at this point.
2. TinyKicks - tinykicks.com: Another California based company developing a kick monitoring patch. Their product is not on the market yet and as it turned out, they are not focused on the patch at the moment, and so were not pursuing further work with it. Therefore a collaboration with them was not possible at this time.
3. BabyBuzz - wsisweden.com/case/libero-babybuzz/: A product developed by the Swedish diaper brand Libero. Their concept is similar to Fibo but instead of a patch the expectant mother is wearing a bracelet and every time the baby kicks she pushes a button on her bracelet which sends a buzz via Bluetooth to another bracelet which her partner is wearing. The project of BabyBuzz was discontinued in June 2018.
4. FMAM Recorder: A research team at Teikyo University in Tokyo has designed and built a new recorder based on fetal movement acceleration measurement (FMAM) with capacitive acceleration sensors. Their research demonstrated high agreement between gross fetal movement detected by ultrasonography and that detected by the FMAM recorder. Furthermore it showed that pregnant women can easily record fetal movement during their sleep at home by themselves whis has until now not been possible[1]. The FMAM recorder is only available for medical research at this point.
5. zPatch: A small fabric sensor patch that can be sewn or ironed onto existing clothing, developed by a research team at Copenhagen University. The patch is designed to maximize sensing capabilities to capture the dynamics of on-body touch interaction and uses a hybrid sensing approach[2]. zPatches provide users with an input channel to control an app on their phone or a remote IoT device with their day-to-day clothing[3]. This might be one possible pathway for future research.

1 Eiji Ryo et al., "A new method for long-term home monitoring of fetal movement by pregnant women themselves," *Medical Engineering & Physics* 34, no. 5 (2012): 570.

2 Paul Strohmeier et al., "zPatch: Hybrid Resistive/Capacitive eTextile Input," *Proceedings of the Twelfth International Conference on Tangible, Embedded, and Embodied Interaction*, (2018): 188.

3 Strohmeier et al., "zPatch: Hybrid Resistive/Capacitive eTextile Input," 190.

6. Cortrium - cortrium.com: A Danish company which is developing the C3 Holter monitoring patch which records high quality 3 channel ECG, with no external wires, and standard ECG electrodes. Although not focusing on fetal activity, Cortrium could share useful knowledge and considerations when developing a patch monitor product. Unfortunately they were unable to participate in the project and gave the feedback that their patch might be too advanced for what it should be used for in the Fibo concept.

7. HAPY medical - hapymedical.com: Danish medical wearable designers which could provide a patch to use for evaluating fetal activity and help with the interpretation of the results. The evaluation will be described in a later chapter.

During the search for a mama device, First Bond Wearables discovered a research team in London focusing on performance of a wearable acoustic system for fetal movement discrimination. The team has designed and optimised a new sensor system embedded in a maternal support band. The package consists of a custom-made inertial measurement unit (IMU) that simultaneously fuses input from 8 acoustic sensors (which detect vibrations resulting from fetal movement) and a tri-axial accelerometer (which detects maternal motions)[4].

State-of-the-art and Partner Reflections

Finding a partner for the mama device has been one of the biggest challenges during the project, especially when reaching out to companies outside Denmark. A key learning is, that it is most valuable to have face-to-face meetings with local companies, as this provides the possibility to show and explain the Fibo concept in detail. This has of course been a challenge concerning finding a mama device partner, as most are placed outside Denmark. As developing a patch from scratch was never a part of First Bond Wearables' plan and would create a significant setback in bringing Fibo to the market according to the current development and production plan, this remains a challenge and will have to be addressed for the project to reach market.

Next steps

The next step is thus to continue to search for a possible mama device partner and keep the conversation going with Bloomlife in case they would have the possibility to collaborate in the near future. Furthermore, as a plan B, Fibo needs to:

- Do more research on other possible solutions that do not involve a patch
- Do more evaluations with HAPY medical
- Contact the research team in London and ask if they are willing to share their knowledge

2. Potential Interaction Technologies

Several interaction technologies can be evaluated when developing a product like the Fibo bracelet. Some of them fit well within the requirements envisioned early on (see page 4), while others were moving away from the original concept (in this case the rotating beads). Below, as an example of how state-of-the-art and potential technologies can be evaluated, we've documented the steps we helped First Bond Wearables carry out to decide on how the interaction between wearer and bracelet could be carried out.

Servo motor

A servo motor[5] was used for the very first Fibo bracelet prototype. It rotated the four small beads which touched the wearers skin, on the sensitive part of the wrist, imitating fetal movement.

Result

The motor was too loud and too big to fit into the Fibo bracelet. Gearing would be needed due to the requirement for large torque and the majority of sensation ends up coming from vibration which is not what First Bond Wearables is trying to achieve.

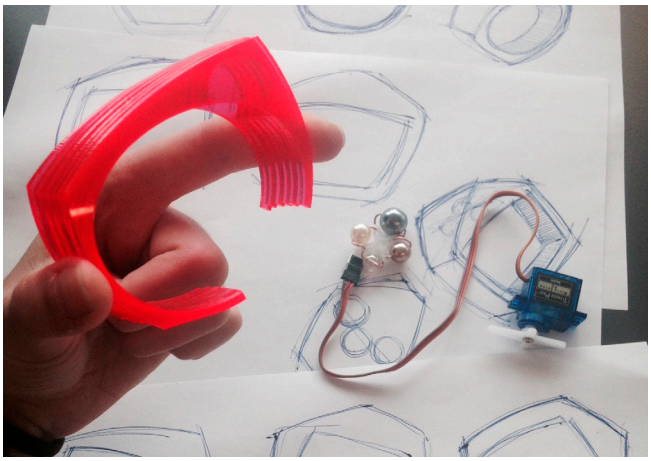


Figure 3: The first prototype of the Fibo smart bracelet, made of plastic and a servo motor used to rotate 4 perls on a wire.

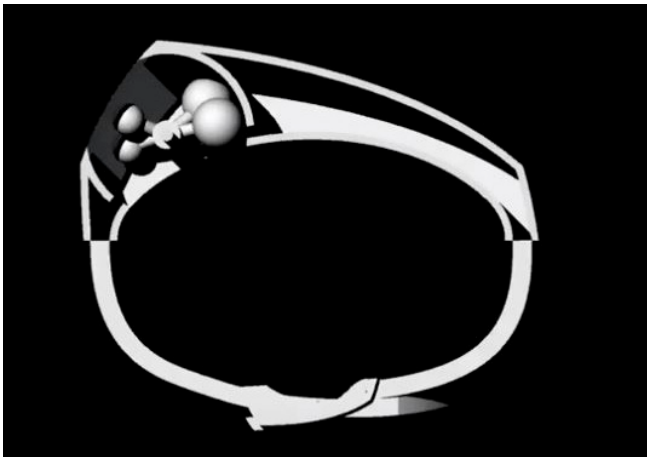


Figure 4: A rendering of the Fibo bracelet showing where the beads are placed in the housing.

4 Lai J, Woodward R, Alexandrov Y, ain Munnee Q, Lees CC, Vaidyanathan R, et al. (2018) Performance of a wearable acoustic system for fetal movement discrimination. PLoS ONE 13(5): e0195728. https://doi.org/10.1371/journal.pone.0195728

5 On Motioncontrol.com a servo motor is described as: The servo motor allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback.

Figure 5: Since a servo motor could not be fitted into the bracelet itself a feel box was created to enable people to feel the beads on their wrist.

Nano 2.0-Gram Performance Linear Long Throw Servo

Being much smaller than a typical servo motor, the nano servo might be a better fit for the Fibo bracelet. The motor along with the beads was still too big for the bracelet (should the placement of the beads be on the 'inside' of the wrist) and therefore another solution was tried out where the motor squeezed the band of the bracelet together.

Result

The result was the same as when using the servo motor, the nano servo was too loud and the squeezing sensation was *interrupted* by the vibration from it.

New piezo actuators from TDK's Epcos group

The millimeter-thin piezo actuators can be driven between 1 and 1000Hz to create versatile haptic effects when embedded into the interface of consumer products.
The actuators combine a multilayered piezo plate construction with cost-effective copper inner electrodes, together with a low-profile titanium cymbals that acts as a mechanical amplifier[1]. The drivers are in small packaging so creating the fetal activity feedback was thought to be easier than what could be done with the motor driven ones, and should be small enough to be placed inside the bracelet. This solution has extremely fast response, and therefore, doing a fast pulse sequences and adjust both the intensity and duration to the scale to mimic fetal movement should not be a problem. These piezo actuators are small, and almost have an order of magnitude lower power consumption, thus allowing smaller battery or longer lifetime.

Result

We were unable to design a hard enough surface so the impact would be noticeable. It ended up being similar to having a buzzer that slightly vibrates. This solution is great for buttons and other things that feature a hard surface to press against but having a flexible strap consumed too much of the impulse and rendering this solution was not very useful.

1 Julien Happich, "Piezo actuators for millimeter-thin haptics," *eeNews Analog*, http://www.eenewsanalog.com/news/piezo-actuators-millimeter-thin-haptics (accessed Nov. 05, 2018)

FLEXINOL smartwires

Flexinol is a type of wire that contracts when heated. This heating can come from putting a high current through it and when wrapped around the wrist, this can give a sensation of pressure similar to a hug. By applying the wires to the bracelet, the idea was to go back to the squeezing feedback.

Result

The wires gave the best result of what has been tested so far. The feedback was completely quiet and subtle but could clearly be felt on the wrist (see Figure 6).
There is still significant testing to be done, though, and the actuators still have not been driven to their maximum potential. In the first evaluations, the wires were too slow to mimic hiccups but the solution could be to use multiple wires in the bracelet and fire them in sequence, resulting in succession of contractions.
One flaw these wires have is that they use significant power which might be a problem if the bracelet is meant to last a whole day.

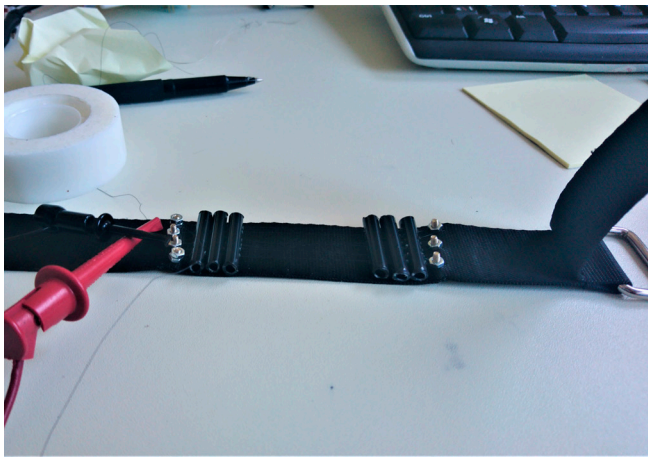


Figure 6: A prototype of the Fibo bracelet with FLEXINOL smartwires.

Interaction Technology Reflections

Using a motor and rotating beads in the Fibo bracelet did not seem to be the best solution for mimicking fetal activity.
Placing the beads on the sensitive part of the wrist, or the 'inside' of the wrist, created challenges with the size of the bracelet. In order to be placed there, the beads, housing, and strap could only be few millimeters thick since too much thickness could annoy the wearer. The bracelet could get too big and the motor would be too loud and create vibration which is one of the main sensations First Bond Wearables was trying to avoid.
The squeezing feedback is a promising development as it gives the wearer the silent, subtle notification which the Fibo bracelet is aiming for.

Next steps

Further testing and development of the squeezing feedback using the flexinol smartwires and other possible technology is needed. We recommend, that First Bond Wearables evaluates other linear actuators, such as the Solenoid Electromagnet Pull Micro, as they should be able to produce a hit (kick) instead of vibration. One consideration for testing of linear actuators could be to try to place them on the side or top of the bracelet as they might be too tall for the bottom.

3. Fibo Connectivity Plan

For many smart products, there will be a communication need. Either between product and, for instance, the cloud - or between different local products. This, as addition to the hardware and electronics challenges, adds up to the overall complexity - especially for small startups.

As mentioned, Fibo consists of two devices, a mama device (a fetal activity-monitoring patch) and partner device (the smart bracelet). The two devices need to communicate wirelessly and at this point it is not decided which technology will be used for this communication. Different scenarios have been drawn to give a better overview and understanding of possible ways to develop and test the concept of Fibo.

In a communications-technology focused workshop, First Bond Wearables had those scenarios defined and mapped out. The resulting challenges and considerations are listed below:

Considerations when developing a connected product

- How to get the fetal movement data?
- How to send the fetal movement data from the mama device to the partner device? (wi-fi, Bluetooth, GSM?)
- How far does the device have to be able to send?
- How accurate should Fibo be? Detect every activity or is 2/3 enough?
- How much delay can there be between the mama device and partner bracelet?

From dream scenario to reality

Following are the steps a company like First Bond Wearables could take when developing Fibo - a connected product:

Dream scenario: A dream scenario for Fibo, is that it is not connected to a smartphone and is an independent product. The two devices would communicate wirelessly where the mama device detects and sends fetal activity data to the partner device and the data is stored in the cloud. Being independent of a smartphone, would make it much simpler and platform agnostic for the user, as every step you need to take to connect wearables to infrastructure will be a roadblock for usability and degrade user experience.

Step 1 (scenario 1): In order to make the concept of Fibo work without using smartphones a Bluetooth station could be used instead. This could be done to test proof-of-concept while still staying within the technical requirements set by First Bond Wearables. The mama device detects and sends fetal activity data to Bluetooth station 1, placed close to the expectant mother. Station 1 then sends the data to Bluetooth station 2, placed close to the partner, which finally sends the data to the partner device. The data is stored in the cloud. This scenario is the first step towards realising the dream scenario in a simple and realistic way.

This solution is not thought to be the most ideal for going-to-market since the Bluetooth stations would always have to be close to the user and at this point it is not realistic to expect the users to always remember to bring such stations with them everywhere they go. This could be used in the places the user uses the most eg. at the office desk or in the kitchen or living room in their home.

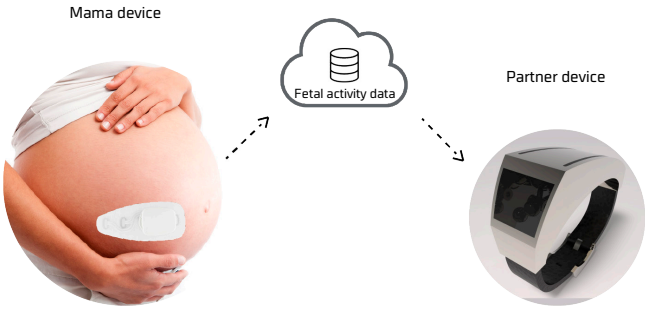
Step 2 (scenario 2): Should step 1 not present any problems then step 2 could be to add smartphones to the concept for faster and easier go-to-market. In this case the smartphones would replace the Bluetooth stations in scenario 1 and an app would be created as a part of the concept.

If the data is stored in the cloud (the app) then this could be a good solution for Fibo since it is highly likely that most of Fibo's user already have smartphones and more features could be added to the concept through the app. However, it is hard to predict how this could change the value of Fibo and if this is moving too far away from the original concept of no smartphones - no screens.

Step 3 (scenario 3): In this scenario the original concept is followed and the dream scenario realised. The mama device communicates directly with the partner device through wireless technology - could for example be GSM. The data is stored in the cloud. The users (expectant mother and partner) only have to use the mama device and partner device which would keep the concept very simple. This scenario would however require the devices to be able to communicate through a great wireless range, preferably without delays.

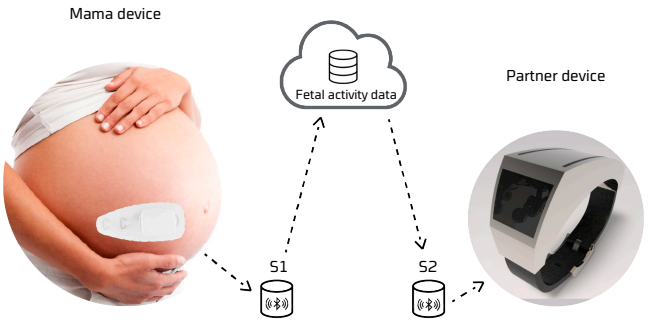
Connectivity Plan Reflections

This workshop focused on what realistic steps First Bond Wearables could take to make Fibo a functioning, connected product which could be tested with future customers and then taken to market. The workshop did not go through all possible wireless technologies which could be relevant for Fibo, however, such an overview is given in the Step 2 (SOTA) technology report. At this point it is not relevant for First Bond Wearables to spend time on cloud solutions as that depends on which technology scenario they end up using for Fibo. It is also not clear at this point who will own the data since it is still unknown if First Bond Wearables will develop the mama device themselves or partner up with another company which would provide the device. Therefore we would also have to look into the issue of privacy and ethics.



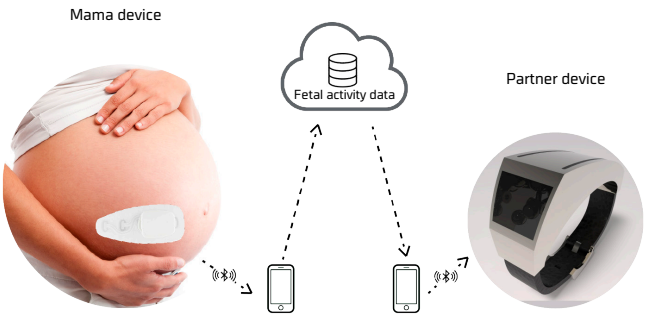
Dream scenario:

- No screen
- No app
- Mama device and partner device are connected
- Patch detects fetal activity and sends directly to bracelet
- Activity data is stored in a cloud



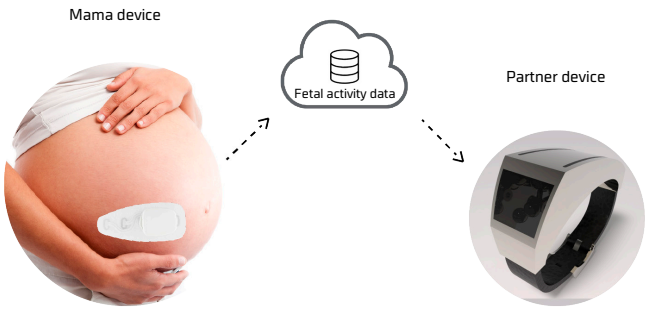
Scenario 1:

- No screen
- No app
- Fetal activity data is shared via Bluetooth
- Bluetooth stations in stead of smartphones
- The patch communicates with S1
- S1 communicates with S2
- S2 communicates with bracelet
- Activity data is stored in a cloud



Scenario 2:

- Patch shares fetal activity to a smartphone app via Bluetooth
- App stores the data in a cloud
- App communicates with the partner's smartphone app
- Partner's smartphone communicates with bracelet



Scenario 3:

- No screen
- No app
- Patch shares fetal activity directly to bracelet (eg. via GSM)
- Activity data is stored in a cloud

Key Partners

- Bloomlife
- Holscher Design
- TinyKicks
- Tackle Studio
- Apple Girl (leather)
- IdemoLab

Key Activities

- Partnership
- Hardware prototyping
- Hardware testing
- Persona
- Aesthetics + Materials
- Service design

Key Resources

- Sandra: Business development
- Eszter: Branding/ Graphics
- Henriette: Production technology
- Vanessa: Hardware
- Petra: User research
- Gunnar: General startup help
- Opening Projects: Law

Value Proposition

- Partner can feel the movement in real time
- Happy experience
- Mom sharing special moments
- Lifestyle bracelet
- Father connects with unborn baby
- Baby's identity being built before birth

Customer Relationships

- Dear X, letter of welcome
- Service: Online chat
- Sharing website/ Forum

Channels

- Website
- Blogs/podcasts
- Medical: dr./ midwife
- Maternity shops
- Parental courses
- Renting 3 months
- Retail: Matas/ farmacy

Customer Segments

- Dads
- First time parents
- Grandparents
- Solid demographic view - first timers

Cost Structure

Fixed cost:
- Material
- Warehouse

Variable cost:
- Manufacturing
- Shipping

Net present value:
- Money invested now - what is that worth in eg. 4 years?

Required rate of return:
- How much do you need to earn to keep the business running and pay off initial investment and keep earning money ?
- Usually set for you
- 10% - 15%
- Break even - before you pay off anything, just when the variable costs and fixed costs are paid off. Not earning but not loosing money
- Look at IRR (Internal Rate of Return)
- Plastic molding to save money

Revenue Streams

Renting	1200 DKK	3 months

4. Business Development: Explorations in Startup Programs, Competitions and Incubators

Integrated in developing a product like Fibo, First Bond Wearables needs continuous focus on business development. The team attended a full day workshop with Henrik Blach, Innovation Consultant at FORCE Technology. The workshop focused on the business model canvas, sharpening the value proposition and identifying one or more business models. The workshop resulted in First Bond Wearables having a great overview of Fibo's current key business elements, as shown above, and a possible solutions for moving forward with the company, eg. where and how to sell Fibo, how much should the product cost and key factors for the total cost of production.

Startup programs and competitions

As many other startups within this space, an extensive part of the early life is applying for funding and startup-programs. During the project First Bond Wearables has applied for various startup programs such as Danish Tech Challenge, InnoFounder and DigitaliseringsBoost. These programs either provide financing and/or incubators with consulting in the relevant areas for the startup. First Bond Wearables has also applied to and entered various startup and pitching competitions both in and outside Denmark. Following are summaries of each of these experiences along with the pros and cons of each as First Bond Wearables experienced it.

Programs

Mindset Accelerator
mindsetaccelerator.dk

Pros:
- 6 weeks program
- Learn to identify qualities and drawbacks of the idea/business
- Sharpen the idea/business through customer development, experiments and prototyping
- Personal coaching
- Become a part of a well defined program, run by The Invention Advisory Service of The Danish Technological Institute

Cons:
- Only for KEA students
- The program is only run if there are enough sign-ups

InnoFounder
innofounder.dk

Pros:
- Monthly grant of 15.000 DKK (per participant)
- A lump sum of 35.000 DKK
- Provides a workspace
- Sparring with advice givers
- Helpful post-application in planning for the next stages

Cons:
- Application process was frustrating because explaining the concept of Fibo within the application limits was very difficult (short application)
- Application was not accepted primarily due to misunderstanding of the concept
- Only for recent graduates (up until 1 year after graduation)

DigitaliseringsBoost
digitaliseringsboost.dk

Pros:
- Up to 600.000 DKK (max 33% of the salary) in support for the teams involved in the product development
- Up to 150.000 DKK funding to involve a knowledge institution in the product development
- Workshops and conferences where the product/ concept can be presented
- Consulting

Cons:
- A lot of confusing paperwork to be filled out once in the program
- Challenging to establish a collaboration with relevant partners - primarily due to payment and how to register hours
- Long wait for receiving payment (3-6 months)
- A requirement for getting accepted was to establish a collaboration with a patch company within 4 months of the start of the program

Danish Tech Challenge

dtusciencepark.dk/futurebox/danish-tech-challenge

Pros:

- Provides a workspace
- Day to day sparring and advice and weekly meetings with experts (DTC or your own)
- Opportunity to network with other companies and startups
- 500.000 DKK award for the best start-up (after completing the DTC 4 month program and pitching in front of large audience)
- Possible to apply multiple times (DTC will give feedback on what is missing in order to be accepted)

Cons:

- The application was not accepted primarily due to how early Fibo is in the development process

Competitions

Creative Business Cup DK

creativebusinesscup.com/cbcdanmark

Pros:

- In 2018: First Place: 25.000 kr. + One-year membership of the Danish Chamber of Commerce
- In 2018: Environmentally friendly high-quality prints of promotion and professional materials: Business cards for 2-3 people, 2 roll-ups and 500 flyers sponsored by Mercoprint.
- Possibility to connect with investors and the global market
- Media coverage

Cons:

- Our application was not accepted for the program (no feedback received)

Microlegat

mikrolegat.ffe-ye.dk

Pros:

- A grant of 25.000 DKK (for the top 3 ideas out of 8 finalists which are chosen to pitch live in front of a jury)
- Easy application process:
  - Written application
  - Financial plan
  - Introduction video

Cons:

- The grant is only available for Danish students
- The application was not accepted primarily due to the jury's position on hardware, wherein they believed that the future was in data and apps

Polar Bear Pitching
polarbearpitching.com

Pros:
- 1st Prize: 2000 EUR, Certificate and Publication at Polar Bear Pitching website
- Fantastic media coverage
- Possibility to meet investors and network
- It's super fun!

Cons:
- You have to pitch in an icehole - it's freezing! (This is also a part of the fun)

Figure 7: First Bond Wearables pitching in the icehole at Polar Bear Pitching. Photo: Kari Arontie.

Innovative Business
opfind.nu

Pros:
- 170.000 DKK divided between 6 finalists
- Opportunity to pitch and receive feedback from a jury
- The jury asked very tough but relevant questions which made us think of our product from a different perspective
- Possibility to meet investors and network

Cons:
- None

Figure 8: The Fibo team after receiving a grant of 30.000 DKK at Innovativ Business.

Berlingske Business Boost
businessboost.business.dk

Pros:
- Top 10 ideas receive the Business Boost-package:
  - 8 intensive workshops
  - Access to and participating in an Investor day
  - Consulting and networking

Cons:
- The pitch happens in an elevator

Wearable Technology Innovation World Cup
innovationworldcup.com

Pros:
- Cash prize of 10,000 EUR
- Possibility to expand network
- Media coverage

Cons:
- None

Competitions First Bond Wearables considered but did not apply to

InnoBooster
innovationsfonden.dk/en/programmes/innobooster

Pros:
- Up to 5.000.000 DKK invested in the company/ startup
- Significant stepping stone in realizing the product
- Guidance and network

Why First Bond Wearables didn't apply:
- Since we were still seeking the mama device partner it was not appropriate to apply at the time

Venture Cup
venturecup.dk

Pros:
- 10.000 DKK awarded to category winners
- 100.000 DKK awarded to overall winner

Why First Bond Wearables didn't apply:
- You're not allowed to have a CVR number (and we already had one)

First Bond Wearables has also participated at a series of events including:

Culture night at IDA 2016
universe.ida.dk/kulturnatten

Tech BBQ 2017
techbbq.dk

High Tech Summit at DTU 2017
hightechsummit.dk

Figure 9: First Bond Wearables at Tech BBQ in 2017.

Business Development Reflections
Applying to the programs was in most cases very time consuming due to a lot of paperwork and pitching practice. The InnoFounder program is only available for recent graduates and therefore the window for getting in was not very significant.

Although the people at Væksthus were very helpful, the paperwork and time registration for DigitaliseringsBoost turned out to be complicated since companies had to register their time and be paid back 33% several months after work had been completed. Since First Bond Wearables was also lacking the mama device partner, this combination of factors led to a discussion with Væksthus wherein it was decided to continue the program and apply for an InnoBooster on the side which could give better and more simple funding. However, doing so would mean more paperwork and a lot of time spent on the application.

At the time of writing this report, First Bond Wearables is still considering this although having put the program with DigitaliseringsBoost on hold due to lack of a mama device partner.

Next steps
Apply for InnoBooster and/or find investors.

Evaluating the Patch

The patch provided by HAPY medical is a CE marked Holter monitor, AMORS/AMS3000, with a 3D accelerometer measuring and recording capability (measuring at 800Hz with 4g sensitivity and storing at 512Hz) and a user-event button. It was used for 3 weeks, to evaluate fetal activity in an expectant mother who was, at the time the evaluation was conducted, 34+2 to 37+2 weeks pregnant.

The expectant mother would place the patch where she could feel most fetal movement and wear it for an hour at a time while she was sitting down. Whenever she could feel a kick or a movement she would tap on the patch for registration (see Figure 10).

Together with HAPY medical and IdemoLab, First Bond Wearables then looked at the data to see if the patch had indeed detected some fetal activity before the registration tap.

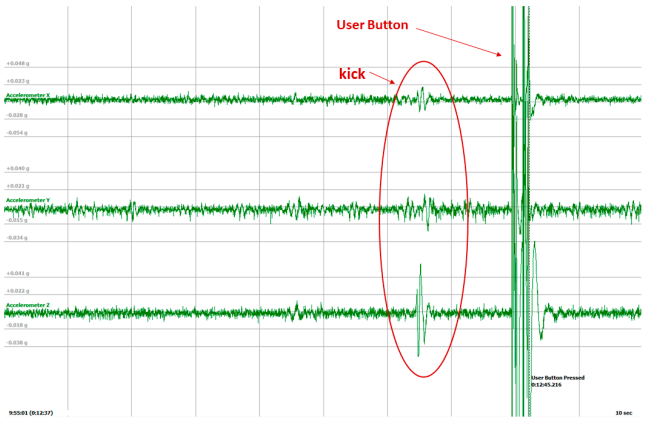


Figure 10: The graph shows the fetal activity which the patch detected right before the registration tap.

Result

The patch could detect fetal activity 2 out of 3 times, using only accelerometer data.

Feedback from the expectant mother

- The patch was comfortable to wear and did not disturb or annoy
- Thinks the patch should only be worn when the baby is active (would probably not wear it all day)
- It has to be easy to put it on and take it off
- Would like to have a little box she could put the patch in when not in use (would carry the box in her purse)
- Thinks it is interesting and worth it to wear the patch for a partner
- Thinks it is more meaningful to have a patch directly detecting fetal activity from the belly instead of having a product such as connected bracelets with vibrating notification

Patch Evaluation Reflections

The evaluation did prove that the concept of Fibo does work and creating a working prototype is a possibility at this point. The results from the evaluation can be used to apply for funding for further testing (eg. InnoBooster) should that be the way First Bond Wearables decides to go.
The patch used for this evaluation is too advanced and expensive for what is needed for Fibo and therefore a more simple version could be developed which would still fulfill the requirements of the concept.

Next steps

Possible next steps, should First Bond Wearables decide to develop the mama device themselves, might include:

- Apply for funding using the early, initial results from the evaluation.
- Conduct further evaluation with HAPY medical - eg. with women further and shorter along in their pregnancy. Also evaluate what happens when the woman is on the move and not sitting completely still - does the patch detect the activity then?

Future Customer Landscape

As part of the initial research done in the Fibo student project, a Bachelor report was written about the future customer segment. This is presented here as an executive summary to provide perspective on the types of customers First Bond Wearables hopes to engage with in the future;

"Eight face-to-face, qualitative interviews with first time expectant parents were conducted. It was important to get insights from couples since Fibo is to be used by both parents. The women were in different stages of their pregnancies, from week 16 to week 35, when the interviews were conducted. This gave a wide insight into their experience of the pregnancy where factors such as feeling the baby's movements had in some cases not yet been experienced by neither parent, and in other cases they had only been felt by the mother.

During the interviews, the participants were asked about the father's involvement in the pregnancy and if the involvement had been sufficient from both the mother's and the father's point of view. All four couples thought the father had been involved as much as possible by going to midwife and hospital visits, discussing and reading about pregnancy with his partner, and taking antenatal and birth preparation classes.

The product was enthusiastically received by the women in the study and they would all wear the patch in order for their partner to feel the baby's movements, if that was what he wished. The expectant fathers sounded very interested in Fibo, in fact, more interested than the expectant mothers, and most of them were positive that they would use Fibo despite

not owning, nor be interested in wearables. They claimed they would use Fibo when they were away from their partner (eg. when working) and especially if they would have to be away for longer time periods (eg. worktrips).

The insights from the participants helped further develop First Bond Wearables' target group and build a deeper understanding of the company's future customers. The customers are first time parents, living in Scandinavia and are between 27 and 34 years old, this based on the average age of first time expectant parents in Scandinavia[1].

Another interesting aspect, which has not yet been tested, is the concept of Fibo from other couple's point of view, such as same sex couples as well as families having a baby with the help of a surrogate mother."

Challenges

The main challenge during this project has been to involve a patch company which already has or is willing to develop the technology needed for the concept of Fibo to work. The ideal partner was found to be Bloomlife and throughout the project both IdemoLab and First Bond Wearables reached out to them with different proposals for collaboration, without success. Many other possibilities have been explored both in and outside of Denmark, however, since fetal activity monitoring is both complicated and rooted in a predominantly medical domain, this has not been an easy task. Developing a new patch for Fibo has not been a part of the company's plan and would create a significant setback in bringing Fibo to the market according to the current development and production plan. Other challenges included time registration and payment in the DigitaliseringsBoost program which was problematic for partners who needed to be paid. Finally, First Bond Wearables experienced a challenge in realizing their initial concept, a bracelet which contains beads which rotate on the skin. As described, there are several potential other solutions but none which accurately represent the original concept.

10 Takeaways for Other Startups

This process has been lengthy and involved many stakeholders. As we write this report, we can present 10 key takeaways for other companies embarking on a similar journey:

1. There is always a consultant who will help you. In each of the applications First Bond Wearables made, working with IdemoLab or Welfare Tech, or anyone else, there has always been someone who has been willing to answer the startups questions. It is important, though, to learn how to ask them, which bring us to point 2.
2. Make a list of questions: What is it you need to know? You might have a question called "What do I need to know?" and that's okay to ask.
3. Sometimes your dream partner is unavailable, and so is plan B. In this case, this was Bloomlife and TinyKicks. First Bond Wearables didn't have a feasible backup plan (but are still hoping to partner with someone).
4. Save all the applications you do, you can always re-use this material for other applications.
5. Learning to pitch your product is underrated, it is extremely useful to be able to both quickly pitch and casually talk about your product, introducing it into conversation without coming across as a startup.
6. There are so many opportunities with hardware and the final solution may be far from what you initially imagined, so start prototyping early, and often. Fail fast. Try things out in context and see how it goes, you'll learn so much with every evaluation and every new hardware iteration.
7. Ask everyone for help but be respectful of their time. Sometimes people will be able to help you themselves and other times you can be respectful and say "I know you are busy, so maybe you can direct me to someone else."
8. Seek technologies in similar domains to learn from them. In this case, First Bond Wearables went with other patch producing companies, when it wasn't possible to find partners in fetal monitoring. They had great experiences working with HAPY Medical and learned much from this collaboration.
9. Don't overthink applications. At the time First Bond Wearables team was applying to many of these programs, they were finishing their program at KEA and barely had time to fill out the application and send it off. As a result, we ended up learning quickly on the job, and in retrospect, it was beneficial to jump in and just get started.
10. Say yes to opportunities. It's overwhelming, but suddenly you find yourself pitching in an ice hole (Polar Bear Pitching) and making all sorts of amazing network connections who help you further in your path.

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