

Making the Digital Real

Insights from Startup-Researcher Partnerships

A group of people in a lab setting looking at a small orange robotic arm. The arm is orange and white, with a white gripper. A man in a dark blue shirt is pointing at the gripper. Other people are in the background, some looking at a computer monitor.

Skylab Digital is a digital innovation and entrepreneurship hub. We facilitate the development of sustainable solutions in, and for societies. We drive collaboration between startups, companies, domain experts, students, researchers and public institutions through applied technology, “making the digital real”.

Introducing digital innovation matchmaking

Artificial Intelligence is no longer science fiction. A broad range of Danish startups leverage AI and related digital technologies to optimize existing solutions, or to create entirely new business models. Corti applies machine learning to the triaging of inpatients while Sani Nudge employs IoT (Internet-of-Things) technology to encourage better hand hygiene in the health care and elderly care sectors. These, and the other startups in this brochure have one common denominator; they spring from collaborations that involve the enthusiasm and knowledge of both entrepreneurs and university researchers.

Skylab Digital, inaugurated in January 2020, is organized to facilitate more of these type of collaborations. Skylab Digital is an interdisciplinary partnership between the University of Copenhagen (KU), Copenhagen Business School (CBS), the Technical University of Denmark (DTU) and the IT-University of Copenhagen (ITU).

This booklet portrays a selection of Skylab Digital and DTU Computes innovation partnerships with primary digital health startups who have been matched with a researcher to strengthen the companies' technology development.'

It is grants from the Danish Business Authority, Danish Industry Foundation and the Ministry of Research that have paid for these knowledge programs.

<https://www.skylab.dtu.dk/>

By combining the resources of four of Denmark's leading universities, the chances are high that any young company with a digital business idea can find an academic counterpart with the relevant interests and competences. This booklet portrays a selection of Skylab Digital's innovation partnerships with digital health startups who have been matched with a researcher to strengthen the companies' technology development.

DTU Compute and DTU Skylab create startup-researcher partnerships within a palette of areas e.g. health, sustainability and digitalization. In this collection of cases focus has especially been on the health field (including contributions to solving Covid 19).

As a company or researcher, you can get help solving your technological challenges so do not hesitate to contact us.

RESPONSIBLE TECHNOLOGY DEVELOPMENT

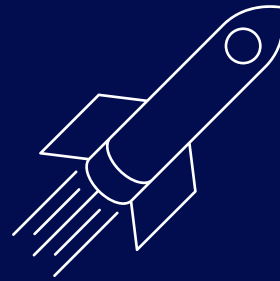
The increasing power and capabilities of technical solutions raises important questions regarding ethical behavior and the responsible gathering and use of data. We are making headway in the safe application of AI.

**[https://www.compute.dtu.dk/
kunstig-intelligens-dtu/etik](https://www.compute.dtu.dk/kunstig-intelligens-dtu/etik)**

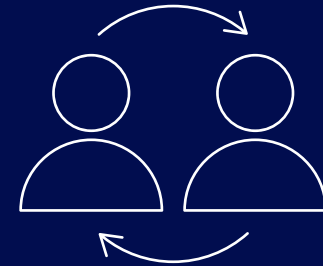
Our Collaboration Process



Kick-off to clarify company needs and academic match



The launch of a roadmap and startup-research partnership



The ongoing exchange of knowledge is ensured through meetings and workshops with both company and academia

This brochure portrays Skylab Digital's approach to Startup-Researcher partnerships. We also accelerate digital startups through funding, business development support and go-to-market access.



Affordable diagnostics for epilepsy

In low-income countries, some 30 million people have undiagnosed epilepsy. BrainCapture has developed a solution.

// The researchers assist us with the AI related part of our data processing. Fortunately, there is a large overlap between the interest of the company and academics.

**Tue Lehn-Schiøler,
CEO, BrainCapture.**

BrainCapture develops diagnostics for epilepsy. Epilepsy is a neurological disorder involving occasional seizures during which the patient may lose muscular control. In severe cases, a seizure can be fatal.

Worldwide, more than 50 million people have the disease. Standard diagnosis is made on the basis of a so-called electro-encephalo-gram (EEG) detecting certain brain waves characteristic of the disease. Following diagnosis, a doctor will be able to subscribe medical treatment. In about 70 per cent of cases, an inexpensive drug program will be efficient. However, some 30 million people suffering from epilepsy are undiagnosed according to WHO estimates.

“While equipment for EEG measurements is standard in industrialized countries, it is often too costly to be available in many lower income countries. At BrainCapture, we have developed a cheap solution which has the potential to help a very large number of people,” says Tue Lehn-Schiøler, CEO, BrainCapture.

Data input requires filtering

The company’s solution has both hardware and software components. The hardware is a wearable hood equipped with electrodes, and the software is an app that can be installed on a smartphone. The electrode measurements are collected by the app via BlueTooth. Further, the app will process data and provide diagnosis.

“Only through the application of AI is this possible. At least, we need to better filter the data gathered at the input. Otherwise, the calculations would be effected by noise from irrelevant signals which cannot be totally avoided,” Tue Lehn-Schiøler explains.

For instance, just by blinking during the recording, the subject will induce strong transient signals that potentially may destroy the measurements.

“In an industrialized country, an EEG technician is normally present during the recording, and can detect disturbances and instruct the subject. In our solution, we cannot rely on a technician be-

ing present, so we have to set up the system to self-adjust for disturbances, and avoid producing a potentially false diagnosis if the quality of the recording is evaluated as unsatisfactory.”

Overlapping interests

BrainCapture collaborates with DTU Compute through the AI Entrepreneurship program. The company was founded in July 2019.

“Actually, we began the collaboration with DTU Compute even before the company was established. Primarily, the researchers assist on the AI related part of our data processing. Fortunately, there is a large overlap between the interest of the company and the academic interests.”

“The only challenge is the time it will sometimes take to set up meetings. These are busy people. Still, they are busy for a reason. They are skillful and therefore their collaboration is in high demand. Generally, the cooperation is smooth, and I appreciate how the researchers are always very open.”



Applying AI to the playground

CADO imagines a future where sensors provide data on the use of its outdoor facilities.

// The researchers inspired us to be more ambitious. This demonstrates the value of partnering with people that are not part of our line of business and therefore have a different perspective.

**Lars Pehrson,
engineer, CADO.**

Headquartered in Solrød Strand, CADO is a Danish-owned company present in Denmark, Norway, and Sweden, specializing in outdoor facilities such as playgrounds, outdoor fitness, water basins etc. CADO will typically engage in a dialogue with its customers on the specific design for each facility.

“Interacting with the researchers at DTU Compute has provided us with new insight on which digital technologies are relevant to our line of business. Also, we have gained a clearer picture regarding the readiness of the various types of technology,” says Lars Pehrson, engineer at CADO.

Some of the technologies in focus are intended to provide administrative improvements such as better management of assignments, digitization of development processes etc. Other technologies may find their way to the playgrounds. This is Lars Pehrson’s field of work:

“We are always keen to learn how the playgrounds and the various types of equipment function under everyday use. While we may believe that we have come up with an amazing new installation, the verdict lies in the users taking it to heart. In the future, we imagine for sensors to provide this information.”

Raising ambitions

Usage data will be helpful to CADO during the development process, and may also assist clients in operating the sites.

“Should a given piece of equipment prove to be largely idle, the client may react and replace it with a different type of equipment more to the liking of the users,” says Lars Pehrson.

“Initially, we were thinking of something simple. Just a solution to let us know whether the individual piece of equipment was in high, medium, or low use. However, the researchers inspired us to be more ambitious. At which hours during the day is the equipment used? And are the users mostly boys, girls, or both genders - and how old are they?”

“This just demonstrates the value of partnering with people that are not part of our line of business and therefore have a different perspective.”

Seeking to take things to the next level

Still, extensive use of AI at playgrounds is not just around the corner, according to Lars Pehrson:

“First and foremost, having had some of our own ideas tested by the researchers was a really nice thing. Also, it was valuable to brainstorm on some wilder ideas. However, as a private enterprise we can only pursue ideas which promise to give us return on investment, and we don't seem to be quite there yet. Jointly with the DTU Compute researchers, we are in the process of applying for funding to take things further. It would be a pity, if we had to give up before we are ready to take things all the way.”

Overall, the collaboration is a positive experience, Lars Pehrson sums up:

“When an enterprise approaches an academic institution, some of their ideas might not be fit for practical implementation. We knew that, however, and were prepared to engage in steering the direction of the collaboration. In this way, a nice balance has been found. On the one hand, we have gained new inspiration, while, on the other hand, things have not been allowed to drift so much that we have lost sight of the ultimate aim of practical implementation.”



Better triaging through voice analysis

Corti has developed software able to detect signs of heart failure, COVID-19 and several other medical conditions.

// The researchers keep pushing the limits of AI applications. We are always looking for innovations which we might adopt in our context, enabling us to offer our customers even better solutions.

**Lars Maaløe,
CTO, Corti.**

Corti specializes in AI for computer-aided medical decision making. The software seeks to analyze patient health, and help support health-care personnel when triaging patients, in order to reduce both over- and under-triaging. For instance, the general call center for triaging in Denmark, 1813, is equipped with Corti software.

The functionality is based on a combination of the content of a conversation and voice analysis. Corti began by developing a system able to detect indications of heart failure. Since then, a range of other illnesses have been added with COVID-19 being the latest.

With every “new” condition to be included, the developers will need to apply machine learning, providing the computer a large amount of recorded conversations while in each case specifying whether the condition of interest was present. For the COVID-19 application, Corti was able to obtain more than 100,000 medical

interviews from the Harbourview Medical Center in Seattle, USA.

Pushing the limits of AI applications

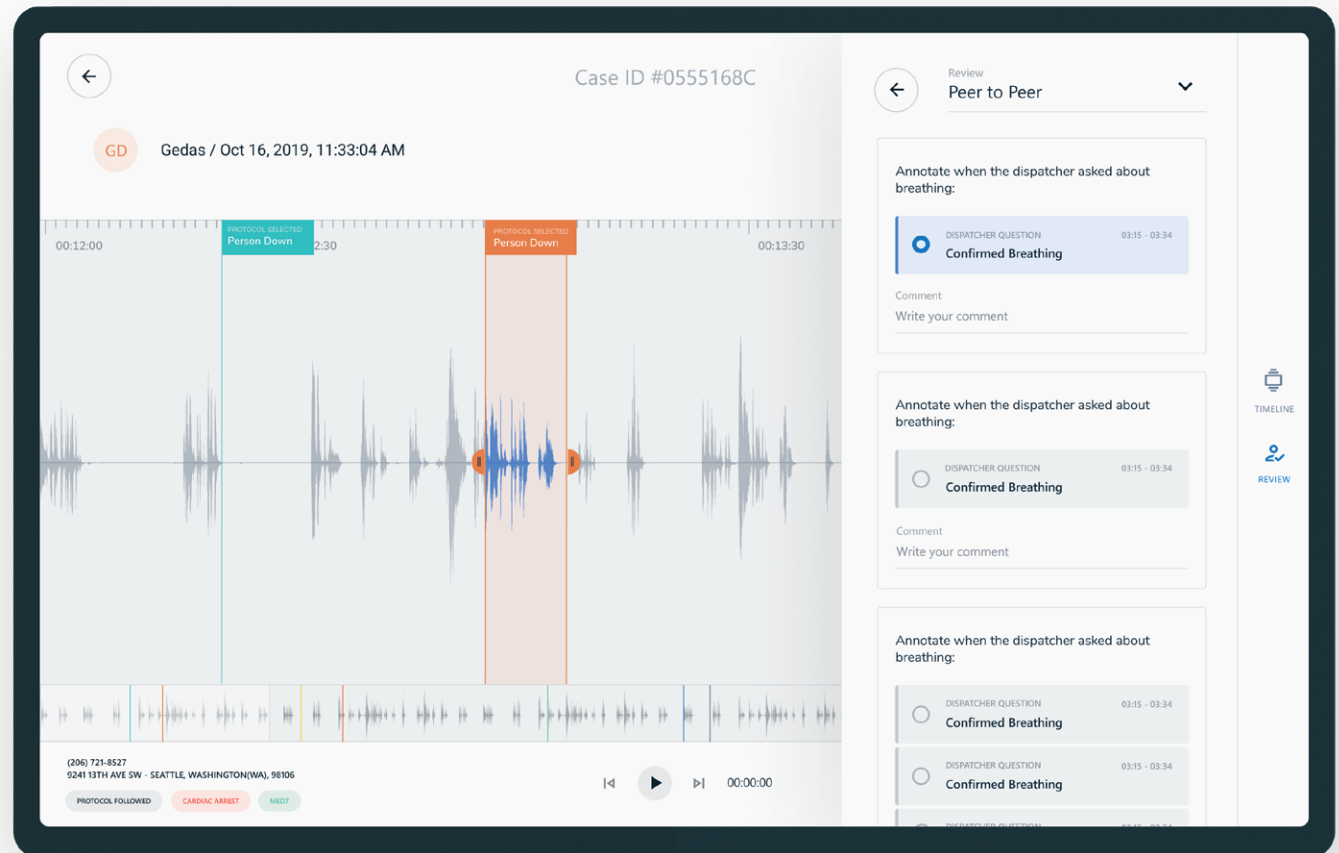
Since being established in 2016, Corti has seen rapid growth. The majority of the now 45 employees are experts in machine learning or other AI disciplines. Still, cooperating with DTU Compute adds an additional dimension, according to CTO Lars Maaløe:

“We need to be right at the cutting edge. The researchers keep pushing the limits of AI applications. We are always looking for innovations which we might adopt in our context, enabling us to offer our customers even better solutions. In return, the researchers get the chance of applying their ideas to real-life data, thereby allowing them to publish scientific articles of increased value. So, both parties benefit strongly from the collaboration.”

Sprung from DTU Compute

The fact that Corti has its origin at DTU Compute might explain why the company doesn't engage in AI Entrepreneurship or similar programs at the department, says Lars Maaløe:

"Such programs are valuable to companies looking to establish collaboration with DTU Compute, but in our case the connection was already very strong from the first day. Through our network at the department we will always know who will be the right researcher to approach. Therefore, we prefer to move directly to a joint research project. For instance, we are very fond of the Industrial PhD program. The same goes for shorter, agile projects allowing us to collaborate with a given researcher on a specific task."



Smart toilets for the gastric ward

Digital solutions from Measurelet are able to replace laborious and potentially unhygienic existing routines.

// The researchers are good at challenging our ideas, requiring us to explain why we do things in a certain way. This raises the level of our innovative processes.

**Marie Lommer Bagger,
CEO, Measurelet.**

Measurelet specializes in health care technology for collecting data from patients' bodily fluids. CEO and founder Marie Lommer Bagger is a nurse and, based upon her experiences from working at a gastric ward, she and a colleague came up with the idea behind the company.

Calculating patient bodily fluid balance is a key task for the nurses at a gastric ward. How much liquid input does the patient receive through beverages and food, and how much liquid leaves the body through urine and excrement? Traditionally, this involves collecting urine and excrement in bedpans, which are then weighed at a designated room. After weighing, the bedpan is either rinsed or - if disposable - thrown out.

"This workflow is both very laborious and potentially unhygienic. Therefore, we have invented a "smart" toilet," says CEO Marie Lommer Bagger.

Collecting data with every flush

The toilet is equipped with sensors that collect the relevant data during patients' normal use and automatically report results. The first

prototype was installed at DTU in September 2019. To the user, the experience will be just like visiting any other toilet at the university. However, each visit generates data for the young company. So far, the toilet has been flushed more than 1,200 times.

"As the prototype still serves its purpose well, we just keep it in operation and thereby generate more data. However, we already have enough data to be able to design an improved prototype II. Most often, your first prototype will be very simple, and the next more advanced. We chose to do things the other way around, equipping the first prototype with an excessive number of sensors. Thereby, the sensors could provide mutual validation. Then, for the second prototype we limit the number of sensors based on the new information on which sensors proved most valuable and accurate."

The data processing has been carried out in collaboration with Scientific Assistant Josephine Perch Nielsen, DTU Compute.

"Josephine solved a task that was essential to us. Further, she has contributed with her

knowledge of Machine Learning, allowing us to enhance the value of results from the measurements. For instance, it is interesting to be able to remove “noise” from false values, which may occur at times.”

The full fluid balance overview

Alongside the development of the smart toilet, Measurelet has expanded its field of interest, Marie Lommer Bagger notes:

“As a nurse you want to have the full overview of the patients’ fluid balance. Besides input and output, also the level of physical activity and other factors influence the fluid balance by affecting the level of sweating.”

This has inspired Measurelet to develop more products and a digital platform, Measurelet Fluid Monitor, collecting data from the various products, providing clinicians with the full patients’ body fluid overview. As the work involves further application of Machine Learning and other AI disciplines, there is a basis for even closer collaboration with DTU Compute, Marie Lommer Bagger underlines:



“Besides having saved us valuable time by solving specific tasks, the fact that we collaborate with a DTU department serves as a recognition. Moreover, the researchers are



good at challenging our ideas, requiring us to motivate why we do things in a certain way. This raises the level of our innovative processes.”

Specialty tools just in time

Clever algorithms help NetHire predict customers' demands for the rental of specialized equipment.

// Based on the figures, you can decide on which level of service you want to maintain. Nobody has applied this way of thinking to our line of business before.

CTO and owner Johnny Noisen, NetHire.

NetHire specializes in software for managing the logistics' of specialty tools rental. The fundamental business idea came from the realization of the potential for a better exploitation of surplus equipment in the construction sector.

"The sector has machines and specialty equipment in excessive amounts, but no one seem to know where they are and when," as CTO and owner Johnny Noisen puts it.

In 1989, before the birth of the internet, Johnny Noisen initiated the development of a digital system for the rental of specialty tools. Today, it is possible for a contractor with a specific tool requirement at a working site to grab his smartphone, find the tool at NetHire's portal and have it delivered, typically in less than one hour.

Inspiration from emergency ward solution

In spite of having come a long way, Johnny Noisen is striving for further improvements, which led him to approach DTU Compute.

"I happened to read somewhere that Postdoc Anders Reenberg Andersen was running a pro-

ject on algorithms for management of personnel and equipment at hospital emergency wards. It occurred to me that this type of problem is very similar to what we are facing."

There is no way of telling how many patients will show up at a hospital emergency ward on a given day, and the kinds of health problems they will present. Nevertheless, it is possible to detect patterns in historic data and use the results for scheduling how many doctors and nurses are to be called in, and which types of medical equipment should be ready.

NetHire and DTU Compute were able to obtain EU funding for a project in which Anders Reenberg Andersen was allowed access to the company's historic data.

"Students from DTU and other universities are constantly visiting to do various projects with us, but this was the first time we took part in a research project based on soft funding. The experience proved to be very positive. The DTU Compute researchers are sharp, and the spirit of the collaboration is always great," says Johnny Noisen.

Demand is dependent on the weather

As the team hoped, the methodology from the emergency ward proved applicable to the tool-rental domain.

“For instance, the project delivered interesting insights into how changes in weather conditions trigger certain changes in demand for the various types of tools,” says Johnny Noisen, continuing:

“Overall, we had to admit that even for a company like ours, having come a long way in digitized optimization, the potential for improvement remains significant. To give an example, our stock of straining equipment proved to be five times larger than justified by the demand.”

Avoiding the purchase and storage of excessive equipment provides a large economic advantage for a company like NetHire. Still, some extra capacity is required, Johnny Noisen underlines:

“It goes without saying that you will never be able to accurately predict what customers will require on a given day. What you can do, however, is quantify the risk of having to disappoint



the customer relative to the capacity you have in place. Based on these figures you can decide on which level of service, you want to maintain.

Nobody has applied this way of thinking to our line of business before.”

Digital interpretation of X-rays images

Machine learning allows computers to interpret medical images with high accuracy.

// We have obtained a better understanding of which tools may be relevant to us. We need to be constantly prepared to adopt methods that maximize the data efficiency of our products.

**Mads Jarner Brevadt,
CEO, Radiobotics.**

Radiobotics specializes in software for the interpretation of medical X-ray imagery. Training a computer to recognize specific objects in images is a well-established discipline in numerous other applications. Known as machine learning (ML), the training involves feeding the computer a large number of images while in each case letting the computer know whether the object is present at this image or not. When training is completed, the computer will be able to interpret new images, typically at the same level and sometimes even more accurately than the most skillful human experts can.

“Working with interpretation of medical imagery does give you some challenges. To illustrate, if I were to teach a computer to recognize cats in images, I would be able to download plenty of images straight away, and any person could tell the computer which images had cats. In contrast, medical images are a scarce resource,” explains Mads Jarner Brevadt, CEO, Radiobotics.

Pushing algorithms to the limit

Typically, access to medical images requires a research collaboration and appropriate ethical per-

missions. Access to data is limited and requirements for anonymization, data management and storage are high. Furthermore, a medical expert is required to interpret the data – another scarce and costly resource. “Therefore, we need to push our Machine Learning algorithms to the limit in order to maximize the value of the X-ray images we are able to access and of the interpretations we get from medical experts,” says Mads Jarner Brevadt.

Radiobotics was founded in 2017. One of the founders, Martin Axelsen, earned his PhD at DTU Compute, and collaboration with DTU researchers has been ongoing. This is valuable for Radiobotics, Mads Jarner Brevadt underlines:

“Machine Learning is a complex field, and it is just not possible for us to employ experts in all ML disciplines. We are happy to be able to collaborate with researchers that are at the cutting edge and able to advise us on which new methods are relevant for the type of data we specialize in.”



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Gearing up on deep learning tools

Funding from Copenhagen Health Tech Solutions recently allowed Radiobotics and DTU Compute to take the collaboration to a higher level. During a three-month project, two DTU Compute candidates worked in Radiobotics supervised by Professor Ole Winther, DTU Compute.

“The project allowed us to investigate new tools especially within deep learning. While we have not implemented any of these tools yet, we have obtained a better understanding on which tools may be relevant to us. We need to be constantly prepared to adopt methods that maximize the data efficiency of our products,” says Mads Jarner Brevadt.

Radiobotics expects to carry out the first test installations of its solutions at hospitals in both Denmark and abroad before the end of 2020, paving the way for commercial operations to take off during 2021.



Next level hand hygiene

Sani nudge applies AI for the improvement of hand hygiene at hospital wards and care centers for the elderly.

// We would not have been able to enter into a research project of this magnitude without DTU Compute. As a young company, raising the funding and attracting the expertise needed would just not have been possible.

**CTO Morten T. Egholm,
Sani nudge.**

Sani nudge specializes in systems designed to motivate good hand hygiene, primarily in the healthcare and eldercare sectors. Founders Theis Sigbert Helmar Jensen (CEO) and Morten T. Egholm (CTO) while studying for their degrees in engineering at the DTU campus in Ballerup. Jointly, they developed a sensor capable of detecting the use of a dispenser for soap or hand sanitizer. When combining these measurements with a local IoT (Internet-of-Things) system, information about the standard of employees' hand hygiene can be obtained. Data collection is automated, meaning the healthcare staff can go about their work just as they normally would.

In a traditional motivational campaign, a nurse with training in hand hygiene will visit a ward to instruct the employees and to observe the current level of hygiene.

"This will most often paint too rosy a picture. Naturally, people will make an extra effort when knowing their instructor is watching. This is known as the Horton effect. Our system provides you with the genuine everyday reality," Morten T. Egholm explains.

Obtaining additional value from data

Notably, data is anonymous, meaning that hospital management will not be able to monitor individual employees. Instead, the system provides a picture of the performance of the entire staff of a given ward. The data can be split to see the performance of different categories of employees.

Sani nudge was founded four years ago. Considering how COVID-19 and other infectious diseases have highlighted the importance of hand hygiene, it is hardly surprising that demand for the solutions provided by Sani nudge is strong and on the rise. Nevertheless, the company is looking to expand its suite of products and services. This has led to a collaboration with researchers at DTU Compute.

"We are looking into how a hospital ward or an eldercare center may obtain additional value from the data, once they have installed a system for monitoring of hand hygiene," says Morten T. Egholm.



Large joint project on COVID-19

Sani nudge have participated in the Digital Health Solutions program and is currently collaborating with DTU Compute on a major research project focused on COVID-19.

“When a patient or employee has tested positive for COVID-19, it will be possible to generate data that show which employees have been in contact with the person. We imagine, the system should be designed to show each

employee his or her risk of having contracted COVID-19 as a score from 0 to 10.”

Besides Sani nudge and DTU Compute, project partners are Aarhus University Hospital and the elderly care center Sølund. The project is funded by Innovation Fund Denmark and the partners. The goal is having a commercial solution ready in 2021. The idea for the project came from the two Sani nudge founders.

“Approaching the researchers at DTU Compute was the natural first step. Besides the fact that they are at the cutting edge of the field, they have also worked on our data previously. All in all, we would not have been able to enter into a research project of this magnitude without them. As a young company, raising the funding and attracting the expertise needed would just not have been possible.”

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SkyLab Digital is an interdisciplinary partnership between the University of Copenhagen (KU), Copenhagen Business School (CBS), the Technical University of Denmark (DTU) and the IT-University of Copenhagen (ITU).

