

Celebrating 4 years of Do IoT Fieldlab



**Do IoT**  
Innovation in Internet of Things  
**Fieldlab**



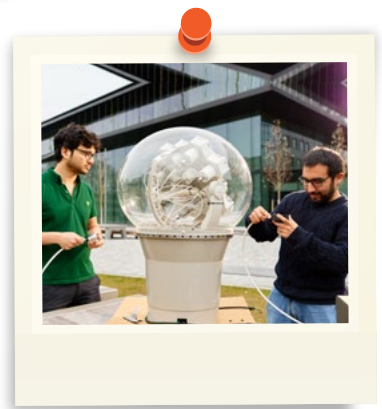
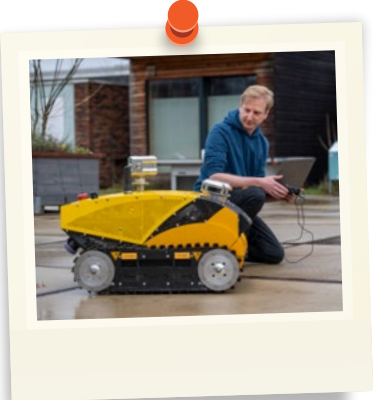


**Do IoT**  
Innovation in Internet of Things  
**Fieldlab**



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What is

# DoIoT Fieldlab?

**Delft on Internet of Things (Do IoT) Fieldlab drives the acceleration of innovations in the field of IoT. As a TU Delft fieldlab, we initiate and stimulate collaboration between science, industry and government.**

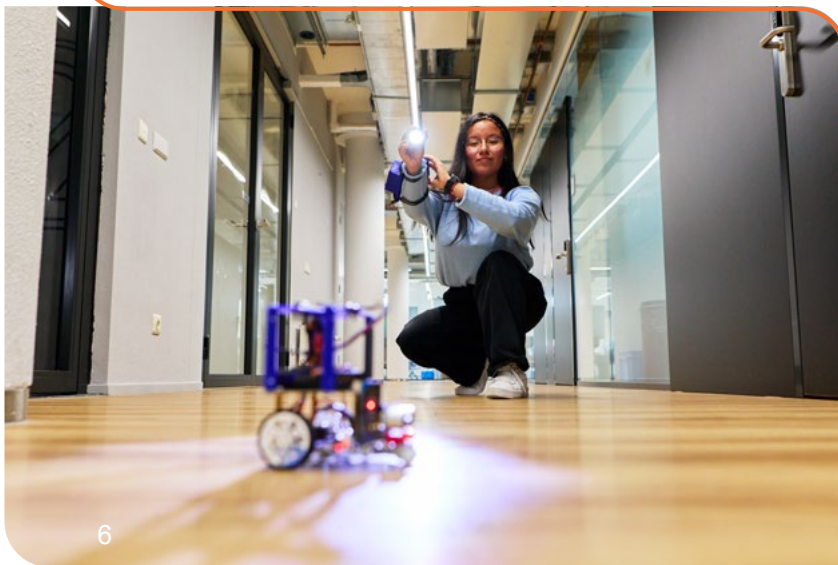
The use of mobile data continues to increase. This calls for new practical applications. We facilitate groundbreaking research and support companies in realising innovative products and services. Applications with sensors, smart robots, drones, mobility services and online tools that will be needed in the future.

We offer facilities based on the latest wireless communication technology (including 5G). Not in a classic laboratory, but in a real-life environment.

Scientists and students develop new technologies, perform practical tests and gather data. Start-ups can try out their new IoT applications and improve their product prototypes with end-users. And administrations can gather insights for the development of future policy.

Increasing knowledge by dissemination is crucial to the digital transition. We aim to serve society by connecting and sharing. Varying from day-to-day advice to organising workshops and networking events, and from organising student challenges to participating in international fairs.

You can see Do IoT Fieldlab as a breeding place that facilitates business creation. An open platform for experimenting, learning and sharing knowledge.



A man with a beard, wearing a black zip-up hoodie over a blue t-shirt, is looking upwards with a focused expression. He is holding a large, circular, black fabric structure that is suspended in the air. The structure is decorated with several green sensors or cameras, each with a glowing green light. A red laser line is visible, passing through the center of the structure. The background shows a modern, brightly lit interior space with white walls and a blue door. The overall scene suggests a collaborative effort in a laboratory or workshop setting.

Working together on  
tomorrow's products

4-year anniversary

# Celebration

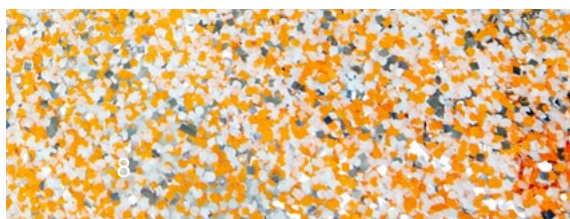
**Fernando Kuipers**, professor Internet Science at TU Delft, initiated scientific collaboration in the field of IoT. In order to make this knowledge useful for society, he envisioned a place of innovation. A fieldlab, where scientific research, profound expertise and practical product development come together. Together with **Lenneke de Voogd**, innovation manager at TU Delft, he initiated Do IoT Fieldlab.



It has been a great journey. Adventurous, interesting, challenging. We are highlighting this moment by looking back on the fruitful collaborations and the tangible results. And we take pride in having created a firm foundation for future research and development. We'll keep accelerating the development of future products and services that meet society's needs.



In the past years, we have established broad public-private partnerships. We are now approaching the ending of the four year project with governmental funding. Therefore, we are celebrating our successful start, settlement, development and future continuation!



“

We are pioneering on unexplored territory and sharing our knowledge to meet society's challenges.

*Fernando Kuipers*  
Scientific Director

“

To witness an entrepreneur's twinkling eyes when their product becomes viable is so rewarding.

*H. de Voogd*  
Programme manager



# Retrospect

Four years ago we started from scratch. And then, step by step, we built up our fieldlab. An overview of the milestones and memorable moments.



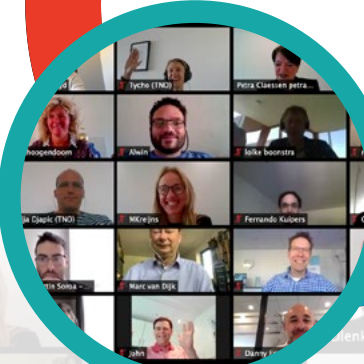
## May 2021 Start of SME funding

The Province of Zuid-Holland, in collaboration with the European Regional Development Fund, makes € 500,000 available to companies developing new innovations based on 5G technology. This funding will make the expertise and facilities of Do IoT Fieldlab easily accessible to innovative entrepreneurs.



## July 2020 ERDF funding granted

The European Union will contribute 1.5 million euros through the programme "Kansen voor West". We can start building our facilities!



## October 2019 Launch Do IoT Fieldlab

The Do IoT Fieldlab is founded by TU Delft, TNO, the municipality of Delft, Metropolitan Region of Rotterdam The Hague (MRDH), municipality of Katwijk, Holland Rijnland and the Province of Zuid-Holland.

## May 2020 Kick-off programme with partner meeting

Tough situation during Covid pandemic. Meetings take place online out of necessity. Spirits are up, though: we're going to make this work.



## August 2021 Installation 5G antenna

Large milestone! We start building our private 5G test facilities at The Green Village and Unmanned Valley.



## November 2021 Networking event: Unlocking 5G

During a networking event, we literally unlocked our 5G research facilities. Researchers, students, entrepreneurs and governmental parties can experiment with a customised 5G configuration.

## February 2022 5G tests with Audus

Audus Technologies aims to improve cloud-based audio processing, in order to minimise latency. They start testing with our 5G installation.



## May 2022 Measuring 5G

Strong collaboration between 18 European parties, performing 5G measurements. The Dutch National Institute for Public Health and the Environment (RIVM) is involved.



## July 2022 Robotics and VR

Two new use cases are launched:  
an inspection robot and a VR  
training platform will be developed.



## October 2022 Networking event: 5G on air

Amazing what future technology will bring us... This  
networking event was a mix of technical lectures, live  
demos with drones and an information market.



## June 2022 Collaboration with other fieldlabs

Fieldlab 5Groningen visits our fellow fieldlab  
Unmanned Valley, to witness the current and  
future possibilities with drone technology.





## August 2023

### First test drive

First test drive of Conical System's remote controlled microcar: Swing. Designed and built from the ground up, it's purpose is to alleviate the dense urban traffic in creating a more sustainable city commute.



## July 2023

### Smart robots in the greenhouse

Kick-off of the "Do IoT for greenhouse horticulture" project. Aim is to accelerate digital innovations in the Dutch Province of Zuid-Holland to ensure sustainable and efficient food production. The use of 5G, sensors and robots is central to the experiments.



## September 2023

### Networking event: 5G Works

Celebrating Do IoT Fieldlab's 4 year anniversary! During this event we are sharing the tangible results with 5G, demonstrating the coolest new technologies and are connecting you to valuable partners in our network! Glad to celebrate with you... we hope you enjoy this special 4-year anniversary booklet.

# Getting started with



**Anup Bhattacharjee is our dedicated wireless network expert. He assists companies in getting started with 5G. In the past years, he has experienced that companies are glad to rely on him before taking their first steps into the 5G universe.**

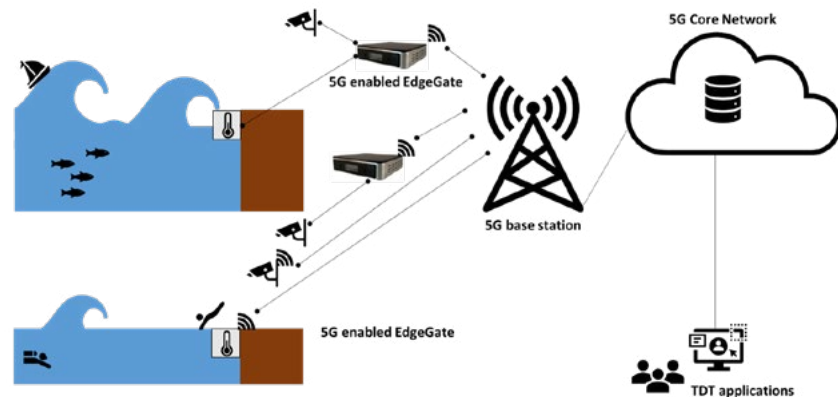
Many entrepreneurs are curious about 5G: they read about promising networks that offer amazing possibilities for businesses. But there's a problem: many companies can't figure out how to use 5G for their needs. That's where Anup comes in: he's like a translator between the companies and the Do IoT fieldlab-experts who know about 5G.

His job is to turn the complicated things that companies want into simple points that match up with 5G technology. This way, everyone can talk and work together smoothly. He's been doing this for the past four years and has helped over 20 companies already.

Most of the times the companies that come to us, are thinking of 5G as just high speed. But there's more to it. Anup helps them to understand this by using the translated requirements for their use case as to what other 5G functionalities will assist their case. Balancing between getting all the details right and not making things too complicated is always a challenge. In the end, Anup's job is to make 5G simple and helpful for everyone involved.

Anup: " This has been a great opportunity for me to learn how to interface between the theoretical side of 5G and how industry and the potential users perceive it. It is very satisfying when the users of the technology understand what 5G can actually do for them and get a good impression of what their product will actually look like. As I keep getting deeper into the technology, I want to be able to interface with the people outside the 5G/6G knowledge circle and help them to actually understand the value of the new generation communication technologies from various facets."

Anup's explanatory visualisation shows the 5G enabled video cameras, water level sensors and EdgeGate devices that are connected to non-5G Video cameras and water level sensors. The set up is meant to find out the current situation of the water levels to detect flooding.



“

I simplify things by  
connecting what a business  
needs with what 5G can do.

*Anup Kinam  
Bhattacharjee*

**Anup Bhattacharjee**

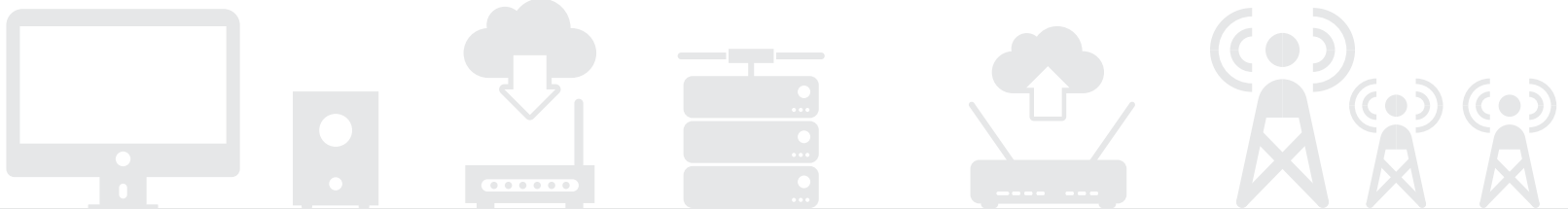
Dedicated wireless network expert

# Our 5G test facilities

**5G is the latest generation of mobile communications and is the successor to 4G. 5G is much faster, can send much more data, is more reliable and also provides longer battery life. Network latency is many times lower.**

Thanks to these advantages, a lot of new applications are possible. For instance, more and more devices in the home will be connected via the Internet (Internet of Things), allowing you to control them remotely. It will also be possible to send live data from all kinds of measuring devices and sensors and thus monitor them remotely. Because the data is sent at lightning speed, it becomes possible, for example, to perform operations with remotely controlled robots. We will also see self-driving vehicles in the future thanks to 5G.

The Do IoT Fieldlab networks are 5G stand-alone networks: This means 5G radio on 5G core and secures the highest bandwidth, capacity, availability, and lowest latency. This is essential for real-time management and steering of business processes. This variant of 5G is not yet available in the Dutch market. This is due to a delay in the 5G- 3,5Ghz auction process. Do IoT Fieldlab enables SME's meanwhile to perform experiments and testing on the best-in-class 5G Stand Alone networks.



## The Green Village

This is a unique fieldlab, located on the TU Delft Campus, where sustainable innovations are key. Our 5G test facility offers the opportunity to carry out tests both indoors and outdoors.

**THE GREEN  
VILLAGE**



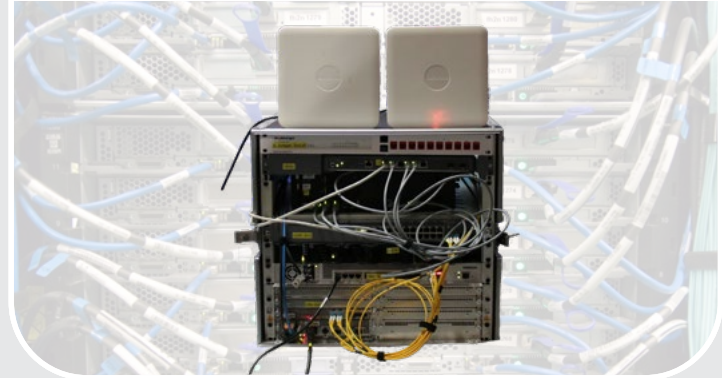
## Unmanned Valley

This former military airfield in Katwijk is a hot spot for tests with drones. However, other applications are also possible, such as testing with robots in a hangar or on the outside terrain



## Mobile Kit

For those who want to test with 5G at a specific location, such as a greenhouse, a warehouse, an office building, or elsewhere, the mobile 5G test kit offers a solution.



After the auction we expect three variants of 5G networks in the market:

**Public 5G networks:** they will support 4G and 5G. For businesses it's important that the public MNOs will setup 5G stand-alone networks to enable the benefit of the full 5G experience. We expect that the MNOs will start with 5G radio on 4G core to have a fast roll-out of a 5G network. The low latency of < 20ms will not be able on these types of networks in this phase.

**Private 5G networks:** these are networks similar to the Do IoT Fieldlab network. These are fully private, and operate on private spectrum, company owned. It's operating full independent of an MNO network. A 5G private network has an own core, own radio network own simcard and Edge server, and is fully designed for customer demand. This type of network delivers the full promise of 5G technology.

**Hybrid 5G networks:** these networks are a combination of Private and Public. A company can have a full private network on site and make use of a MNO network outside the Private network.

“

**We assist entrepreneurs in translating their experiments into practice.**

**Bas Piek**

Commercial director MCS

## Inspection robots in harsh environments

**Establishing a solid foundation for communication between robot, data processing environment and control room.**

ExRobotics, the global market leader in autonomous inspection robots within extreme conditions, wants to further develop current robots with 5G technology. ExRobotics is using DoloT Fieldlab's 5G facilities to develop a design and first prototype of a 5G-enabled inspection robot. In addition, the most stringent safety certification is being prepared.





## Use case

### Virtual training in the manufacturing industry

**Remote interaction between trainer and multiple users from different locations.**

SenseGlove, an innovative start-up specialised in Virtual Reality, develops 'extended reality' (XR) techniques for virtual training of industrial employees. In a fully simulated work environment the training glove actually gives sensing feedback, creating a realistic feeling of touching and handling objects.

Did you know?

# 5G compared to 4G

10x



**Decrease in latency:**

Delivering latency as low as 1 ms.



10x

**Connection density:**

Enabling more efficient signaling for IoT connectivity.

3x



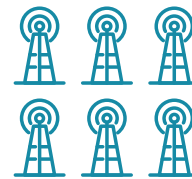
**Spectrum efficiency:**

Achieving even more bits per Hz with advanced antenna techniques.

100x

**Traffic capacity:**

Driving network hyper-densification with more small cells everywhere.



**Experienced throughput:**

Bringing more uniform, multi-Gbps peak rates.



10x

100x



**Network efficiency:**

Optimizing network energy consumption with more efficient processing.



# Collaboration is key

**The Netherlands is a frontrunner in the development and implementation of 5G technology. TU Delft conducts groundbreaking research in the field of IoT and there is great market potential for new products that utilize the opportunities 5G offer. Linking fundamental research to possible applications in a realistic environment ensures that these innovations can reach society more quickly.**

There are countless possibilities for using 5G to develop the products and services of the future. Think of drones that perform a task together, livestreaming of high resolution medical scans or a building that maps out an escape route for you in the event of a fire. Sensor technology will be crucial in the development of connected cars and specialised robots in greenhouses, for example. Therefore, a strong partner network in the public and private sector is essential to transform innovations from an idea on the drawing table into a tangible product.

Do IoT Fieldlab closely collaborates with other fieldlabs on TU Delft Campus and leading tech companies in the region. Our partner network in the province of Zuid Holland supports our activities, in order to contribute to economic growth. We work together with policy makers at Metropoolregio Rotterdam Den Haag (MRDH), the region Holland-Rijnland, the municipalities of Delft and Katwijk and the province of Zuid-Holland.

“

**Through strategic collaboration and the fusion of cutting-edge research, we transform visionary concepts into tangible solutions.**



**Kemo Agović**  
Director TU Delft Innovation  
and Impact Centre

## Latency & bandwidth in 5G live audio

**Early-stage testing of the viability and exploration of the technology's possibilities.**

Audus Technologies, a Dutch company specialized in cloud based audio solutions for hearing impaired, is testing a cloud based hearing aid solution. Processing sound in the cloud will lead to better fitting algorithms, a higher level of customization and real time software updates. The technology will improve people's hearing by improving the source of the sound they are listening to.





## Use case

### Wireless train detection

**Counting passing railway wagons with wireless sensor technology.**

RailConnected develops wireless sensors for the railways, to register passing trains. As opposed to the current, wired axle counters, the new technology will save a tremendous amount of excavation work and hence time, costs and disruptions to the timetable. The greatest challenge lies in testing whether 5G can meet the very stringent safety standards (SIL4) for train traffic.

# Converting theory into practice

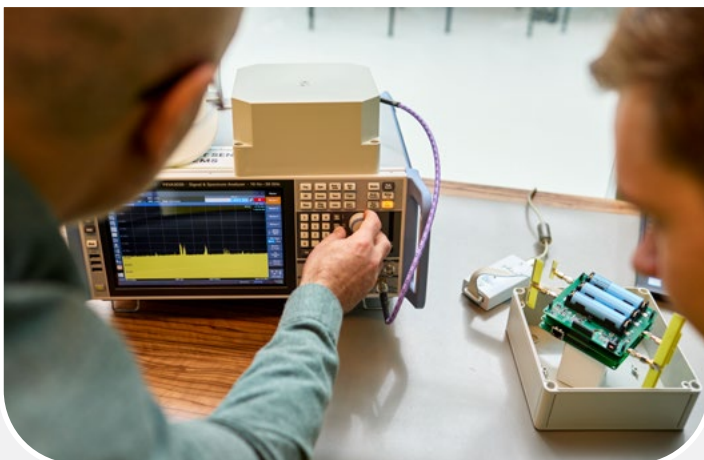
**The introduction of 5G will enable many innovations and improvement of digital processes. Before 5G is broadly introduced, the possible effects of electromagnetic fields on the surroundings must be clear. Do IoT Fieldlab is involved in this research.**

The development and deployment of new technologies always give rise to many questions. First of all, on the capabilities and engineering challenges. Moreover, it is important to determine whether there are any side effects or even unwanted risks. Therefore, the European Union has launched various initiatives to conduct research into

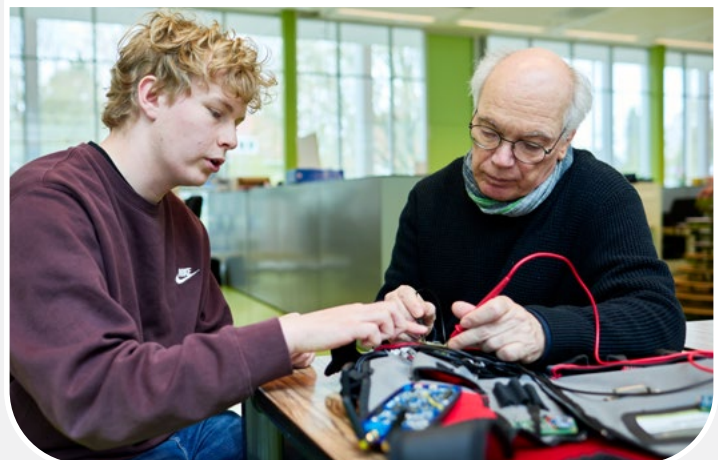
understanding and identifying possible effects. Researchers in twenty organisations collaborate in the European NextGEM project to objectify and validate the features of 5G.

Marco Spirito, Associate Professor Electronic Circuits and Architectures at TU Delft and John Bolte, Professor Smart Sensor Systems at The Hague University of Applied Sciences (Haagsche Hogeschool) jointly conduct the research on TU Delft Campus.

Erdal Korkmaz and Stephan Littel measuring the custom-developed node properly “senses” the FR1 signals.



Fidelis Theinert and a Haagsche Hogeschool student testing the response of the FR1 RF-EMF sensor when integrated in a wearable vest.



Leila Gottmer testing the new hardware line-up forming, which will be the "heart" of the mm-wave RF-EMF wearable sensor that Haagse Hogeschool will integrate in their vests.



Richard Coesoij assembling and "tuning" the last sensor in the Antenna Dome, a solution pioneered at TU Delft to reduce the measurements of complex 5G antenna modules to a few seconds.



By joining forces, TU Delft and Haagsche Hogeschool cover both theory and practice, to produce objective results.

“

Only measurements contain 100% of the physics. That is the rewarding side of developing instruments and sensors.

A handwritten signature in orange ink, reading "Marco Spirito".

**Marco Spirito**  
Associate Professor  
Department of microelectronics

TU Delft and The Hague University of Applied Sciences combine their expertise in a complementary way: the TU Delft team conceives concepts. After lab tests, tests in a realistic environment are necessary. That's where the Haagsche Hogeschool comes in. Tweaking the bolts and screws because they are experts on the hardware is very important in ensuring the results are useable and tangible. By using the Do IoT Fieldlab's 5G facilities, together we can fully customise and objectify the technological settings and preconditions.

## Fast and secure 5G data platform

Exploring and exploiting the possibilities of 5G in the development of innovative data-driven services

For future digital applications, a highly secure platform is key. AccessHub's objective is to help companies connect different devices safely and easily to innovative 5G data-driven services and applications.





## Use case

### Intelligent Bicycle Path

**Quality comparison of various sensors, quality of their connectivity and insights on most suitable sensors for certain situations.**

Do IoT Fieldlab, Mobility Innovation Centre Delft and TU Delft are testing an innovative sensor technique. Sensors in, above and underneath the road surface of a bicycle path register passing cyclist and pedestrian flows. Other measurements concern the quality of the road surface, the amount of precipitation, temperature and iciness. The combination of innovative sensors and unique measurements make this bicycle lane so intelligent that it is able to 'understand' how it is used.

# Networking Events

Our main focus is connecting people and sharing knowledge. What better opportunity than networking events, with a combination of presentations, interactive discussions and live demos of the latest experiments? During our yearly events, we surprise, inspire, and look out for new opportunities. Make sure you follow our updates on LinkedIn for upcoming events!



October 2019

**Launch Do IoT Fieldlab**

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Networking events are essential to share knowledge and strengthen ties. BTG encourages and fully supports these events.

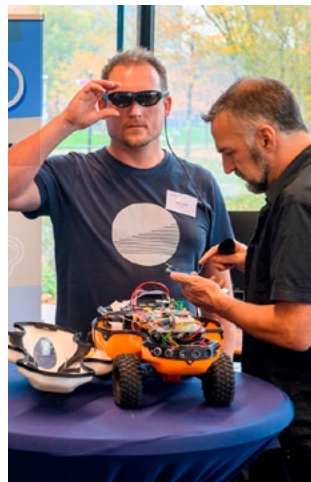
**Petra Claessen**  
President BTG



November 2021

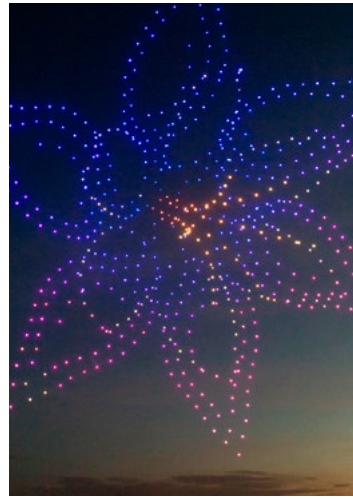
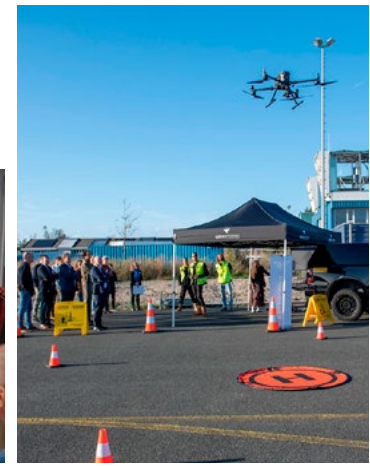
**Unlocking 5G**

During this event we literally unlocked our own private 5G facilities at The Green Village.



October 2022  
**5G on air**

Unprecedented demos with  
drones and sensor technology at  
Unmanned Valley.  
Bonus: magical drone show  
at dusk



September 2023  
**5G works**

The latest experiments with  
a.o. autonomous cars and  
robots. Today, we share this  
4-year anniversary booklet  
with the attendees!



### Shared transportation at the right spot

**Remotely monitored and controlled  
vehicles to alleviate dense urban traffic**

With the self designed and created microcar 'Swing', Conical systems wants to contribute in advancing sustainable urban transport, making it more accessible, eco-friendly, and seamless. Safely test driving in a demarcated environment allows to measure accuracy, response time and behavior of the vehicle.





## Use case

### Airplane drone inspection

**Detecting the slightest damage for faster and highly accurate aircraft maintenance**

Every aircraft must be regularly inspected for anomalies. Mainblades combines visual drone inspections with artificial intelligence, to detect and identify small damages such as lightning strikes and paint peeling. Speeding up the process, without any concessions to accuracy is very valuable to get the aircraft faster ready for service.

**A strong digital communication network is crucial for the Netherlands. It is the backbone for innovation, economic growth, and tackling societal challenges. Therefore, it is imperative to keep investing in a fast, reliable, available, and secure digital infrastructure.**

While 5G deployment is ongoing in the Netherlands, the next generation of communication networks is already being developed. We have joined forces with dozens of telecom companies, technical universities, and knowledge institutions to accelerate the development of 6G. This is a public-private partnership of 60 organisations, working under the name Future Network Services (FNS).

The upcoming 6G technology will surpass 5G's possibilities. Along with increased capacity, speed, and reliability, 6G will also introduce unique applications and services that demand high levels of performance, including full-sensory and digital twin applications.

# What's next?

The combination of virtual and real-world experiences opens up exciting opportunities for skill development, healthcare, entertainment and more, ushering in a new era of multi-sensory connectivity.

The Netherlands is striving to establish a dominant global position in 6G technology by 2030 through the FNS program. The program will focus on research, development, and innovation in smart components,



smart networks, and leading applications in key sectors. The core values of the program will revolve around digital autonomy, reliability, and sustainability.

Do IoT Fieldlab has a significant role in advancing technology. The knowledge and experience that we are gaining together with our partners with 5G is extremely



## 6G will be revolutionizing connectivity, AI and immersive tech for the future

ChatGPT

AI driven natural language processing tool

valuable, and we will continue exploring the full potential of 5G for years to come. Additionally, we will collaborate with our colleague fieldlabs in other regions to create a national 6G testbed. This will again provide an opportunity for scientists, students, companies, and governments to create and test real-life applications in an operator-independent network. These applications can then be improved and further developed based on the results of the trials.

This is what makes our fieldlab stand out: strong collaboration, flexibility, and an open-minded approach. We are excited to help create essential, sustainable solutions for a better society.



# Partners



## Programme Partners



Do IoT Fieldlab is made possible by

In collaboration with



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**Concept:** Studio Convex (Martijn Verbeij), Nadia Haïfi

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Innovation in Internet of Things  
**Fieldlab**

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