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iRoom Interface Design

Access to intelligence data gathered by drones

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PREFACE

Noun: preface; plural: prefaces 1. An introduction to a book, typically stating its subject, scope or aims.

This master thesis represents the last phase of my student life at the University of Twente. My time as a student in Enschede is over but I enjoyed every minute of it. I learned a lot both inside and outside the lecture rooms but, I couldn't have done it by myself and therefore want to thank a few people who were part of this journey.

First, I thank Innovatielab (iLab) for the opportunity to be part of the team and write my thesis at their company. I also like to thank my colleagues for their cooperation and for being able to talk about the project and certain ideas even when working from home. Furthermore, I thank the members of both project iRoom and project Drones for their support during the last nine months. Special thanks to Michael Krämer for being my internal supervisor. In a time where I could only visit the iLab a few times and my computer was my best friend, you made me feel welcome in an online environment.

Secondly, I also thank Arie Paul van den Beukel for his support and guidance during the project and Micha Consten who was my internal supervisor for the first half of the duration of my graduation project. The extensive feedback and some nudges in the right direction helped bring my graduation project to a pleasant end.

Last and certainly not least, I thank my friends and family for their support and motivation. My parents and boyfriend deserve a particular note of thanks: your wise counsel and kitchen table conversations have, as always, served me well.

ABSTRACT

In our current society, things are changing at a rapid pace, on the side of technology but also on the social and the economical side. Furthermore, sensor technology to scan and detect information in an environment is rapidly developing. Therefore, it is of vital importance to the police to keep up with these new developments and to use these technologies to their advantage. In 2018, the police unit Limburg started experimenting with certain technologies in small experimental environments called 'Proeftuinen'. One of those Proeftuinen is focused on the use of drones, also called Unmanned Aerial Vehicles (UAV), in combination with sensors and ultimately in combination with what is called the iRoom.

The iRoom is a 365/24/7 intelligence room in which information is received from both internal and external parties, filtered, and dispatched to the right people at once. The goal is to have the acquired sensor data simultaneously and in real-time entering the iRoom, but also on location within the ongoing operation. This thesis focuses on what kind of data can be gathered by a drone and implemented in the iRoom that has added value for the iLab and accordingly develop an interface with which users of the iRoom would effectively and efficiently have access to this data. The thesis is divided into two parts: an analysis of what kind of data can be gathered by drones and a design part in which the iRoom interface design is developed and tested by users.

To determine what kind of data can be gathered by drones the thesis looked at the use of drones both inside and outside the police. The analysis shows that no operation in which a drone can be used is the same. Therefore, upfront must be determined which sensors would have the most added value during the operation. Additionally, the goal and the location of the operation should be narrowed down to prevent unnecessary deployment. The analysis also indicated the three main purposes of the deployment of a drone to the police. The aim to gather data, observe people or objects and validate findings. A drone can be deployed in diverse circumstances and with many different goals in mind. This makes a drone a versatile tool that suits the police.

In the second part of the thesis, there is amongst other things addressed who will be working in the iRoom and their perspectives and visions of the iRoom interface design. This information is translated into requirements that are used during the development of both low- and high-fidelity prototypes. The created high-fidelity prototype is used to conduct user tests. After the first user test, there was iterated on the iRoom interface. Then the second round of user tests was conducted. Based on the outcome of the user tests can be concluded that the iRoom interface design is a user-friendly, multi-purpose interface that fits the requirements and the wishes of both the users and the clients.

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ABBREVIATION LIST

Table 1 Abbreviation list

Abbreviation	Meaning
AI	Artificial Intelligence
ANPR	Automatic Number Plate Recognition
DRIO	Dienst Regionale Informatie Organisatie
EM	Electromagnetic Spectrum
FO	Forensische Opsporing
GMS	Geïntegreerd Meldkamer Systeem
HOvJ	Hulp Officier van Justitie
ILT	Inspectie Leefomgeving en Transport
IMEI	International Mobile Equipment Identity
LE-DINFRA	Landelijke Eenheid Dienst Infrastructuur
LiDAR	Light Detection and Ranging
LMS	Landelijke Meldkamer Samenwerking
MAC	Media Access Control
ME	Mobiele Eenheid
MoBa	Mobiel Banditisme
OC	Operational Centre
OOV	Openbare Orde en Veiligheid
OSINT	Open Source Intelligence
OVD	Officier Van Dienst
PD	Plaats Delict
PDC	Politie Dienst Centrum
PGE	Potentieel Geweldadige Eenlinge
RIEC	Regionaal Informatie en Expertisecentrum
RPAS	Remote Piloted Aircraft System
RTIC	Real Time Intelligence Centre
SAR	Search and Rescue
S-BvL	Speciaal-Bewijs van Luchtvaardigheid
SSD	Speur en Specialistische Dieren
SUS	System Usability Scale
UAV	Unmanned Aerial Vehicle
VOA	Verkeersongevallenanalyse

1. INTRODUCTION

This chapter elaborates on the motive for the graduation assignment, the defined research question and the method and deliverables of the graduation assignment. Furthermore, a thesis overview will be given.

Motive

In our current society, things are changing at a rapid pace, on the side of technology but also on the social and the economical side. Furthermore, sensor technology to scan and detect information in an environment is rapidly developing. Therefore, it is of vital importance to the police to keep up with these new developments and to use these technologies to their advantage. In 2018, it was decided by the police unit Limburg to experiment with certain technologies in small experimental environments, in Dutch called 'Proeftuinen', located throughout the Netherlands. Currently, the research is focused on sensing & real-time analysis, predictive policing, cyber & cyber intelligence, forensics & forensics intelligence etc. There is also a focus on the installation of a different kind of Operational Centre, called 'iRoom' in the Operational Centre in Maastricht (Venema, 2019).

One of the Proeftuinen, which is hosted by the iLab, is researching the use of drones in combination with sensors. Based on the Proeftuin UAV, project Drones was established which focus is researching the added value of the use of drones during operations. Related to project Drones is project iRoom. The iRoom is a 365/24/7 intelligence room in which information is received from both internal and external parties, filtered, and dispatched to the right people at once. The relation between project Drones and project iRoom is the goal to have the acquired sensor data simultaneously and in real-time entering the iRoom, but also on location within the ongoing operation. This way a quick overview can be created of all available, relevant data. Decisions can be made based on this data after which data-driven deployment can take place. Both project Drones and project iRoom are closely related to the graduation assignment (Venema, 2019).

The goal of the graduation assignment is to determine what kind of data can be gathered by drones and implemented in the iRoom that has added value to the iLab and accordingly develop an interface with which users of the iRoom would effectively and efficiently have access to this data. The main question related to the goal is:

How to supply the iLab with an interface that can be used to pinpoint the required data from drones and the implementation of the sensor data in the iRoom?

Method

To answer the question a research and design process has been executed in which amongst other things field studies, interviews and scenarios were used. The following paragraph describes briefly why and how the method is used and the purpose of the method within the project. In Appendix i: Plan of Approach can be found.

Field studies are used to observe how the drone and sensors are used during an operation. This data can then afterwards be used to make design choices in the design phase and to determine whether certain sensor applications could have added value for the iLab and the iRoom. Interviews with future employees of the iRoom could give more in-depth information about the perspectives and vision on an iRoom interface design. In the analysis phase scenarios are created based on police cases. This to determine the role of the drone in those scenarios and the 'extra' data gathered by the drone. During the concept development phase and testing of the interface design, the same scenarios that were created earlier are used. The scenarios are used to create cases in which certain tasks must be performed within the interface. This way the interface can be tested by several people and the gathered feedback can be used to iterate on the interface design.

Deliverables

- Overview of data from a drone that has added value for the iLab.
- Test results from user tests.
- Recommendations for further interface improvements.
- The final Interface design and all preliminary designs created during the project.

Thesis overview

Chapter 2 gives an overview of the company and the available set of sensors, drones, and the predetermined Proeftuin use cases. This way a collective basis is created for further research regarding project drones. The thesis will continue with an analysis of all the aspects of the use, sensors, and application of drones both inside and outside the police. To gain insight into the deployment of drones and the use of sensors, interviews were conducted with people from both inside and outside the police. The analysis concluded with a selection of Proeftuin use cases that will be taken as a starting point for the development phase. Based on the selected Proeftuin use cases, use case examples will be given in which drones are used. These examples will help determine the attributing role of the drone in the different use cases and which data is 'extra' available when using a drone. Based on the given examples' conclusions are drawn about the main purpose and benefits of using a drone during deployment.

Next will be researched who will be working in the iRoom, the different positions within the iRoom and the sensors which will be implemented in the iRoom interface design. The overall purpose of the interface is to visualize the data gathered by drones clearly and understandably. To get a better understanding of the perspectives and visions of people on an iRoom interface design, interviews are held with people involved in project iRoom. This is done to align the ideas of both the clients and the people involved in project iRoom about the functionalities within the iRoom interface design. Based on the interviews a list of requirements is created which is the starting point of the development of the interface. Furthermore, personas are created to narrow the audience for which is designed, and it will help identify the areas in which the people working within the iRoom differ. In the development phase, a roadmap with questions is used to determine all the elements required in the iRoom interface design and how the elements relate to each other. When the answers to the questions are clear, prototyping is used to develop both low and high-fidelity prototypes of the interface. Furthermore, user tests will be set up. The user tests will partly be based on the scenarios that were created earlier in the project. The user tests will describe a situation in which certain tasks have to be performed. The scenarios and goals of the user tests are predetermined and used to determine the success of the user tests. Based on feedback from the user's, iterations will be done, and a second user test will be conducted among the same group of participants. The report will conclude with a convergence of the results of the user tests and a discussion of the future implementation within the iRoom and iLab.

2. ORIENTATION: POLICE ORGANISATION AND DRONE TECHNOLOGY

This chapter delivers a basic orientation of the project and provides background information about the police organisation, the available drones and sensors and the rules regarding flying with drones within the police.

2.1. National police force

The national police force consists of ten regional units with each a chief constable. The regional units are divided into districts with each a frontline team. Each frontline team provides basic police services in (parts of) municipalities. A frontline team consists of constables, senior constables, neighbourhood police officers, detectives and one or more team chiefs. The frontline teams answer calls from emergency assistance, resolve traffic-related issues and assist the public (Veiligheid, 2016). Below a description of several roles within the national police force:

Ministry of Security and Justice
The Ministry of Security and Justice has full ministerial accountability for the national police. The minister has to approve the budget and creates guidelines in which the police force operates (Justice, 2011).

National Police Commissioner
The National Police Commissioner is in charge of all ten regional units and the national force (Justice, 2011).

Police Service Centre
The Police Service Centre, in Dutch "Politie Dienst Centrum" (PDC), provides operational management services, for instance, finance, communications, human resources and ICT. This results in that officers working at the regional units have more time to spend on actual police work (Justice, 2011).

National Operational Centre cooperation
The "Landelijke Meldkamer Samenwerking" (LMS) is a network of ten Operational Centres which are virtually connected and collaborate in a standardized multidisciplinary way. The LMS is going to be the Operational Centre of the future and is created to help people who call 112 quicker and in a more efficient manner. Additionally, it should help the ambulance personal, fire brigade, police and military police with better facilitation of required assistance when dealing with a crisis or disaster (LMS, 2020).

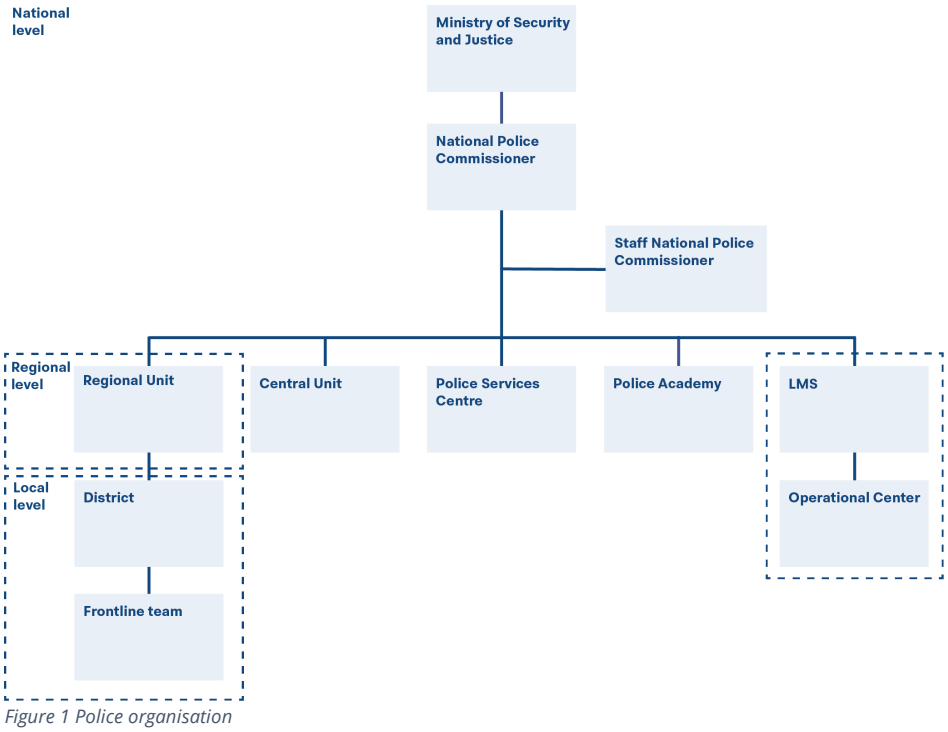

Figure 1 Police organisation

2.2. Operational Centres

In the Netherlands, there are twenty-two Operational Centres. Ten of those Operational Centres are LMS locations. Operational Centres are 24/7 available to help people during emergencies and to support emergency services during incidents, crises, or disasters. The ambulance personal, fire brigade, police and military police work closely together 24/7 to help people in the best way possible and to respond to emergencies quickly and efficiently (LMS, 2020).

2.3. iRoom

The iRoom is a 365/24/7 intelligence room in which information will be received, filtered, and dispatched to the right people at once. The iRoom will consist of fifteen identical workstations with multiple screens. The information on the screens can be ordered based on the needs of the employee. Additionally, there will be the possibility to stream images from a certain workstation to a central video wall. The information on the video wall can also be changed and sorted by the director. Daily, six to eight people will be working in the iRoom. The occupancy can change based on needs and incoming alerts. The iRoom will be situated near the Operational Centre of Maastricht with which will be communicated during events, high impact incidents etc. The communication between the Operational Centre and the iRoom will mostly happen via phone, mail, Dragonforce[1]and in-person. The iRoom is currently still in the development phase and not yet operational (Venema, 2019).

2.4. Proeftuinen

As mentioned earlier Proeftuinen are small experimental environments. There are currently six Proeftuinen but only four are still operational. Furthermore, there are a few nondisclosed Proeftuinen. The goal of the Proeftuinen is to cover every aspect of the use and implementation of drones. This information is shared to determine possible use cases and for instance pros and cons about the use of drones during operations. Below a description of the operational Proeftuinen.

Figure 2 Example of how the iRoom could look like

2.4.1. Proeftuin FO-VOA

The Proeftuin FO-VOA is based in the east of the Netherlands and focuses on determining the added value of the use of drones for "Forensische Opsporing" (FO) or forensic investigation in English and "Verkeersongevallenanalyse" (VOA) which is traffic accident analysis purposes in English. People from the forensic investigation department concentrate on finding evidence at the scene of a crime, a fire, or a traffic accident. Since a few years, there is a collaboration between the FO and VOA which resulted in the FO-VOA.

2.4.2. Proeftuin OOV

The "Openbare Orde en Veiligheid" (OOV) Proeftuin or public order and safety in English, is in the north of the Netherlands and focused on finding the added value of the use of drones for OOV purposes. OOV scenarios are cases related to (expected) public order disturbances or schedulable events. Examples are protests, loitering, or firework nuisance.

2.4.3. Proeftuin Cable drone

The cable drone (also called a tethered drone) is a Proeftuin of the provinces Zeeland and West Brabant. The goal of the Proeftuin is to use the cable drone during events such as Concert at Sea or Decibel Outdoor to facilitate a birds-eye view of the activities happening on the ground. The cable which is connected to the drone is the powerline (50 to 100 meters long. The power line ensures that the drone can stay in the air for longer periods. Additionally, a tethered drone is safer compared to a non-tethered drone because a fly away (an error that causes the drone to fly uncontrollably) is not possible (Paez, 2020).

1 Dragonforce is a mobile team collaboration platform which can be used to track personnel in real time, send secure messages and to delegate group members to manage an operation (Drakontas, 2015).

2.4.4. Proeftuin Tracking dogs in combination with drones

There also existed a Proeftuin about the use of tracking dogs in combination with drones. The Proeftuin had the main purpose of testing whether the dogs and their sense of smell are affected by drones hanging nearby. Because this was the only purpose of the Proeftuin, the Proeftuin was cancelled. Tracking dogs are part of the department "Speur en Specialistische Dieren" (SSD). The SSD department is responsible for the deployment of tracking dogs or other specialist animals to support during police deployment. Police rescue dogs are mostly deployed in cases wherein the missing person is at high risk. Examples are missing children, elderly people or confused or suicidal people.

2.4.5. Proeftuin Unmanned Aerial Vehicle

The Proeftuin UAV is the Proeftuin of which this graduation assignment is part. The Proeftuin UAV has the goal to research the added value of the use of UAVs in combination with sensors. This is done with the help of the use cases described in Appendix i: Plan of Approach. Furthermore, the contribution to the development of the iRoom and the deployment of drones is of importance in the Proeftuin UAV.

During the graduation assignment, a selection of drones is available at the iLab, below a description of the drones and their purposes.

2.5. Drones

The drones, currently available at the iLab are the DJI Matrice 210 V2, the DJI Inspire 2 and the DJI Mavic Pro. Below a description of the specifications of the three drones, in the remainder of the project, there will be focused on the implementation of the DJI Matrice 210 V2 in combination with some of the sensors in paragraph 2.6.

2.5.1. DJI Mavic Pro

The DJI Mavic Pro is a drone that is mostly used by the police when people or vehicles must be tracked. The Mavic Pro is the most silent drone and is the smallest one. The Inspire 2 can fly 20 minutes on one battery charge and can fly up to 65 km/hour. To fly the Mavic Pro only one person is required and only one sensor can be mounted underneath the drone (Dienst Communicatie, 2019).

Figure 3 DJI Mavic Pro (bol.com, 2017)

2.5.2. DJI Inspire 2

Figure 4 DJI Inspire 2 (bol.com, 2020)

The Inspire 2 is mostly deployed during traffic accidents, crime scene investigations, crowd control or missing person cases. The Inspire 2 is a bit larger than the Mavic Pro and can fly up to 80 km/hour. Same as for the DJI Matrice Pro only one sensor can be mounted underneath the drone and only one person is required to be able to fly (Dienst Communicatie, 2019).

2.5.3. DJI Matrice 210 V2

The Matrice 210 V2, shown in Figure 5, is built to withstand the most extreme weather conditions and was designed for inspection purposes. The drone has 17-inch propellors and has a closed chassis to make the drone almost water-resistant. Additionally, the drone supports multiple gimbals like thermal imaging camera's and can fly up to 35 minutes on one battery charge. The functionality to mount two sensors underneath the drone in combination with the 35 minutes flight time was the reason why the iLab chose to work with the Matrice 210 V2 (DJI, 2017a).

Figure 5 Matrice 210 V2 (Skytools, 2020a)

2.6. Sensors

Below a description of the functionality of the sensors which can be currently used at the iLab or are soon available at the iLab.

2.6.1. Zenmuse Z30 with a zoom lens

The Zenmuse Z30 is a long-range aerial zoom lens for industrial application. It has up to 30x optical zoom which can be used to do detailed inspections while keeping a safe distance to the object/subject. Additionally, the Zenmuse Z30 has up to 6x digital zoom and can take pictures and video's in full HD 1080p resolution and up to 30 frames per second (DJI, 2017c). Lastly, the Zenmuse Z30 can also be used in low light conditions (DJI, 2018a).

Figure 6 Zenmuse Z30 (Skytools, 2020a)

2.6.2. Zenmuse XT2 thermal sensor

Figure 7 Zenmuse XT2 (Skytools, 2020c)

The Zenmuse XT2 thermal sensor is a highly sensitive thermal sensor that can gather visual and thermal data simultaneously. It has a 4K visual camera with a 19 mm lens + a Tau 2 Thermal Core sensor. The temperature can be measured in real-time, and the thermal sensor can lock on to the highest temperature in the frame with heat track. The camera can also lock on to other desired objects with quick track. A temperature alarm can be set to a certain temperature to alert the drone pilot of objects exceeding the set maximum temperature. The Zenmuse XT2 is rated for use from temperatures ranging from -40 ˚C to 135 ˚C (dependant on the amount of gain) (DJI, 2018b).

2.6.3. Zenmuse X7 with 4 lenses

The Zenmuse X7, visible in Figure 8, has a 35 mm sensor for video recording with a video resolution of up to 6k. Additionally, the Zenmuse X7 can be used in all lighting conditions and is durable and lightweight. Lastly, the Zenmuse X7 has an ultra-short flange distance which allows a compact lens design and DJI offers 4 lenses that can be combined with the Zenmuse X7 with focal lengths of 16, 24, 35 or 50 mm (DJI, 2017b).

Figure 8 Zenmuse X7 (Skytools, 2020b)

2.6.4. Hyper- and multispectral cameras

Based on recent development at the iLab, hyper- and/or multispectral cameras were added to the list of sensors that can be used in combination with the Matrice 210 V2. Normal cameras which operate within the three bands, red, green, and blue, provide the colour image we see in regular photographs. However, there are many bands in the electromagnetic spectrum (EM) which certain cameras can distinguish. For example, 100% reflectance would be received when light reflects from a smooth white surface because no light is absorbed by the material. Colour, roughness, but also texture can change the quantity of light reflected to the camera. The amount of reflection for each wavelength is recorded by the camera and both processed and analysed to create a multitude of information. Multi- and Hyperspectral cameras take this reflected electromagnetic spectrum energy from the surface and record the response (Ewing, 2020). Visible (red, green, and blue), infrared and ultraviolet are regions in the electromagnetic spectrum. Each region is categorized based on its frequency. Humans can see visible light from 380 nm to 700 nm.

The difference between multispectral and hyperspectral cameras is the band in which they operate. A multispectral camera, visible in Figure 9, operates within 3 to 10 wider bands and a hyperspectral camera operates within hundreds of narrow bands. As a result, hyperspectral cameras have a higher level of spectral detail, but this also adds a level of complexity (GISGeography, 2020).

Figure 9 Micasense Altum kit (MicaSense, 2020)

2.6.5. Electronic nose

An electronic nose is a device with which chemical substances can be detected and sometimes even stored. Jaap Knotter Lector Advanced Forensic Technology at Saxion developed an electronic nose called the "snuffel drone" to detect chemical substances and to gather samples. Every chemical substance has a unique chemical fingerprint which can be identified by the "snuffel drone". The stored samples can be tested in an accredited system and used as forensic evidence. Chemical sniffers or sniffers, in general, can locate hemp, drugs but also the cause of a fire. Specific details about the working principles of the electronic nose are not available at this moment.

2.6.6. LiDAR

LiDAR stands for Light Detection and Ranging and is a method based on optical measuring technology. This technology is applied in two ways: one as a time-of-flight lidar and the second as a doppler lidar. The time-of-flight lidar measures the distance between the lidar and the object by transmitting pulses of light. The time between transmitting and receiving the reflected photon is calculated by a receiver. The Doppler lidar measures the speed of the object by making use of the doppler effect. The doppler effect is the change in frequency of a wave when a source (or receiver) is moving relative to the medium. The targets composition and speed change the properties of the transmitted light which provides information for the lidar instrument about the composition and speed of the object. (Sentech, 2020).

Apart from the several sensors which can be mounted underneath the drone, there are also regulations regarding flying with a drone. In the next paragraph a short overview of the regulations when flying with a drone.

2.7. Regulations

There are certain restrictions and regulations which must be followed when flying a drone. To begin with, pilots must acquire the Remote Piloted Aircraft System (RPAS) operator certificate. Furthermore, the drone must be tested and requires a "Speciaal – Bewijs van Luchtwaardigheid" (S-BvL). To be able to fly the drone at least three people are required, the pilot who operates the drone itself, the payloader who operates the payload like cameras or other sensors and the observer which watches out for birds or other possible hazards. Below a description of the rules which apply when flying a drone, based on the source (Overheid.nl, 2019):

- The drone may not fly higher than 120 meters or 400 ft above the ground or water.
- The drone must always be visible by the pilot and payloader.
- The drone must stay within 500 meters from the pilot and payloader.
- It is forbidden to conduct a flight within 150 metres (horizontally measured) of crowds of people, rural areas, motorways that are in use, or roads in use at a maximum speed of 80 kilometres per hour.
- Prior to the flight, the location, duration, pilot and payloader must be registered in Skyops[2] and the flight must be announced to the Operational Centre.

Apart from the mentioned rules, there are also technical restrictions that must be followed. For instance, the drone can only last 25 minutes on a battery charge. An alert will go off when it is time for the drone to go back to the starting position and swap the batteries. Furthermore, must be considered which sensor combinations are made in certain situations like a night flight or a large area that needs to be visualised. Lastly, the drone can't be used when it is raining or during strong winds (Tornij, 2018).

[2] Skyops is a system in which all flight operations are registered a visible for other pilots

3. DRONE ANALYSIS

This chapter studies the use of drones both inside and outside the police. Furthermore, the implementation of the sensors will be researched, and conversations are held with police personnel, drone pilots and payloaders about the possible use cases for the drone and the implementation of the sensors.

3.1. Use of drones within the police

This section is based on data gathered from the Proeftuinen. Below a description of the use of drones and the experienced (dis)advantages of using a drone during operations.

3.1.1. FO-VOA

Because of promising initial applications of drones in the east of the Netherlands, it was decided to start a Proeftuin from September 2017 onwards. The goal of the Proeftuin is and was to use drones during forensic investigations (FO) and traffic accident analysis (VOA). The requirement was that the drone had to be on-site within 30 minutes. The advantage of using a drone is the speed with which a total image of the accident can be created compared to a thorough examination from the ground and the clarification which can be given by the birds-eye view images from the crime scene. The road where the accident has happened can also be released quicker when a drone is used (Hilbrands, 2020).

An evaluation report written by Henk Hilbrands (project manager drone team Eastern Netherlands) states that the quick deployment of drones during a highly complex traffic accident certainly has added value. A traffic accident can be marked as 'highly complex' when the accident happened over a length of approximately 50 meters. A drone can boost the quality of an investigation by the earlier mentioned birds-eye view images which are made of a crime scene. These images can, later, be transformed into 3D images which create new perspectives of a crime scene and are of added value when there is a viaduct or other height differences on the crime scene. Soon 3D images could be made with LiDAR. Additionally, when a drone visualises a crime scene from above there is no disturbance of the crime scene on the ground. Lastly, when a crime scene is not yet declared safe because of possible chemical substances on the scene a drone can still be used.

Research by Adeline van den Berg (operational specialist) is following the statement by Henk Hilbrands about the added value of the deployment of drones during highly complex traffic accidents. Adeline states that normally the VOA takes overview photos with a pole camera (Examples in Figure 10 till Figure 12), but this is not necessary when a drone is deployed. Additionally, places that are difficult to reach in the crime scene can be accessed with ease when using a drone. Lastly, the added value of the use of drones in VOA cases can be increased when the collaboration between the teams present at the crime scene can be improved and the time of arrival can be decreased (Van den Berg, 2020).

Dries Cramer, a drone pilot in Eastern Netherlands mentioned the added value of drones during smaller crime scenes like for instance a zebra crossing where someone was hit by a car. In comparison with the pole camera, the drone can create an overview of the crime scene in one sweep whereas the pole camera must be positioned first. Furthermore, the drone can create near telecentric pictures of the scene because of the height. This makes the pictures suitable for conducting measurements. The pole camera takes pictures under an angle Figure 10, so the pictures need to be "reangled" afterwards. Furthermore, the pole camera is positioned on a police bus or a pole that must be moved by VOA personnel which makes it a cumbersome task.

An advantage of the pole camera over the drone is that the pole camera can be used in every weather condition, whereas the drone cannot fly during strong winds or rain. The remark that drones have added value to 'highly complex' traffic accidents is based on the arrival time of the drone team on the scene. When the arrival time is considered irrelevant, both Adeline and the drone pilots agree that drones could have added value in every traffic accident. However, the pole camera is still required as backup during strong winds or rain.

Figure 10 Overview picture pole camera

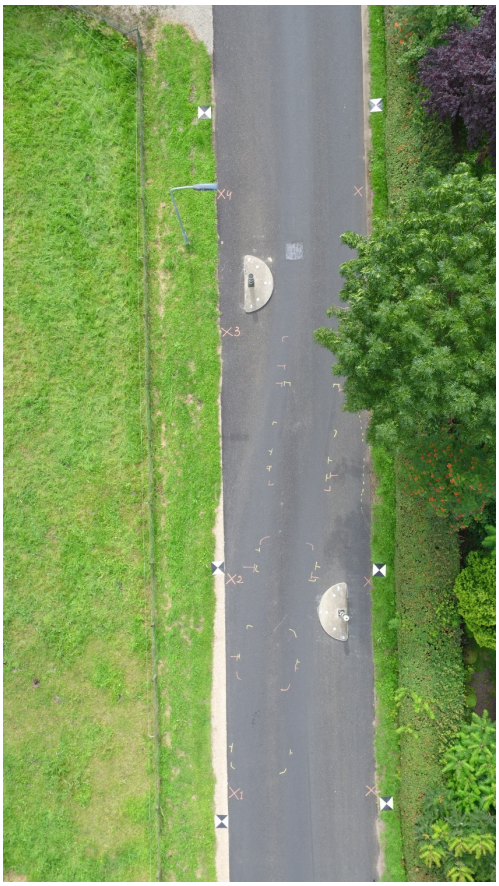

Figure 11 Overview picture taken with the drone

Figure 12 Overview picture pole camera

3.1.2. Public order and safety

Because of operational-technical reasons, the "Landelijke Eenheid Dienst Infrastructuur" (LE-DINFRA) decided to stop the deployment of helicopters during OOV-scenario's. But the requests for areal support during protests or other possible public order disturbances kept piling up. Therefore, was decided to introduce drones as an alternative for creating an overview during OOV deployment. An example of an OOV deployment in the duration of the Proeftuin was the deployment of a drone during a soccer game. Based on footage taken with the drone several people were arrested. The drone can also be used during object security (embassy) and personal security. The advantage of using a drone for these purposes is that risks can be spotted earlier, like for instance, "Potentieel Geweldadige Eenlinge" (PGE-n). During the ongoing COVID-19 pandemic, the drone has already been used to stimulate people to stay 1,5m apart. Lastly, the evaluation report written by Peter Cnossen (Chief constable Eastern Netherlands) states that when drones are used in collaboration with helicopters during, for instance, protests more situational awareness can be created for the policemen and commanders on the ground.

Another possibility where drones can be used is during observations. An example is a case wherein a policeman who was in disguise bought something from a person in a car park in the centre of Groningen. This case demonstrates that a drone can be used when the goal is to observe and keep a low profile during an operation with a certain amount of risk involved (Cnossen, 2019). The XT2 thermal sensor which is compatible with the Matrice 210 V2 was also used during this OOV deployment. The XT2 could also be used to tackle loitering during the night. People are easier distinguishable in the night by the heat signatures made visible by the XT2.

Based on observations during an OOV deployment in Arnhem can be concluded that not every case for which a drone is requested is suitable. The OOV deployment in Arnhem took place on the roof of the largest building in Arnhem. The goal was to scan a certain neighbourhood for youths who riot and light up fireworks. The neighbourhood was quite large and could not be mapped with the camera in one shot. Besides, regulations regarding flying with drones state that "It is forbidden to conduct a flight within 150 metres horizontally of crowds of people, rural areas, motorways which are in use, or roads in use at a maximum speed of 80 kilometres (Overheid.nl, 2019)." Therefore, the drone could not be positioned directly above the place where the fireworks were fired. The time it took for the drone to be positioned on a spot away from people and roads but near the fireworks and with the camera directed in the right direction simply took too long. Based on this experience the pilots decided after a few attempts to end the deployment.

However, an OOV deployment a few days earlier with the same purpose was successful. The difference in deployment was that the location was narrowed to a certain flat in the neighbourhood and the drone could be positioned near the roof of the flat. From there the payloader could scan the area surrounding the flat by rotating the camera. The pilot and payloader were located on a hillside with a view of the flat which was under surveillance. This way the drone did not have to go to the location after a certain signal like fireworks but was stationed at that location till something happened (apart from the battery swap every 25 minutes).

Another remark is the difficulty with which a location can be pinpointed based on instructions from other policemen or based on where for instance the fireworks were first seen. This difficulty has to do with the way the pilot and the payloader view the streets of Arnhem through the camera located on the drone and their perception based on what they see in front of them. Therefore, it is of importance to take aspects like, viewing angles, and perception of the real world into consideration when designing the interface.

Figure 13 Drone image farmers protest (nu.nl, 2020)

3.1.3. Tracking dogs in combination with drones

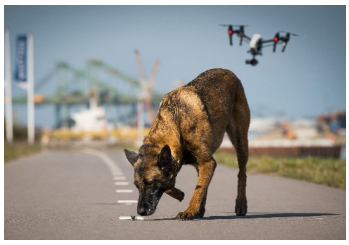

Figure 14 Tracking dog training with a drone (Zondervan)

Every year the police receive between 30.000 and 40.000 missing persons cases. Half of those cases originate from institutions. Most cases turn out to be innocent and the missing person is found relatively quickly. Unfortunately, some cases require more time and effort to determine the whereabouts of the missing person. These cases are called urgent missing person cases. In these cases, the police have an assistance role whereby the starting point is that the person is involuntarily missing, or the missing person is at high risk. In these cases, tracking dogs are often used to track down the missing person. Tracking dogs are mostly used during missing person cases in rural areas. This because in cities many scent tracks can confuse the tracking dog and make it harder for the tracking dog to follow the scent of the missing person (based on a conversation with Coen Zondervan, operational expert forensic investigation and tracking dog handler).

As part of the Proeftuin research was conducted on the effect of nearby drones on tracking dogs. This research was conducted in a closed warehouse in which 16 dogs were tested for 12 months on their response to a stationary hanging drone or a drone that flew near the dogs, Figure 14. The results were that none of the dogs had difficulty or were hindered in their duty while a drone was hanging nearby. Based on this information drones were used in collaboration with tracking dogs during missing person cases. Based on experiences from Coen Zondervan and other people participating in the Proeftuin multiple ways were described in which drones have added value in urgent missing person cases.

For instance, drones can help create an overview of an area and can plot the missing person, colleagues, and other people in the search area. This way dynamically can be determined whether more police personnel is required or if the search area needs to be enlarged. A plan of how to search the area can be created quicker and possible leads like an abandoned car or bike can be found faster with eyes in the sky. Lastly, the chances of finding a missing person can be increased by deploying a drone in urgent missing person cases and the speed with which a missing person can be located can be decreased which extends the survival rate (Zondervan, 2018).

3.1.4. Investigation

In the OOV Proeftuin, the drone was not only used during OOV cases but also to investigate possible hemp plantations. In particular, the XT2 was used to find deviating heat signatures of, for instance, roofs of houses. Deviating heat signatures could mean there is a hemp plantation located in the house or something else that produces more heat than an average household. Based on the information provided by Henk Hillbrands, drones and thermal sensors are also used to gather the last piece of information which could be the pivotal point in a police investigation. Thermal sensors are based on information provided by René Faessen (drone pilot) not ideal to find possible drug waste dumping sites or drugs labs. This originates in the fact that drug waste dumping sites or drugs labs have no distinct heat signature which can be focused on during the search.

Another sensor that could be proven helpful in those cases is a thermal and hyperspectral camera. These cameras can gather intel on soil composition, (mal)nutrition of crops and possible crop diseases. Based on hyperspectral data, soil compositions can be determined which could give insight into possible drug waste dumping sites (Ewing, 2020). Research by (Goldshleger, 2009) suggests hyperspectral imaging is a powerful tool to distinguish cannabis plants from several other vegetation types. Additionally, was presented in the research that spectral identification can take place at different distance levels, even from the air. Lastly, the researchers concluded that cannabis plants have a different spectral signature in very narrow spectral bands in comparison with other vegetation species.

Figure 15 Deviating heat signature apartment building (Marc Engbrocks)

Another application for the hyperspectral camera could be finding graves of people who are missing and (maybe) became victims of a crime. They can be hidden or buried across the country. The most common method to finding such hidden graves is by witness statements. But it is a labour-intensive process, and the witness statements are not always trustworthy. Therefore, hyperspectral cameras could speed up the process and help gather reliable information about the possible location of hidden graves. Furthermore, hyperspectral cameras can scan the surface of the possible location of the grave without disturbing the scene. Currently, the police are in collaboration with Saxion researching the implementation of hyperspectral cameras in combination with drones and multiple other sensors to find possible hidden graves (TechForFuture, 2019).

3.2. Use of drones outside the police

Drones are increasingly used both inside and outside the police. Below some examples of the use of drones outside the police and their (dis)advantages.

3.2.1. Farming

Drones are more and more often used by farmers for both planting and analysing purposes. Drones can be used for soil and field analysis, crop monitoring, health assessment but also irrigation. Multispectral imaging of crops (based on the amount of green and infrared light reflected), can be used to track the changes in health and maturity of the crops. With the help of this technology bacterial or fungal infections can be identified and dealt with earlier. Drones that are equipped with thermal sensors are used to identify fields with "hydric stress" (inadequate water of sufficient quality) and drones with radar and LiDAR can even be used for crop spraying as they can scan the ground and disperse liquids quickly and efficiently (Commission, 2018).

3.2.2. Environment and transport inspection

When a cargo vessel transports a liquid cargo there is the possibility that there will remain liquids and fumes in the tank of the vessel. The fumes and liquids first must be removed before a new cargo can come onboard. A vessel can discard the liquids and fumes by degassing the tank. This means the vessel will release all the fumes into the air, but this is not always and everywhere allowed. The "Inspectie Leefomgeving en Transport" (ILT) is responsible that this is done by the law.

It has consequences for both people and the environment when a vessel discards fumes and releases them into the atmosphere. To prevent this a restriction was filed in 2006 which states it is not allowed to degas petrol while sailing. Also, benzene and other emissions which contain more than ten percent benzene are not allowed to be degassed. In general, it is not allowed to degas near populated areas, bridges, and locks but outside those areas, it is, under certain conditions allowed. The ILT checks whether cargo vessels live by the rules with the help of a sniff pole, also called e-nose. These sniff poles measure the air composition and register when the air composition changes, for instance, when a vessel is degassing. When this happens the ILT inspector contacts the responsible vessel and requests more information about the cargo. When as a result the vessel indeed transported an emission, which is not allowed to be degassed or is degassed in the wrong place it will get a warning or is fined.

Unfortunately, e-noses are not stationed everywhere near the inland waterways. Therefore, drones are used to take pictures and make videos on these spots. The inspector uses these pictures and video's to scan for possible open tank covers or connected hoses which are possible signs of degassing activities (Toezine, 2020).

Figure 16 Use of drones during inspections (Voorham, 2019)

3.2.3. Fire brigade

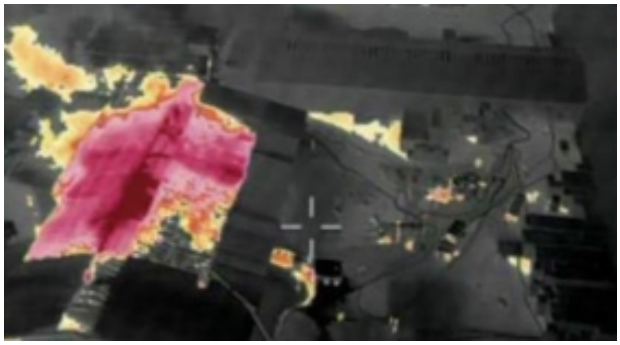

Figure 17 Example false colour thermal image large fire GRIP 1 in Daarlerveen (Twente, 2020)

From 2015 onward the fire brigade in the Netherlands also uses drones. First in a pilot project "Vliegen met drones, Brandweer Nederland" which was a success and resulted in the deployment of drones by the fire brigades throughout the Netherlands. Over the years the fire brigade has been given dispensation to fly closer to crowds and populated areas. Additionally, the fire brigade can use a drone during the night. Examples of possible scenarios in which the fire brigade used a drone are incidents involving dangerous substances, accidents involving water, Search and Rescue activities (SAR), combating fires in nature or during the investigation of the cause of a fire. During drone deployment, both optical cameras and thermal sensors are used. Optical cameras are used to create an overview of the incident and the smoke plume development. Thermal sensors on the other hand are used to locate heat sources and people who are possibly still in the building. Another example of drone deployment is calamities by which chemical substances are involved. Like a chain collision with a truck with chemical substances. A drone can then be used to determine which chemical substances are inside the truck, by locating the numbers written on the side of the barrel (Visscher, 2020).

The fire brigade has developed a 'snuffel drone', or e-nose in collaboration with Saxion and Robot Electronics Borne. This 'snuffel drone' can measure directly and on the spot which and how many chemical substances were released during a fire or accident. This is helpful to determine possible health risks for, for instance, the environment. In June 2020, a drone was deployed to determine the composition of chemical substances in a slurry pit in Schalkwijk. As a result, the waste dumped in the slurry pit consisted of drug waste that originated from the fabrication of speed and XTC. This way a 'snuffel drone' could also be helpful to the police to track down possible drugs waste dumping sites or drug labs (Venderbosch, 2020).

In Figure 17 an example of a thermal imaging palette used by the fire department. Since the start of the development of infrared cameras often distinctive pallets are used which run from black through blue, magenta, orange, yellow to bright white. However, every thermal pallet must be interpreted differently due to that the colours correspond to different temperatures.

3.3. Results

Based on a thorough analysis of the use of drones both inside and outside the police and with the help of evaluation reports of all the Proeftuinen two tables were created. In these tables, a selection is made of which sensors can be used in which use cases both inside and outside the police. What must be considered is that the drone can only carry two sensors simultaneously and not all sensors' combinations can be made due to the limited number of degrees of freedom available underneath the drone. The hyperspectral camera, the chemical sniffer and the LiDAR are greyed out because they are not operational yet. Table 2 and Table 3 will be compared to the Proeftuin use cases defined by the iLab. Lastly, a final selection will be made of Proeftuin use cases which will be focused on in the duration of the project.

Table 2 Selection of which sensor can be used in which use case inside the police. The columns which are greyed out are sensors that are not yet operational within the iLab.

Use of drones inside the police						
Drone use cases	**Zenmuse Z30**	**Zenmuse X7**	**Zenmuse XT2**	**Multi- / Hyperspectral camera**	**Chemical sniffer**	**LiDAR**
FO-VOA						
Crime scene	✓	✓	✓		✓	✓
Traffic accident	✓	✓			✓	✓
OOV						
(Expected) public order disturbances	✓	✓	✓			
Scheduled events	✓	✓	✓			
Urgent missing person cases	✓	✓	✓			
Investigation						
Hemp plantation	✓	✓	✓	✓	✓	
Drugs labs	✓	✓		✓	✓	
Chemical waste	✓	✓		✓	✓	
Hidden graves	✓	✓	✓	✓		

Table 3 Selection of which sensor can be used in which use case outside the police. The columns which are greyed out are sensors that are not yet operational within the iLab.

Use of drones outside the police						
Drone use cases	**Zenmuse Z30**	**Zenmuse X7**	**Zenmuse XT2**	**Multi- / Hyperspectral camera**	**Chemical sniffer**	**LiDAR**
Farming						
Planting	✓	✓				✓
Analysing			✓	✓		
Inspectie leefomgeving en Transport (ILT)						
Degassing	✓	✓			✓	
Fire department						
Dangerous substances	✓	✓	✓		✓	
Accidents involving water	✓	✓				
Search and Rescue activities	✓	✓	✓			
Combating fires in nature	✓	✓	✓			
Investigation cause of fire	✓	✓	✓		✓	

3.3.1. Use case selection

In the plan of approach, a short description is given about every Proeftuin use case predetermined by the iLab. Additionally, in the plan of approach, Appendix i: Plan of Approach, Proeftuin use cases are matched based on corresponding drone use cases or corresponding use of sensors. The matches made in the plan of approach are revised based on new insights from the analysis. Lastly, the Proeftuin use case *Illegal outdoor cultivation of hemp* was changed into *illegal cultivation of hemp* because of an increase of hemp plantations in Limburg. This way both hemp plantations and outdoors cultivation of hemp are part of the Proeftuin use case. Below the final list of Proeftuin use cases.

- *Entertainment areas & Events*
  In the Proeftuin use case, entertainment areas & events are both focused on the use of UAVs near café's or during fairs and focused on events like the 'City Swim' or Solar, both situated in Roermond. The use cases are a match with the drone use case **OOV**, described in paragraph 3.1.2.

- *Ad-hoc upscaling*
  Ad-hoc upscaling is related to **OOV** operations in which for instance a protest is escalating and more police forces or even an ambulance is required. Ad-hoc upscaling is also related to other operations or **investigations** which could turn out to be more advanced and extra personnel is required.

- *Forensic intelligence on crime scenes*
  A Proeftuin called 'forensic intelligence' located at the iLab is researching the use of sensors when investigating a crime scene. The goal would be to live-stream the crime scene into the iRoom and use this data to combine the process of 'intelligence-oriented scenario thinking' with the forensic activities on the crime scene itself. The drone use case **FO** matches this subject.

- *Illegal cultivation of hemp & Drug waste dumping*
  Both Proeftuin use cases illegal cultivation of hemp and drug waste dumping match with the drone use case **investigation**. The drone use case **investigation** covers hemp plantations but also drugs labs, chemical waste, or hidden graves, see paragraph 3.1.4 for more information.

The Proeftuin use cases Project national holiday resorts, Cross-border crimes, Collaboration with the defence department and Inzet Proeftuin MoBa[3] Roermond are greyed out on the next page. These cases are not yet operational or do not fit within the described drone use cases and are therefore excluded. However, based on the gathered literature some assumptions can be made about the possible use of sensors in those greyed out use cases. This is made visible in Table 4.

[3] MoBa stands for "Mobiel Banditisme" which means mobile banditry

Table 4 Cross-referencing table 2 and 3 with Proeftuin use cases. The columns and rows which are greyed out are sensors or use cases that are not yet operational within the iLab.

Proeftuin use cases	Drone use cases	Zenmuse Z30	Zenmuse X7	Zenmuse XT2	Multi- / Hyperspectral camera	Chemical sniffer	LIDAR
Entertainment areas	OOV	✓	✓	✓			
Events		✓	✓	✓			
Ad-hoc upscaling	OOV / Investigation	✓	✓	✓		✓	
Forensic Intelligence on crime scenes	FO	✓	✓	✓		✓	✓
Illegal cultivation of hemp	Investigation	✓	✓	✓	✓	✓	
Drug waste dumping		✓	✓		✓	✓	
Project national holiday resorts		✓	✓	✓			
Cross-border crimes		✓	✓	✓		✓	
Collaboration with the defence department		✓	✓	✓	✓		✓
Inzet proeftuin MoBa Roermond		✓	✓	✓			

As mentioned earlier, Table 4 is based on literature and conversations with people inside and outside the police. The table is only an overview of the possible sensors which can be used during operations. Additionally, has been expressed by multiple colleagues and drone pilots that every operation is different. Different weather conditions, location, time of the year etc. Therefore, beforehand must be considered which sensors are the most suitable for the operation based on the information at hand. Lastly, the client must be specific regarding the goal of the operation and the area should not be too big. A quick analysis upfront of the requested deployments of the drone team could prevent unnecessary deployments and could help narrow the goal of the deployment. Based on the match of drone and Proeftuin use cases, literature, and conversations with people inside and outside the police four Proeftuin use cases are selected which will be focused on in the remainder of this project. The selection and thoughts behind the selection are described in the next paragraph.

Table 5 Proeftuin use cases selection. The rows in blue are the selected use cases. The columns which are greyed out are sensors that are not yet operational within the iLab.

Proeftuin use cases	Drone use cases	Zenmuse Z30	Zenmuse X7	Zenmuse XT2	Multi- / Hyperspectral camera	Chemical sniffer	LiDAR
Entertainment areas	OOV	✓	✓	✓			
Events		✓	✓	✓			
Ad-hoc upscaling	OOV / Investigation	✓	✓	✓		✓	
Forensic Intelligence on crime scenes	FO	✓	✓	✓		✓	✓
Illegal cultivation of hemp	Investigation	✓	✓	✓	✓	✓	
Drug waste dumping		✓	✓		✓	✓	

The selection above is based on the goal of the project; to determine which data can be extracted from drone sensors plus the added value for the iLab. Therefore, was chosen to continue with the use cases *Entertainment areas & Events* and *Illegal cultivation of hemp & Drug waste dumping*. The use case *Entertainment areas & Events* was broadened with other OOV related cases like protests. This choice was made because all events were and are cancelled due to the ongoing COVID-19 pandemic. This originates in the fact that no Proeftuin has deployed the drone during events, so no data is available about the use of drones during events. However, more people are protesting against the corona measures and cultural related issues which resulted in more opportunities for the police to use the drone in another setting. Therefore, was chosen to re-focus on protests. The use case Illegal cultivation of hemp was chosen because it includes all sensors except the LiDAR sensor and could therefore be a nice addition to the already chosen use cases. Furthermore, illegal cultivation of hemp is a good example of which sensor combinations can be used in which scenarios. Drug waste dumping is also a growing issue in Limburg which could be a good opportunity to test the sensors during real-life cases.

Below the final selection of the Proeftuin use cases which will be focused on in the remainder of the project.

Table 6 Final selection Proeftuin use cases. The columns which are greyed out are sensors that are not yet operational within the iLab.

Proeftuin use cases	Drone use cases	Zenmuse Z30	Zenmuse X7	Zenmuse XT2	Multi- / Hyperspectral camera	Chemical sniffer
Protests	OOV	✓	✓	✓		
		✓	✓	✓		
Illegal cultivation of hemp	Investigation	✓	✓	✓	✓	✓
Drug waste dumping		✓	✓		✓	✓

3.3.2. Data per use case

Based on the aforementioned selection, of every use case, two examples will be given in which drones are used. The aim is to determine which purpose the drone has in the use cases and which data is 'extra' available when using a drone. The data which is available beforehand without the use of drones is left out of the scope for now due to many differences in operations, location, but also the time of day, weather conditions, available information beforehand or during the operation. The scenarios below are based on a conversation with Marc Engbrocks, drone pilot, and are partially based on real-life operations.

a. Illegal cultivation of hemp example cases

Example 1: Hemp plantation in an apartment building

To make people aware of the danger of having a hemp plantation in their house the municipality of Sittard started a small campaign in collaboration with the police, Enexis and a few other parties. As part of the campaign the police went along the doors and asked people if they could come inside and if they were aware of the dangers of having a hemp plantation in their home. Furthermore, the energy company did test if there were unusual energy consumption patterns in streets or apartment blocks. The unusual energy consumption patterns signify the lights above the hemp plants which are kept on for 12 hours straight and turned off for 12 hours. Based on this information certain apartment buildings were marked as places for possible hemp plantations. Additionally, based on the information from the energy company could be determined which column of apartments could contain a hemp plantation. A handheld infrared camera was used to specify with more detail which apartments in the selected columns could contain hemp plantations. The drone team was asked to verify with the XT2 if the selected apartments indeed were warmer compared to other apartments. In total three columns were selected which possibly contained hemp plantations. The first two apartments in the first two columns were both identified with the handheld infrared camera and the drone. In the last column, the handheld infrared camera could not distinguish which apartment was warmer than the others. Therefore, the drone was used to confirm which apartment in the last column contained the hemp plantation. Based on the information from the energy company, gathered background information on the people living in the targeted apartments and both the handheld and the drones thermal images was decided by the "hulp Officier van Justitie" (hOvJ) to gain authorization to confiscate the hemp in the apartments. In this example case, the thermal images were part of the chain of evidence required to gain authorization to confiscate the hemp.

The role of the drone, in this case, was to confirm the deviating heat patterns of the apartments targeted by the police. This is called 'opplussen' (adding up); the evidence gathered by the energy company, personal information about the people living in those apartments, the data gathered by the handheld infrared camera and the validation with the XT2 led to the authorization to confiscate the hemp in the apartments.

Example 2: Possible hemp plantation in an office building

A client asked the drone team to investigate a possible hemp plantation in an office building. The only information available was that there could be a hemp plantation in the building. The drone team decided to scan the building for deviating heat patterns in the morning. The hemp plantation should have been running all night and therefore should still be warm in the morning. The roof of the building was oddly cold compared to other building in the neighbourhood but other than that no deviating heat patterns were detected. This information was forwarded to the client which had to decide what to do with the information. In this example, the drone was used to detect possible deviating heat signatures and to observe the building.

The role of the drone, in this case, was to observe and gather information regarding the building and possible deviating heat patterns. In this case, the oddly cold roof could be seen as the deviating heat pattern.

b. Drugs dumping example cases

Example 3: Chemical waste dumping

As already explained in paragraph 2.6.5, an electronic nose can be used to detect chemical substances, identify them, and store them as evidence. An electronic nose developed by Jaap Knotter was used at a known chemical waste dumping site. At this location, they used the drone to check whether the waste was indeed chemical waste and to test what kind of chemical waste it was. Furthermore, samples were taken which were later used as forensic evidence. The advantage of using the drone is that no person must go near the waste, a risk analysis can be performed beforehand, and tests can be conducted to see if the waste is harmful. Furthermore, samples can be gathered without disturbing the scene.

In example 3 the drone was used instead of a person to gather data; determine the kind of (chemical) waste and take samples without disturbing the scene. This way is safer for the people on the location and the crime scene can be preserved.

Example 4: Drugs production location

In the fourth example case, the electronic nose was used at a drugs production location. Synthetic drugs have their own chemical profile which is created during the production process. At the production location, the unique chemical profiles were mapped. This profile can be used to connect ongoing cases.

In the second example the drone was used to gather data or to be more specific; map unique chemical profiles. These profiles can, later, be used to connect cases or convict people.

c. Protests

Example 5: Kick-out Zwarte Piet protest

During a Kick-out Zwarte Piet protest in Venlo, both supporters and opponents of Zwarte Piet were present. The groups were kept apart by the “Mobiele Eenheid” (ME) or public order officers in English. During the protest, the drone was used to observe the protest from above and alert the person in charge whenever the drone pilot or payloader saw something which required attention from the police or ME. Furthermore, people who misbehaved or violated the law were video-recorded when possible, which could be used as evidence in court. During this protest, there was no livestream which the person in charge could watch in real-time.

During the protest, the drone was used to both observe and gather data when people violated the law. Based on the example can be concluded that a drone can perform two tasks at the same time; observe and gather data.

Example 6: BlackLivesMatterNL

The group BlackLivesMatterNL held a protest at the Malieveld in The Hague. During the protest, a drone was deployed to observe and communicate that people should keep a 1,5-meter distance from each other. Furthermore, with the drone, a good overview could always be maintained, and the images were live-streamed to the Operational Centre. Lastly, videos or photos could be made when someone violated the law. However, this was during the operation in The Hague not necessary.

In this example, the priority of the drone was to observe the people during the protest. The second priority was to gather data on when someone violated the law or other situations in which videos or photos could become important later.

3.4. Conclusion

Based on the conducted analysis, use case selection and example cases described above the following conclusions can be drawn.

- No operation is the same. Therefore, upfront must be determined which sensors could have the most added value during the operation. The decision can be based on Table 5.
- The location and the goal of the operation should be specified and narrowed down upfront to prevent unnecessary deployment.

Throughout the example cases, the deployment of the drone had three main purposes:

- *Gathering data;* In the example cases, the drone was used to gathered data about the location of (possible) hemp plantations, chemical waste dumping sites and data which could be used in court when someone violates the law.
- *Observe*; The drone was used to observe the people participating in a protest. With the help of the drone was made visible where the public order officers were stationed, where additionally police personnel was required and whether it was safe to go near a drug dumping site.
- *Validate*; The drone was used to verify findings that led to the confiscation of hemp.

Throughout the analysis, selection, examples, and conclusion have become clear that a drone can be deployed in several circumstances and with many different goals in mind. This makes a drone a versatile tool that suits the police and fits within the selection of use cases of the Proeftuin UAV. The next paragraph will be focused on the place in which the data gathered by the drone has to be implemented, the iRoom.

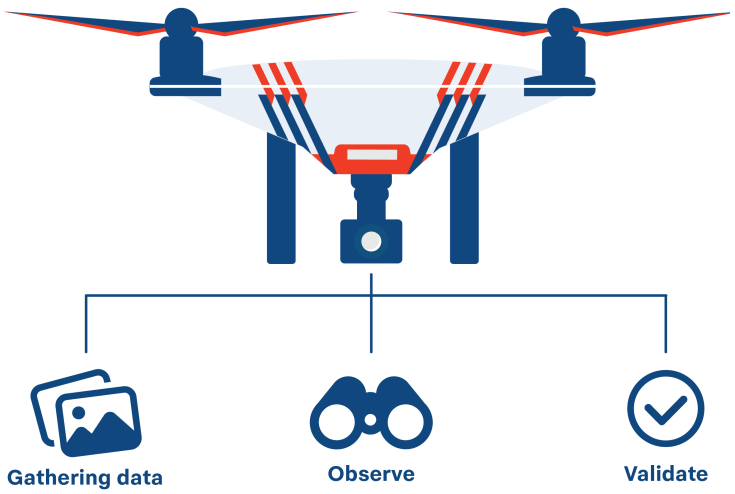

Figure 18 Visualisation conclusion

4. IROOM INTERFACE DESIGN ANALYSIS

This chapter is focused on why there is an iRoom, what the goal is of the iRoom and all the elements which will be part of the iRoom interface design. Furthermore, will be analysed how the data gathered by drones can be implemented in the iRoom in its current state and in a way that has added value for the people working in the iRoom. The future iRoom will be located at the Operational Centre in Maastricht.

4.1. The iRoom interface design

As already mentioned in the orientation, paragraphs 2.2 & 2.3, the iRoom is a 365/24/7 intelligence room in which information will be received, filtered and dispatched to the right people at once. The iRoom is important because of the decrease in 'old' forms of crime and the emergence of new forms of crime. The police must stay involved in these developments to remain effective and reliable, i.e., legitimate, as a police force. New technologies like drones, sensors, and Artificial Intelligence (AI) are becoming available to the police for deployment and to create new opportunities. Therefore, the iRoom was introduced as a 365/24/7 intelligence room in which the whole intelligence chain is available (including collecting, processing, structuring, analysing, interpreting, visualising, and presenting) (Timmermans, 2019). Below a description of the people and different positions within the iRoom.

4.2. People working in the iRoom

The iRoom will be continuously occupied and information will be gathered and distributed to the right people 24/7. By doing this, operations are supported with information when the deployment takes place and not just between nine and five. The 24/7 occupation of the iRoom both creates challenges and is the crucial success factor that can make the iRoom a success.

4.2.1. Positions within the iRoom

There are a few different positions within the iRoom to create a workable and structured environment. Below a description of every role, responsibilities, and cohesion between the positions. The roles are complementary to each other and some roles are fulfilled by multiple people. The information regarding the different positions within the iRoom is based on (Krämer, 2020).

Intake Sensing

The iRoom receives a signal from internal or external parties. This signal will first be handled by Intake sensing which performs a first assessment of the signal. Additionally, Intake Sensing provides an intake based on available sources. When the signal gets priority in a certain situation, Intake Sensing will perform a thorough search based on available sources. The search will be focused on upgrading the signal. What sources could help with upgrading the signal will always be the question at hand. If the signal with the upgraded information turns out to be relevant, then immediate coordination with OSINT and analysis takes place.

OSINT

OSINT receives the upgraded information, leads, from Intake Sensing. It has the preference that a search question will be provided by both Intake Sensing and Analysis to be able to search in a more specific direction on social media. The whole process enriches the information which is available internally and supports the execution of work inside the iRoom.

Analysis

In relevant cases, the role Analysis will appoint a few scenarios. These scenarios could lead to possible follow-up research inside the iRoom. The role Analysis discusses the research demand together with the Intake Sensing and OSINT who will continue with a narrower search to fulfil this research demand. In the meantime, the employee Analysis will monitor the developments from different scenarios. This way he or she can tune in with the information coordinator in an early stage.

Information coordinator
The information coordinator is the receiver of the final product within the iRoom. The information coordinator has the task to follow the cases within the iRoom closely. This creates the opportunity to contact possible customers who take over the final product at an early stage. He or she is familiar with the possible customers within the police and knows the police network. Lastly, the information coordinator is responsible for the quality and distribution of the final product.

Director (optional)
Dependent on the amount of workload and time constraints within the iRoom the need could arise for someone who guides the processes and people within the iRoom. Up to now, everyone within the development team agreed that the role of director can be fulfilled by someone with already another role in the iRoom. When the iRoom expands both in tasks and capacity the requirement to fulfil this role could become more important.

4.3. Sensors within the iRoom interface design

The iRoom interface design will visualise data that is gathered by drones. This data consists of, for instance, the livestream of the camera or thermal imaging from the XT2. The multispectral camera data will not be implemented in the iRoom. This originates in the fact that the multispectral camera has no option to stream the images to the iRoom in real-time. Furthermore, the data which is gathered with the multispectral camera must be analysed by a specialist to be able to interpret the images. However, the ANPR system and data generated with the Wi-Fi Bluetooth sniffer will be included in the iRoom interface design. The ANPR system is added because when the ANPR system is connected to the camera of the drone, the drone can register license plates in real-time during a flight. The Wi-Fi Bluetooth sniffer is not mentioned in the drone analysis because at that time little was known about the capabilities of the device. However, the Wi-Fi Bluetooth sniffer is of added value in the iRoom interface design and therefore the device is explained below together with the ANPR system. A description of the thermal and multispectral camera can be found in paragraph 2.6.

4.3.1. Automatic Number Plate Recognition system

The Automatic Number Plate Recognition system compares license plates with license plates stored in a database. The license plates stored in the database are cars that are wanted by the because they still need to serve several years in prison or have fines that still must be paid. Stolen cars are also registered in the database. When a car is recognised by the ANPR system the police will be alerted. The alert must be checked by an employee of the Operational Centre to ensure that the photo taken of the license place matches the license plate registered in the database. Then employees of the Operational Centre must decide whether there must be taken immediate action yes or no.

Whenever the ANPR system is connected to the drone the drone can scan license plates and alerts when there are hits based on license plates in the database. This could be helpful during traffic controls, surveillance, or missing person cases. During highway traffic controls the drone can be used to quickly communicate when there is a hit and which police officer is the closest to the vehicle. This way the vehicle can be intercepted quickly and efficiently.

Another example could be an ongoing case in which the drone combined with ANPR could be used to check whether the suspect is at home or a possible other location. Lastly, the drone can be used during missing person cases. When a vehicle is found near the location where a person went missing the ANPR can scan the license plate and provide information about the owner of the car.

Several tests were conducted with the drone in combination with the ANPR system. During the tests, the Zenmuse Z30 zoom camera was used to scan the license plates from different distances and heights. Based on both the conducted tests and the given examples can be concluded that it would be more than helpful to be able to use the drone in combination with the ANPR system.

4.3.2. Wi-Fi Bluetooth sniffer

The Wi-Fi Bluetooth sniffer is a device with which both Bluetooth and Wi-Fi data is gathered. The data gathered with the Wi-Fi Bluetooth sniffer consists of the sniffed Media Access Control (MAC) [4] addresses with an accompanying timestamp of the devices in the neighbourhood of the Wi-Fi Bluetooth sniffer. Additionally, the sniffer can gather information about the number of devices connected to a certain Wi-Fi network. Based on the first three groups of two hexadecimal digits of a MAC addresses can be determined the type of device. Furthermore, the brand of the device and sometimes even the series can be determined. Currently, the Wi-Fi Bluetooth sniffer is only used as a static device that is placed near specific locations and has a reach of around 150 meters. The expectations are that the range of the Wi-Fi Bluetooth sniffer can be further extended when mounted underneath a drone. However, currently, the Wi-Fi Bluetooth sniffer cannot be used underneath a drone operationally due to certain regulations and tests which still must be conducted. When the Wi-Fi Bluetooth sniffer is used the data gathered by the Wi-Fi Bluetooth sniffer is send real-time to a database that analyses the data with the help of Elasticsearch. Then the data can be visualised in a program called Kibana. Kibana is an open-source program that allows shaping the data the way you like. For instance, data can be gathered based on how many times a certain device is logged compared to a certain time frame and the strength of the signal.

The Wi-Fi Bluetooth sniffer in combination with the drone could be helpful during missing person cases or in long-term covert operations. During missing person cases the drone can be used to scan a certain area for MAC addresses. These MAC addresses can be linked to certain types and brands of devices and ultimately also to a certain person. During long-term cases, the drone could be used to gather the MAC addresses in and around a certain building. When the drone is deployed regularly near a certain building patterns can be found in the frequency a certain device is logged and when a certain device enters or leaves the building. This information combined with camera imaging could help determine which MAC address is whose and if he/she is home. In the long run, this information can be used to arrest someone.

The implementation of the Wi-Fi Bluetooth sniffer in the iRoom interface design will be partly based on facts and partly be hypothetical. This originates in the fact that currently not all the specification and possibilities of the Wi-Fi Bluetooth sniffer in combination with the drone are known. However, the implementation and iteration on how the Wi-Fi Bluetooth sniffer could be used in the drone dashboard could give the police an idea of future implementations of the Wi-Fi Bluetooth sniffer.

4.4. The perspective and visions of people involved in project iRoom.

To get a better understanding of the perspective and vision of people involved in project iRoom interviews were held. These interviews were held with team members of project iRoom and the clients (Micha Consten and Michael Krämer). Beforehand the interview, there was noted that the interface would only contain information gathered by drones. The knowledge and opinions of people involved in project iRoom together assisted to determine a list of requirements for the iRoom interface design.

4.4.1. The team members of project iRoom perspective and vision on an iRoom interface design

- The interface should be a multipurpose interface in which not only data gathered by drones can be shown and analysed but also data from, for instance, bodycam's, camera surveillance on the streets, or the police helicopter.
- The interface should be useful during both ad-hoc and scheduled cases and should be the same for every employee of the iRoom.
- Communication between the iRoom and the drone pilot or payloader was mentioned as an important part, in which way needs to be communicated was not defined by the interviewees.
- The livestream from, for instance, the drone should be recorded, to be able to rewind the video to for instance check something that was missed before. Furthermore, there should be an option to take screenshots of a paused recording. This way images can be distributed with ease and can be used as evidence.

[4] A MAC address is a vendor specific unique identifier

- When the drone registers a hit of a license plate or a phone with the help of the Wi-Fi Bluetooth sniffer an alert needs to go off or a message should pop up.
- When an operation is done there should be the possibility to gather all the data which was used during the operation and store it. This way the gathered data can be used to draw up an official report.
- The location of the drone should be visible on a map during deployment combined with information about the locations of incoming alerts, colleagues, events etc. This creates an overview of the colleagues on the ground and the possibility to better visualise the location of incidents or even possible flight routes.
- The video wall was mentioned as an important object within the iRoom. The information gathered by an employee on his or her workstation should be easy to add to the information visible on the video wall. The information presented on the video wall should be scalable, easy to move, sharable etc.
- The video wall should have speakers to be able to play videos from social media or other mediums.
- ANPR, livestream and a map with the locations of colleagues, incoming alerts etc. were mentioned as the basic functionalities within the iRoom interface design. These functionalities will probably be always visible in the interface with the option to remove them or minimize them when necessary.
- Lastly was mentioned that a short introduction about thermal and multi-spectral imaging and how to interpret these images was desirable.

4.4.2. The client's perspective and vision on the iRoom interface design

- The purpose of the interface is to show only data gathered by drones in a web-based interface that can be opened on any computer.
- Apart from the livestream from the drone, there should also be the option to rewind the video and take screenshots. Preferably in a way that the livestream continues on another screen while in the 'pause screen' screenshots can be taken.
- The location of the drone should be visible on a map combined with information regarding the view direction of the camera underneath the drone. Furthermore, a compass was regarded as helpful to be able to determine the orientation of the map.
- When the drone is used during protests there should be an option to share a link with access to the livestream. This way the iRoom, client or other colleagues can see real-time images from the drone. Additionally, there is the possibility to request to go to a certain location via police radio or other means of communication.

4.5. Alignment with the literature findings

In the interviews with team members of project iRoom was addressed that the iRoom interface should be a multipurpose interface that is not solely focused on showing data from drones. Other types of information should be addable to the interface. The client on the other hands states that the interface should only contain data gathered by drones. Because the project is focused solely on the added value and implementation of drone data, the iRoom interface will consist of data only gathered by drones.

Both the team members and the clients of project iRoom mentioned the feature to view the location of the drone on a map. The client also mentioned that there should be the option to see the view direction of the camera underneath the drone. The possibility to add the location of colleagues, events, incoming alerts, was also mentioned several times by team members and is in line with findings in the drone analysis phase. Furthermore, it creates more situational awareness for the policemen on the ground and the people working in the iRoom.

There was also was mentioned that it would be valuable to gather the information which was used during an operation and store this information. Or the option to send this information to someone who is, for instance, required to draw up an official report. The client mentioned that the images and videos made with the drone should be handled by the drone pilot or payloader and the information gathered by the iRoom should be handled by the iRoom. This way the drone pilot/payloader and iRoom are and stay responsible for their part of the operation.

Both the team members and the client agreed that there should be the possibility to rewind the recording from the drone. Furthermore, there should be the option to take screenshots of a paused recording. This functionality creates the opportunity to quickly share images of a possible suspect or incidents on which immediate action can be taken. The above-mentioned perspectives and visions reflect the joint vision on an iRoom interface design and will all be considered during the concept development phase.

4.6. Requirements for the iRoom interface design

The requirements are based on the interviews with the clients and team members of project iRoom.

- The interface should only contain drone-related data.
- The interface should be useful during both ad-hoc and scheduled cases
- The interface should be the same for every employee of the iRoom.
- The interface should be intuitive in use.
- The interface should support the people working in the iRoom during their work.
- The interface should be adaptable based on the available set of sensors and the wishes of the user.

These requirements are a starting point for the development of the interface.

4.7. Personas

As mentioned in paragraph 4.2 every person working within the iRoom has different expertise and background. Furthermore, the client who requests a drone deployment also has a different perspective about what he/she wants to see during the drone deployment. Therefore, several persona's will be created which will help to understand and define the users.

Personas help narrow the audience for which is designed by creating the possibility to design for the personas instead of for everyone. Furthermore, personas help integrate the goals and needs of a specific group of users (Miaskiewicz & Kozar, 2011). (Pruitt & Adlin, 2006) described personas as the fictional, precise, and detailed embodiment of the target users. For this project, personas are created to investigate the different types of iRoom interface users.

The interface will be the same for every employee within the iRoom. However, this does not mean that the wishes of the people working in the iRoom will be the same. The personas will help identify the areas in which the people working within the iRoom differ, so there can be made an approach which is tailored to take these differences into account. The advantage of applying user profiling at this stage of the project is that the approach of the project is tailored to suit the customer but still maintains the standard approach.

The interviews held with team members of project iRoom will be used to update personas created earlier by the iLab. Currently, no interviews can be held with the future employees of the iRoom. However, the current work environment and job descriptions of the team member of project iRoom overlap with the positions within the iRoom. Therefore, the interviews held with team members of project iRoom are valuable information that can be used to update the personas. Three personas are created while following the formula for creating personas from (Goltz, 2014).

Persona 1 and 2, on the next page, represent people who could be working in the iRoom. There was chosen to create one persona about an analyst, one persona about a "Dienst Regionale informatie Organisatie" (DRIO) employee and one persona about a chief constable. In the future probably one analyst and multiple DRIO employees will be working in the iRoom.

Figure 20 Persona 1: Ben Andersen, Analyst

Figure 19 Persona 2: Maria Janssen, DRIO Employee

Figure 21 Persona 3: Tom Willems, Chief Constable

Persona 3 represents Tom, Chief Constable in Helmond. Because multiple people can request a drone deployment persona 3 was created to represent this group. People within this group could be a neighbourhood police officer who is present during a hemp plantation case or a police officer who is directing police units during a protest. The personas will be used to better understand and define the users. Furthermore, the personas will be used in the scenario's that are written to determine how the iRoom interface design will be used by its users.

5. IROOM INTERFACE DESIGN DEVELOPMENT PHASE

This chapter will elaborate on the roadmap followed to get to a prototype to conduct user tests with. The required functions, content and main elements will be discussed followed by an overview of the created low and high-fidelity prototypes.

5.1. Roadmap iRoom interface design

A roadmap is developed to determine all the elements within the iRoom interface design and how these elements relate to each other. Questions which are kept in mind are:

- What is the purpose of the interface?
- Which sensor data does it need to contain?
- Which elements need to be implemented in the interface?
- Which functions does it require?
- Does the information presented have added value for the people working in the iRoom?

When the answers to these questions are clearer, prototyping is used to develop low-fidelity and eventually high-fidelity prototypes of the interface. Furthermore, user tests will be set up.

5.1.1. Functions of the interface

To develop the interface a top-down approach is used. First, is focused on the overarching question: 'What is the purpose of the interface' towards more specific questions related to the functionalities within the interface. These questions help to determine the main functions of the interface and stimulate quick decision making and narrowing the scope of the project. The purpose of the interface is to visualize the data gathered by drones clearly and understandably. Furthermore, the interface should include data from the Wi-Fi Bluetooth sniffer, ANPR hits, (thermal) camera, and the livestream. The reason why there is a separate interface for the drone data is to maintain an overview of where the data is coming from. To facilitate this, the interface should be accessible in the iRoom, multiple people should be able to use the interface simultaneously and the interface should be easy to use. Examples of functions within the tool are the option to take screenshots of a paused recording, switch between sensors or change the screen size of the information presented and be able to share the information whenever necessary.

5.2. Content of the iRoom interface design

The available set of sensors, the Proeftuin use cases and the information from the interviewees helped determine the content of the iRoom interface design. However, still, some changes were made to the final selection of Proeftuin use cases. For instance, there was decided to add missing person cases to the list of use cases. This decision was made with the help of information gathered in the analysis phase, provided information by the interviewees and a conversation with the clients. Drug waste dumping, on the other hand, was removed from the list of possible use cases because the multispectral camera will not be used in combination with the iRoom. Because of the changes, a new overview was created of what sensors can be used in which use cases and with which sensor combinations. This new overview, visible in Table 7 was created based on the final selection of use case in Table 6, the information regarding the Wi-Fi Bluetooth sniffer and the possible sensor combinations in Table 8.

5.2.1. Sensor combinations

The Matrice 210 V2 has a dual gimbal mount which means two sensors can be mounted underneath the drone simultaneously. However, some sensors can only be mounted on gimbal 1 or 2 or when mounted together are in each other's degrees of freedom. What also is taken into consideration is that currently, the drone team has only one of each sensor therefore combinations with two times the same sensor was excluded. Table 7 is an overview of all the possible sensor combinations. The Wi-Fi Bluetooth sniffer is not yet operational and fully tested, because of this it is not known whether the X7 and the XT2 can be mounted underneath the drone simultaneously with the Wi-Fi Bluetooth sniffer.

As can be found in Table 8 the Zenmuse X7 is the only sensor that needs to be mounted standalone due to the degrees of freedom it requires. Because of this and the fact that the Zenmuse XT2 and Z30 can be used in every selected use case of the final selection, there was decided to not implement the Zenmuse X7 in the prototype.

Table 8 Sensor combinations with use cases

Use cases / Sensor combinations	Missing person cases	Illegal cultivation of hemp	Protests
Zenmuse Z30	✓	✓	✓
Zenmuse XT2	✓	✓	✓
Wi-Fi Bluetooth sniffer	✓	✓	
Zenmuse Z30 + Zenmuse XT2	✓	✓	✓
Zenmuse Z30 + Wi-Fi Bluetooth sniffer	✓	✓	

Table 7 Sensor combinations

	Zenmuse Z30	Zenmuse X7	Zenmuse XT2	Wi-Fi Bluetooth sniffer
Zenmuse Z30	X	X	✓	✓
Zenmuse X7	X	X	X	?
Zenmuse XT2	✓	X	X	?
Wi-Fi Bluetooth sniffer	✓	?	?	X

Both Table 7 and Table 8 are kept in mind while designing the iRoom interface and creating scenarios that can be used to test the interface.

5.2.2. Main elements

Based on the interviews held with team members of project iRoom and the clients the main elements of the iRoom interface design are described. Together with the desired functions, this information has been translated into a low-fidelity prototype. Below a list and short description of the main elements:

- *Map:* Map with the location of the drone and the possibility to zoom in or out on the map and move the map around.
- *Livestream:* Live imaging from the drone with the possibility to zoom in, enlarge the screen, take screenshots, record a certain part of the livestream, and share this part with colleagues.
- *Recording:* Option to record a part of the livestream, pause-, rewind-, fast forward- the recorded part or minimize, maximize the screen.
- *ANPR system:* List of most recent hits, alert when there is a hit, overview of hotlists, option to add a license plate or remove a license plate.
- *Wi-Fi-Bluetooth sniffer data overview:* Overview of the data gathered by the Wi-Fi-Bluetooth sniffer and the option to search for a specific MAC address.
- *Dashboard:* An overview of all the different elements with the possibility to scale them, minimize them, open them etc.

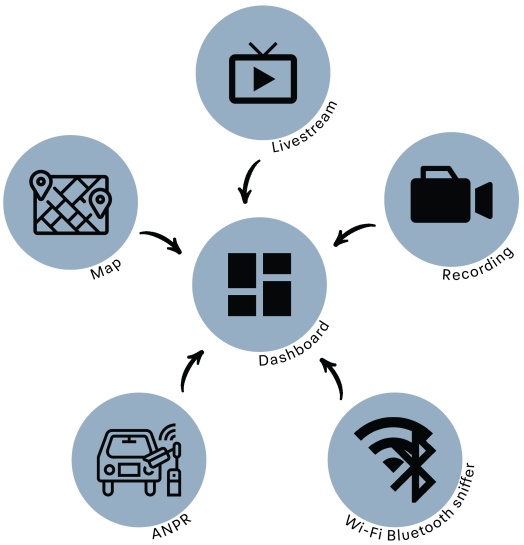

Figure 22 Main elements of the iRoom interface design

5.3. Prototypes

The main elements were input for both low and high-fidelity prototypes. By doing so the information from the interviews and analysis phase is translated into tangible and testable artefacts.

5.3.1. Low-fidelity prototype

To begin with, low-fidelity prototypes are created of all elements within the iRoom interface design. This way can be determined whether basic functionalities are missing and how the elements should look like. The low-fidelity prototypes are created with several post-it notes to stimulate people to give feedback and draw possibilities themselves. Several concepts of each element are created to allow combining ideas or removing them whenever they are insufficient. The low-fidelity prototypes were presented to the drone team and team members of project iRoom because the actual users of the iRoom interface are as explained not available till after this project. More pictures of the low-fidelity prototype can be found in Appendix II: Pictures low-fidelity prototype.

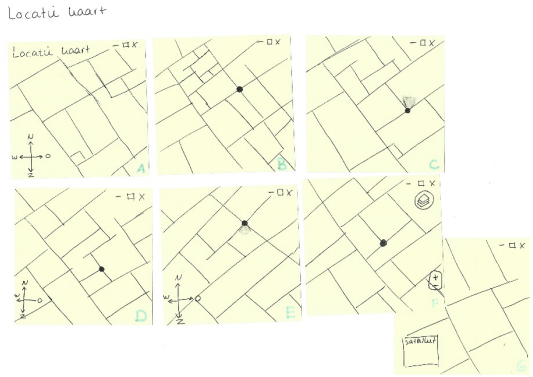

Figure 23 Low-fidelity prototype map element

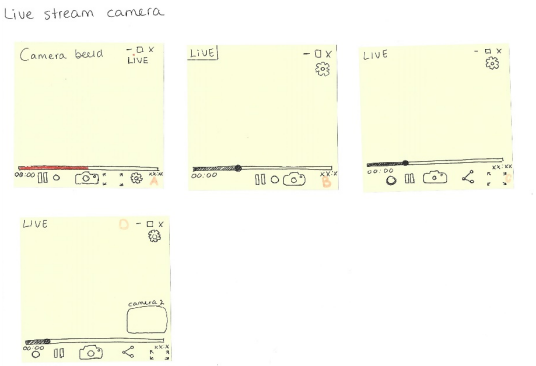

Figure 24 Low-fidelity prototype live stream element

5.3.4. High-fidelity prototype

Based on the feedback from the low-fidelity prototype a high-fidelity prototype of the elements: map, Livestream, recording, Wi-Fi Bluetooth sniffer and ANPR system was created. This high-fidelity prototype was shown to the drone team and team members of project iRoom. Both agreed that these elements and how they look would be a good starting point for the design of the iRoom interface.

The layout and icons used in the high-fidelity prototype, Figure 25, are inspired by the design system Material which is created by Google. Material supports the best practices of user interface design and is therefore used as a guideline. Additionally, within the police, the design system Material will become the standard. The layout and use of icons of the recording element are based on the website YouTube. Lastly, the layout and functions within the ANPR system are based on screenshots from the existing ANPR system used by the police.

Feedback from both the drone team, members of project iRoom and the clients were used during the iteration and the realisation of a more elaborate high-fidelity prototype. This new high-fidelity prototype is made interactive, this way user tests can be performed with the prototype. More screenshots of the different elements within the prototype can be found in Appendix III: Picture's prototype. To test the prototype three scenarios were written to determine the required functionalities within the iRoom interface design. More information about the scenarios can be found in chapter 6.

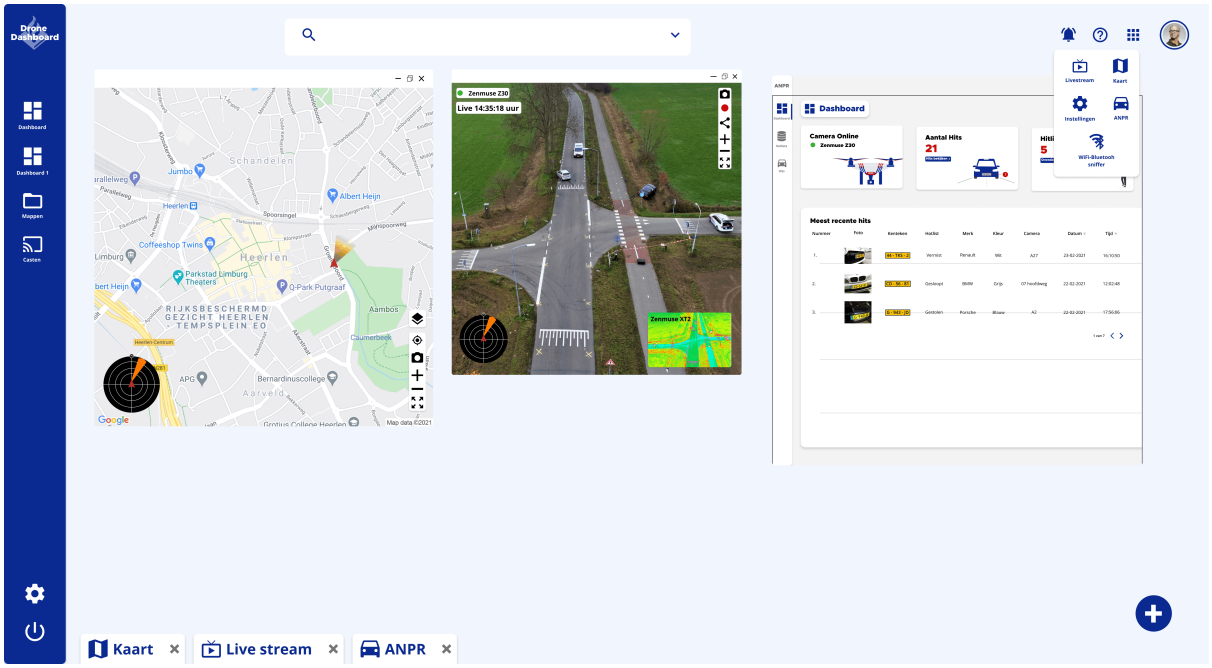

Figure 25 First high-fidelity prototype of the drone dashboard

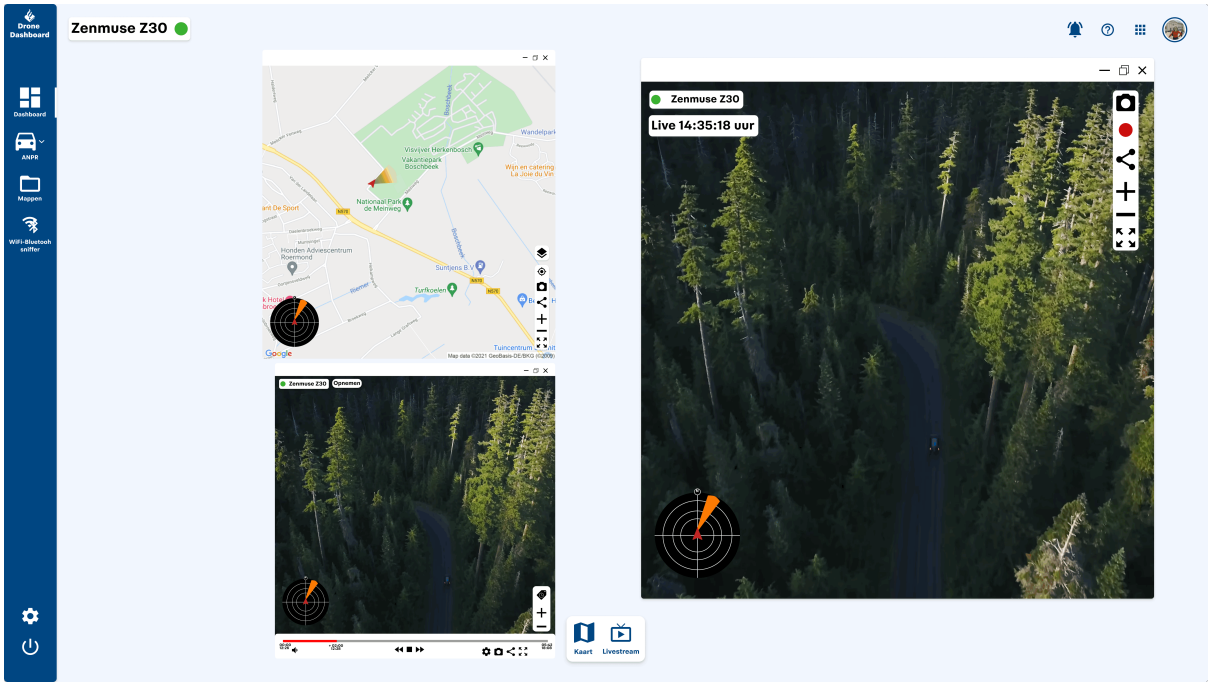

Figure 26 Dashboard of the second interactive high-fidelity prototype

6. TESTING OF THE IROOM INTERFACE DESIGN

This chapter will further elaborate on the written scenarios, the conduction of user tests and the analysis of the results.

6.1. Scenarios

Several scenarios were created to outline the required functions within the iRoom interface design and the relation between these functions. Furthermore, the scenarios will be translated into three cases that are being used during the user tests. The scenarios are based upon the three selected use cases: (1) missing person cases, (2) illegal cultivation of hemp and (3) protests and are based on real-life events. The personas written in paragraph 4.7 are also included in the scenarios. What has been excluded from the scenarios are details like the required battery swaps after 30 min of flight time. The battery swap can be seen as a limitation. However, this limitation will probably be resolved in the future by the development of better batteries and more energy-efficient drones. Therefore, the required battery swap was excluded from the scenario and will not be taken into account in the development of the iRoom interface design. Furthermore, in the scenarios, some steps of the police protocols are skipped. This to maintain the focus on the functionalities within the iRoom interface design and because it was not part of the scope of the project. An example of an excluded part of the protocol is to send a stealth SMS to the phone of the missing person. This has nothing to do with drones or the iRoom interface design in general and is therefore excluded from the scenario.

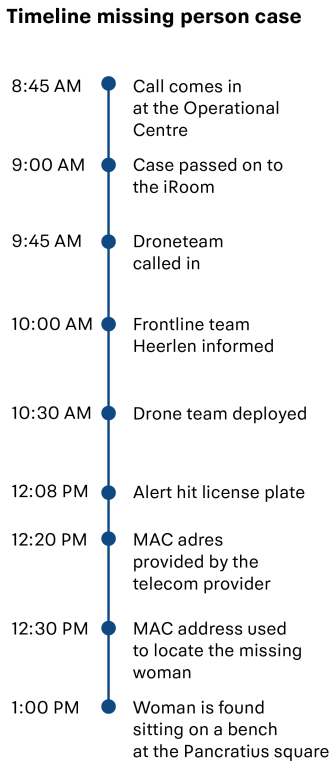

Figure 27 Timeline missing person case

Scenario 1: Missing person

In the control room a call comes in from an employee working at youth services, a client of them has gone missing. It concerns a lady in her mid-20s with mental problems. She has taken her medication for a week and is looking for her father. However, her father is deceased. Because several agencies are involved in the incident the case is passed on to the iRoom. In the iRoom, Maria, a DRIO employee, collects all available information and displays it on the video wall. A photo and the most recent data about her are also visible on the video wall together with the make, colour, and license plate of her car. Maria adds the lady's license plate number to the ANPR system in the drone dashboard. Because the lady called with youth services it is known that she is in Heerlen near the city centre. Furthermore, employees of youth services indicated that she drove to Heerlen by car. One of Maria's colleagues calls the lady's telecom provider to get both the International Mobile Equipment Identity (IMEI) number and the MAC address of the lady's phone.

In the meantime, the drone team is asked to help with the search and to deploy the drone in the vicinity of Heerlen city centre. Together with the iRoom is decided to fly with the Zenmuse Z30 i.c.w. the Wi-Fi Bluetooth sniffer. Both sensors are linked to the drone dashboard before take-off. The Zenmuse Z30 is linked to the ANPR system and the Wi-Fi Bluetooth sniffer to a page in the drone dashboard in which the data can be viewed real-time. The Wi-Fi Bluetooth sniffer can be used to determine whether the phone is in the vicinity, provided the phone is on and Wi-Fi/Bluetooth is turned on. The frontline team in Heerlen is also informed of the disappearance and is asked to send several colleagues in the direction of the city centre.

In the iRoom, Maria is focused on both the livestream and the location of the drone. Maria spots a car that could belong to the missing lady and asks the drone team if they could fly closer to this stationary car. Within a second an alert appears on the drone dashboard of a hit on the license plate number. It turns out that this car does indeed belong to the missing lady and is parked near the Putgraaf. Meanwhile in the iRoom, fellow analyst Ben is busy entering the obtained MAC address of the phone into the drone dashboard. He finds out that the lady is near the Pancratius square in the centre of Heerlen. Maria asks both the drone team and her colleagues on the street to head towards the Pancratius square. Maria sees on the livestream that the lady is sitting confused on a bench at the Pancratius square and being addressed by her colleagues.

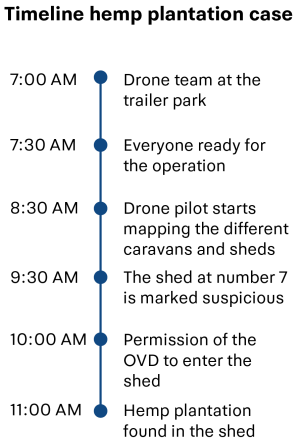

Figure 28 Timeline hemp plantation case

Scenario 2: Hemp plantation

It is Monday 7:00 a.m. today a drone will be used to check a trailer park where a year back a hemp plantation has been cleared. Beforehand, the grid operator has done a block measurement of the electricity consumption. These measurements showed that several caravans are using more electricity than usual. Therefore, there will be focussed on these caravans. The drone team is located near the trailer park and connect the drone to the dashboard in the iRoom. Maria, DRIO employee and working in the iRoom sees that the connection has been established. She opens the livestream and the map showing the location of the drone. Tom, the operator of the Operational Centre, is watching the livestream via the video wall in the iRoom.

Maria currently only sees the normal camera image and asks the drone team if they could share the thermal image with her. Neighbourhood police officer Maarten is also on-site during the operation and receives a link from Maria. This way he can watch the livestream from the drone during the deployment. The operation starts and the drone team starts mapping the different caravans. They take thermal images of each caravan and the sheds behind them. Soon is determined that the shed at number seven is warmer compared to the surrounding caravans and sheds. The suspicion is confirmed by the current measurements taken earlier by the grid operator. In consultation, it is decided that there is enough evidence for the presence of a hemp plantation. The “Officier Van Dienst” (OVD) permits them to enter the shed at number seven. A hemp plantation is indeed found in the shed.

Scenario 3: Protest

It is November 22nd, today there will be a protest in Venlo of opponents of Kick Out Zwarte Piet. This protest has been requested via the municipality and it is suspected that supporters of Zwarte Piet will also come to Venlo to confront the opponents. Maria, a DRIO employee working in the iRoom, has been busy gathering information the past few days. Maria uses police data, combined with OSINT and social media. Furthermore, the mayor decided, in consultation with the police to let the protest against Zwarte Piet take place in the Juliana park in the city centre. By request of the organization, the location of the protest will only be announced one hour in advance. The drone team is asked to make live images during the protest.

Meanwhile, in the iRoom, a briefing is held. Throughout the day, Maria will be dealing with all the information coming in through the drone dashboard and the communication between the drone team and the iRoom. A little after noon, Maria sees that the communication between the drone dashboard and the drone in Venlo is set up. Through the police radio, she is told by Marc, the drone pilot, that they are ready to fly. Maria and Marc consult briefly to see if everything is working properly, and a test run is flown with the drone. Maria sees on her dashboard the livestream of the drone and the location of the drone on a map and reports that everything is working properly. Via the dashboard, she sends a link to the police supervisor Maarten. This way he can watch the livestream of the drone and direct the units on the street upon this information.

Figure 29 Timeline protest case

At two o'clock about a hundred anti-Zwarte Piet protesters have gathered on the square. Twenty to thirty protesters are from Venlo and surrounding areas, the rest are Kick Out protestors from the Randstad who have come to Limburg by bus. They carry signs with slogans like 'Zwarte Piet is witte onschuld' and - in the local dialect - 'Zwarte Piet kin nièt meer'. Then on the livestream is visible that a long-haired man while consuming cans of beer challenges the police for the umpteenth time and is arrested. A commotion ensues and Maria starts a recording to be able to record any other offences and possibly forward it immediately to her colleagues on the street. Moments later, she sees a man wearing a black sweater and a red cap assaulting a police officer and running away. She rewinds the recording, zooms in, and takes a screenshot. She then sends a description and a screenshot of the man via Dragonforce. She also tells them which street the suspect ran into. Together with the description, her colleagues on the street can use this information to catch the suspect. The officer in charge, Maarten, decides to deploy the public order officers to apprehend the suspect who is running away. The suspect runs away from the square, followed by the drone. Police supervisor Maarten directs the public order officers to the location of the fleeing suspect where he is apprehended.

Moments later a second confrontation between the pro-Piets and the police takes place. This time fireworks are thrown at the police. Maarten quickly anticipates what he sees on the livestream and prepares the public order officers. The police supervisor commands a charge which the police horses carry out. This way the public order officers can arrest a few people who were throwing fireworks. The drone makes recordings of the arrests. The Kick Out protestors are sent away to city buses, the protest has come to an end.

6.2. Usability testing of the prototype

As explained in paragraph 5.1 the purpose of the interface is to visualize the data gathered by drones clearly and understandably. To be able to test if the interface does fulfil its purpose, user tests were performed.

6.2.1. Recruitment of participants

The participants for the user tests were selected based on the different positions within the iRoom (paragraph 4.2.1). People with a similar skillset or people who could be working in the iRoom in the future were asked to participate. Furthermore, it was of importance that the people who participated in the user tests had not seen the prototype before. Otherwise, they could be biased or already know how to use the interface. Based on this selection, one Real-Time Intelligence Centre (RTIC) employee, one DRIO employee, one analyst and two other members of project iRoom were invited to participate in the user tests.

6.2.2. Research setup

First, the goals of the user tests were determined and what aspects needed to be tested during the user tests. Below a list of the aspects which were tested during the user tests:

- *User interaction:* How people interact with the dashboard and what goes right or wrong.
- *User experience:* How people experience the dashboard when using it.
- *User needs:* What users need.
- *User expectations:* What users expect from the dashboard.
- *Content:* Whether the content of the dashboard is understandable and sufficient for the user.

Based on the scenarios in paragraph 6.1 three cases were created. (1) A missing person case, (2) a case about a hemp plantation and (3) one about a protest. Upfront, participants received some general information about the user test and the available set of sensors during the test. This originates in the fact that people who will be working within the iRoom will presumably also receive training or general information regarding the systems they will be working with. It also helped the participants to prepare themselves for the user test. The user tests were performed in the interactive iRoom interface design which was designed in Figma[5]. The user tests were conducted remotely.

During the user test for each case, information was provided about who, what, where and how followed by tasks that had to be solved by the participants. The list of tasks the participants solved can be found in Appendix IV: Tasks user tests. The tasks were ordered in such a way that one task did not reveal how the next task had to be solved. Furthermore, all tasks were written in a way that a colleague positioned in the iRoom or otherwise asked something from the participant. This way the participant completely immersed him or herself in the different cases and the drone dashboard. When every task was solved, or a certain case was finished the participant restarted the prototype and a 'new day' began in the iRoom.

After the user test participants were asked to answer a questionnaire regarding the difficulty level of solving the different tasks. The questionnaire consisted of a 7-point Likert Scale from Very difficult (7 points) to Very easy (1 point) to determine the difficulty of solving the different tasks. The questionnaire also included the ten questions from the System Usability Scale (SUS). More about the outcome of the questionnaire can be found on the next page.

[5] Figma: a web based prototyping tool with a focus on user interface and user experience design.

6.3. Analysis of user test

The analysis of the user test was divided into two parts. One part about the different tasks the participants performed and the second part about the System Usability Scale which was used. In the questionnaire, before the more in-depth questions, some questions were asked regarding the background of the participants and the cases which were used during the user test. All participants agreed that the three cases used during the user test were a good representation of the work that will take place in the iRoom.

6.3.1. The difficulty level of solving the different tasks

The scenarios in paragraph 6.1 were written based on the three selected use cases: (1) missing person case, (2) illegal cultivation of hemp and (3) protests. Based on the scenarios there were created three cases in which participants had to solve certain tasks. The scenarios were experienced as valuable in the creation of the context of the user tests. Both the scenarios and tasks were discussed with a process expert (Jo Vossen), with personal experience in similar real-life cases. As mentioned in paragraph 6.1 some parts within the police protocols were out of scope and therefore not mentioned during the user tests.

Based on the scenarios, participants were asked to solve several tasks per case. The tasks which the participants were asked to solve were created with the idea that they should represent what the people in the iRoom would do with the drone dashboard during their work. Furthermore, it should give an idea of how the drone dashboard could be used during deployment. At the start of every case, participants received some general information about what the case was about, what information was available etc. In the missing person case, the participants got the address of the missing woman, her phone number, where she was last seen and her license plate number. Then the participants were asked what they would do with the information at hand. Most of the participants wanted to add the license plate to the ANPR system. Because it was not certain whether participants would directly choose the option to add the license plate to the ANPR system, it was also added as a task within the user test.

Another example of a task is the task to share a screenshot. This task was asked in the context of a protest in Venlo. On the livestream is visible that someone attacks a police officer, the iRoom employee takes a screenshot and is asked to share this screenshot with colleagues at the scene. Some of the participants gave feedback that this is something that already happens at the Operational Centre.

Overall, there can be concluded that both the tasks and cases gave a good representation of how the drone dashboard could be used during a deployment. Like explained earlier participants were asked to answer a questionnaire regarding the difficulty level of solving the different tasks. This however holds no meaning regarding the difficulty level of the tasks themselves. Nonetheless, something can be said about whether participants found the tasks easy or difficult to solve.

A graph was made based on the answers from the 7-point Likert Scale regarding the difficulty level of solving the different tasks. Each task was answered with how easy or difficult it was to solve the task. Very difficult was given 7 points and Very easy was given 1 point. The line in the graph shows the average response per task. The whiskers on the side visualise the standard deviation per task. On the next page will be elaborated on some tasks and the difficulty level of solving the tasks stated by the participants.

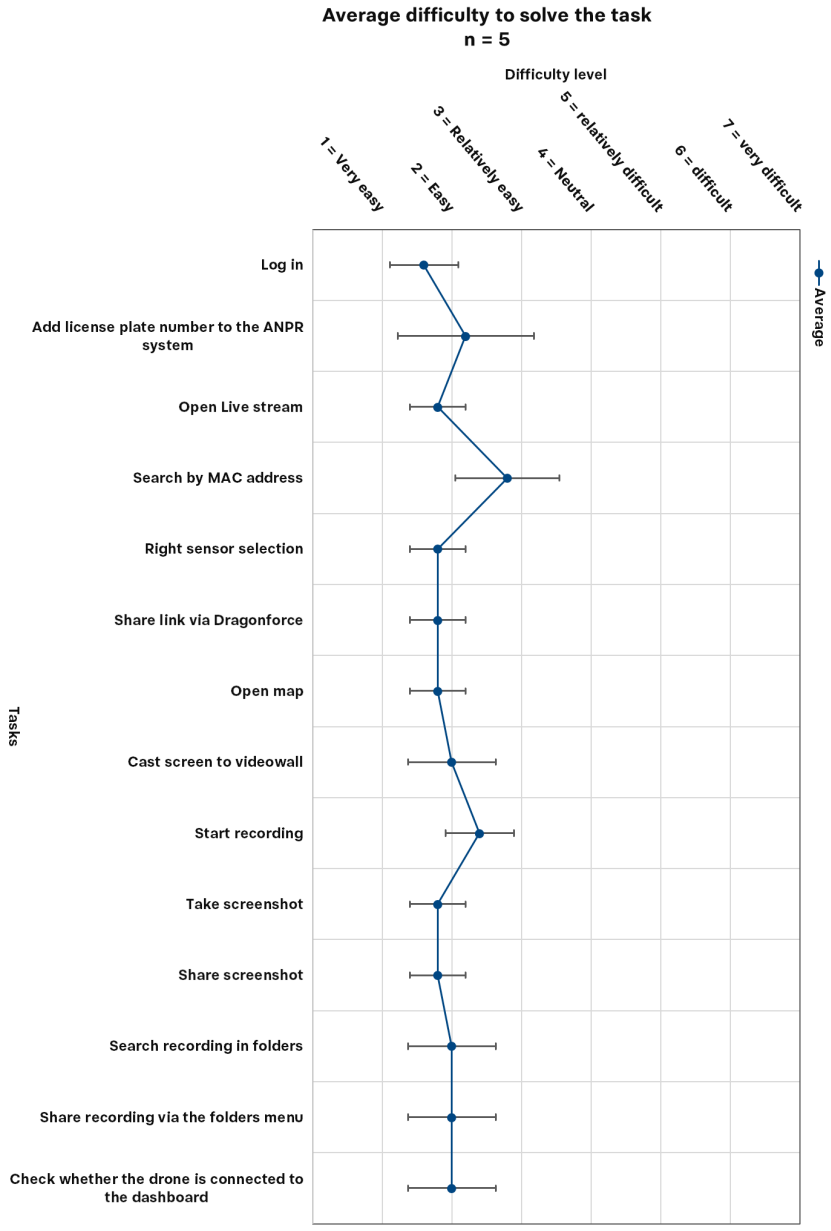

Figure 30 Average difficulty level per task

Based on Figure 30, most participants would say that the tasks were easy to solve. However, the tasks 'Search by MAC address', 'Add license plate number to the ANPR system' and 'Start recording' were on average marked as more difficult to solve. Therefore, below an overview of these three tasks and the feedback which was given during the user tests related to these three tasks. On the next page, an overview is given of all the modification which will be made in the next iteration of the iRoom interface design.

Task: Search by MAC address

Together with 'Add license plate to the ANPR system' these two tasks were the only tasks that were rated with a 4 = Neutral, by the participants. Two participants rated the tasks with a 2 (Easy) and the other two with a 3 (Relatively easy) This could be due to a certain step that was erroneously unavailable in the prototype. This resulted in that participants could not click on the MAC addresses. However, participants could click on 'Zoeken' to find the right MAC address and did so without help. Furthermore, participants mentioned that the map of the location of the MAC address, see Figure 31, was not clear enough. Additionally, no functionalities to zoom in or out could be used to pinpoint the exact location of the MAC address. However, before the user tests, participants were not familiar with what a Wi-Fi Bluetooth sniffer was in the first place.

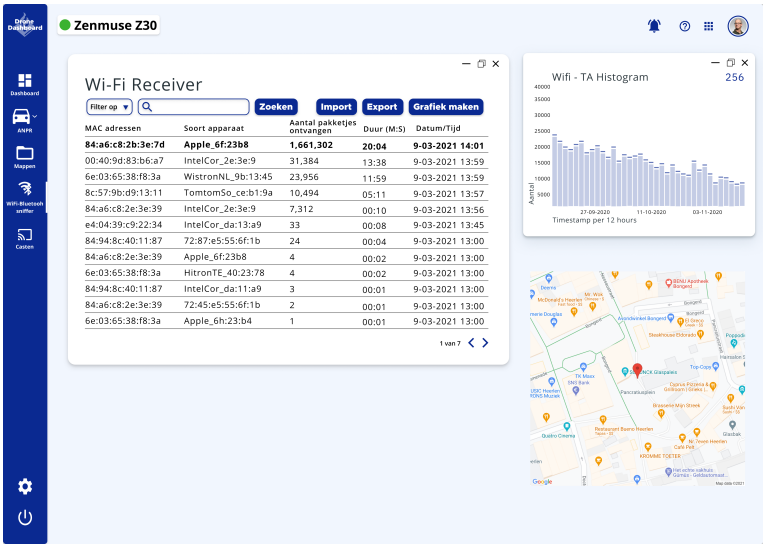

Figure 31 Place in the dashboard to search for a MAC address

Task: Add license plate to the ANPR system

The task 'Add license plate to the ANPR system' had on average a score of 2,2 (Easy). Except for one participant who gave the task a four (Neutral) all the participants gave the task an of two or a one. The participant who gave the task a four had not worked with the ANPR system in the past. The other participants were at some level familiar with the existing ANPR system used within the police. They could navigate their way through the different screens with ease. The feedback was mostly focused on adding certain text fields, choice of wording or additions that could be made.

Task: Start recording

Figure 32 Recording button

Start recording was mentioned as difficult because not every participant recognised the icon, see Figure 32, used as the recording option. However, some of the participants argued that when they would be more familiar with the dashboard, they would remember the icon to be the option to enter the recording mode. There was also asked whether an automated recording that started whenever the drone was connected with the dashboard would be helpful. All participants agreed that this would be helpful whenever something was missed or when someone wanted to look back on the incident. The idea to add a loop recording of 2 minutes which is added to a recording when a recording is started was also marked as helpful by the participants. A loop recording of 2 minutes was chosen because of the useful length. Whether this indeed is a useful length of a loop recording should be tested with users whenever the drone dashboard will become operational.

6.3.2. Overall usability of the iRoom interface design

To check the overall usability of the iRoom interface design the System Usability Scale was used. Below a short explanation of what the System Usability Scale is followed by an analysis of the SUS scores from the participants.

System Usability Scale

The System Usability Scale (SUS), created by (Brooke, 1995), is a Likert scale with 10 questions that gives an overall view of subjective assessments of usability. Scoring is based on a 5-point Likert Scale from strongly disagree to strongly agree. Each answer is assigned a value to calculate the SUS score. Strongly disagree is 1 point till strongly agree which is 5 points. An example of scored SU scale is referred to in the paper by (Brooke, 1995). The average SUS score is 68. A score higher than 68 points could indicate the need for minor changes and a score below 68 points could mean certain parts of the design need to be researched and resolved. The System Usability Scale does not provide feedback on specific problems but does provide insight into the overall ease of use of the iRoom interface design from the users' perspective.

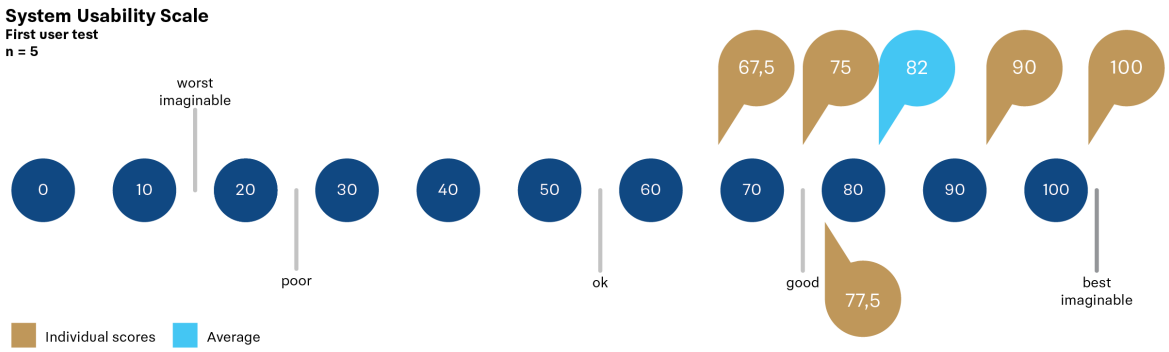

Figure 33 System Usability Scale of the first user test with five participants

Based on the participants' scores can be stated that only minor changes must be made to the design.
What kind of changes will be made is based on input from the participants, the difficulty of solving the different tasks and the wishes of the clients. Below a list of the modifications which will be made based on the feedback.

General modifications

- Add a pop-up message when the connection between the dashboard and the drone is established.
- Whenever a screenshot is taken the photo is saved automatically and does not has to be saved separately before sharing the screenshot.
- Whenever the drone is not connected to the dashboard and there is clicked on the livestream a message should appear that the livestream is not available.
- Casten[6] will be removed from the dashboard because this functionality will be implemented on the computers within the iRoom. This makes it unnecessary to also add this functionally in the dashboard itself.

Recording modifications

- Add the functionality that whenever a recording is started 2 minutes of a loop recording are added to the recording.
- Add the option to tag a certain moment in the recording. A tag is a timestamp in the shape of a dot on the video's timeline. This tag can later be used to find a specific moment in the recording which requires attention.

[6] Casten: way to stream a screen to another monitor

Folder modifications

- A few stills of the created recordings will be added to the folder view of every video. These reference images could help recognise a certain video.
- Add the option to click on the video and show the video in a smaller window in the folder.
- Add a list of tags with the title, description, date, and timestamp.

Wi-Fi Bluetooth sniffer modifications

- Add an accuracy radius around the location of the MAC address.
- Add the option to change the map layers and share the location.
- Add the option that the Wi-Fi Bluetooth sniffer also searches for MAC address and sends an alert of a hit when a pre-entered MAC address is found.
- Whenever a MAC address is selected it will be placed outside the list of MAC address which is refreshed approximately every second. This way the selected MAC address will not disappear out of sight whenever too many new MAC addresses come into view.
- Add a sort column function.
- Add the option to zoom in and out on the map of the location of the MAC address.

6.4. Conclusion

The people participating in the user test saw and experienced the added value of the iRoom interface design. Some of the participants wished the dashboard was operational tomorrow and believed that the dashboard could help them during their future work within the iRoom. The question about whether the interface does fulfil its purpose can be answered with “yes”. The interface does as described by participants visualize the data gathered by drone clearly and understandably. Based on the graph in Figure 30 can be concluded that the tasks were on average easy to solve. However, whether the tasks themselves were difficult or easy is not known. But, even when the participants perceived the tasks as difficult, the tasks were relatively easy to solve. Overall, the participants stated that the dashboard was user-friendly and organized. The cases helped participants experience functionalities that they never thought of before and gave them new insights into what drones could mean for the future of policing.

In the next chapter, the translation from the feedback of the participants to an iteration of the iRoom interface design is shared.

7. ITERATION iROOM INTERFACE DESIGN

This chapter elaborates on the iteration which was made in the iRoom interface design based on the feedback. Furthermore, the setup for the second round of user testing will be discussed and the results of the second user test.

Based on the feedback of the participants, the difficulty level experienced by the participants and the wishes of the clients the following iteration was made. Below an overview of the changes which were made in the iRoom interface design.

General modifications

Some of the participants said that it was not clear to them whether the drone was connected to the dashboard. Therefore, a message was added that pops up when the drone is connected (Figure 34). Additionally, when the livestream or map is opened when no sensor has connected the message in Figure 35 appears. Lastly, when someone hovers over the green circle next to the text Zenmuse Z30 in the upper left corner, a message appears which says 'connected'.

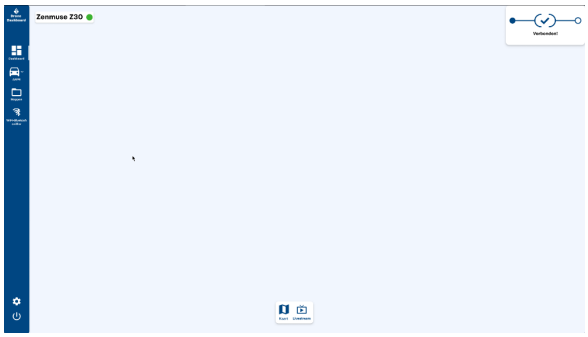

Figure 34 Notification drone connected to drone dashboard

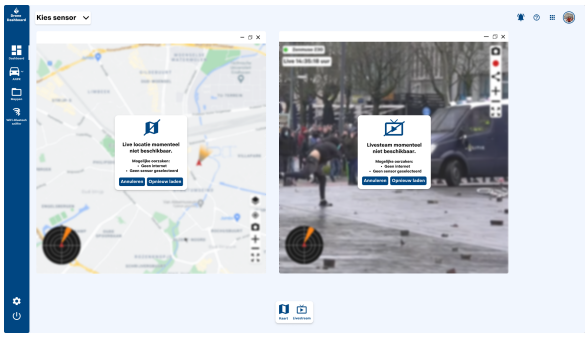

Figure 35 Notification drone not connected

Recording modifications

Based on feedback from the participants the functionality was added that when a recording is started +2 min of a loop recording is added to the recording (Figure 37). Additionally, was added the functionality to tag a certain moment in the recording (Figure 36). This tag can later be used to quickly find a specific moment in the recording which requires attention.

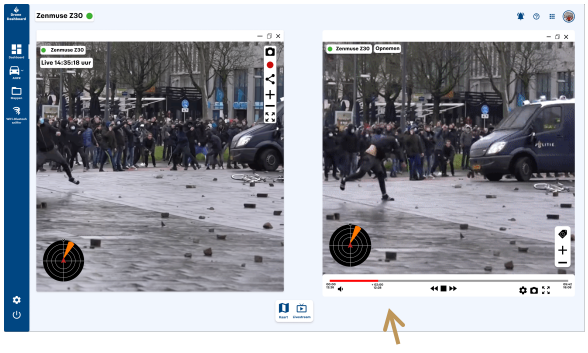

Figure 37 Added tag option and +2 min recording

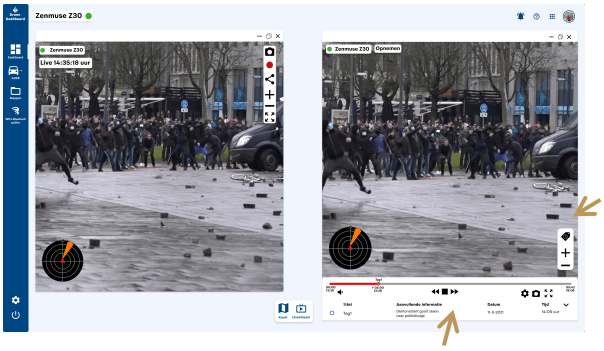

Figure 36 Recording window when a tag is placed

Folder modifications

In the folder element, there was added the functionality to preview four short reference videos of the created recordings (Figure 38). The idea is that a certain moment in the video can then be found quicker. Furthermore, the reference videos could help recognise a specific video. The tags which are placed in a recording can also be found in the folder menu and videos can be played inside the folder (Figure 39).

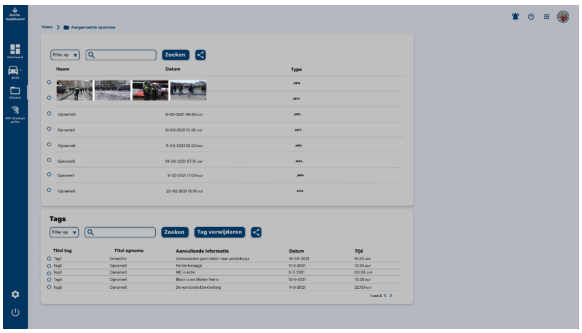

Figure 38 Preview reference videos of a recording

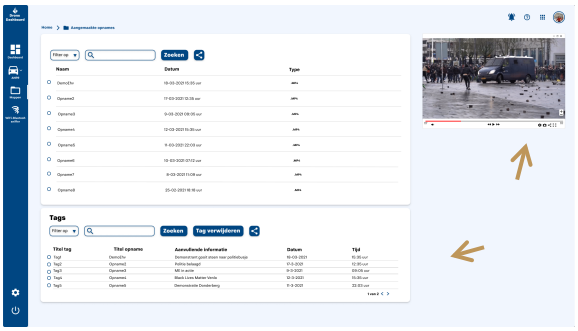

Figure 39 Added tag option and the option to view a recording within the file system

Wi-Fi Bluetooth sniffer modifications

The map layout was changed, an accuracy radius was added and the option to share the location with colleagues on the street (Figure 40). Furthermore, was added the option to add a MAC address and receive an alert whenever the MAC address is found.

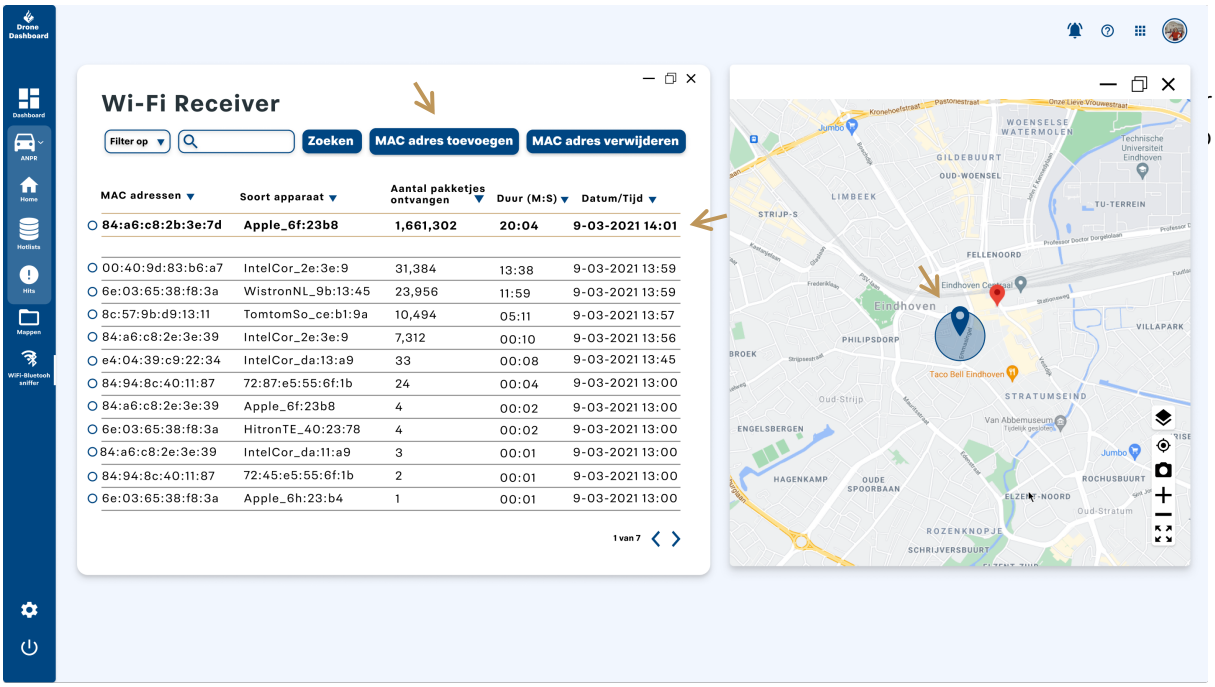

Figure 40 Wi-Fi Bluetooth sniffer modifications

7.1. The second round of usability testing

In the second round of user tests the same research setup was used and the same people were asked to participate in the user tests. The goal of the second user tests was to determine whether the modifications made in the iRoom interface design indeed improve the user-friendliness. Furthermore, was determined whether participants still remembered certain icons and how to perform certain tasks. This could mean some functionalities could be learned by repetition.

Unfortunately, of the five people which were asked to participate in the second user test, only three had time to participate. The participants of the second user tests were an RTIC employee, an analyst and one other member of project iRoom. During the first user tests, three cases were created that were used as a storyline in which tasks had to be performed. The same was done during the second user tests, only this time two cases were created. One case about an evening curfew protest in Eindhoven and one case about a missing girl. Both cases were inspired by the scenarios and the cases used during the first user tests. The participants stated that the three cases used in the first user tests were a good representation of the work that will take place in the iRoom. Therefore, the was no reason to drastically change the cases. Some participants mentioned during the first user test that some images or maps did not match with the cases. Therefore, in the second user test the images, maps and videos were better matched with the case.

Same as for the first user test upfront participants received some general information regarding the user test and the available set of sensors during the user test. The user tests were again performed in the interactive iRoom interface design made in Figma and were conducted remotely. During the user tests first, some general information was provided about the case followed by tasks regarding a colleague in the iRoom or on the street who wanted certain information. Two kinds of tasks were implemented during the second user tests. Repetition tasks, to test whether a participant still knew how to use the dashboard and new tasks to test whether new functionalities were understandable or what could be improved. Whenever a task or a certain case was finished the participant restarted the prototype and a ‘new day’ began in the iRoom.

During the first user test participants were asked to answer a questionnaire regarding the difficulty level of solving the different tasks. The same questionnaire with some adjustments was sent to the participants after the second user test. The same 7-point Likert Scale was used in the questionnaire. In the questionnaire, questions were asked about both the new tasks and repetition tasks to determine whether the usability had improved. The System Usability Scale was also included to determine whether the iRoom interface design had become more user-friendly compared to the first prototype. More information about the outcome of the questionnaire can be found on the next page and an overview of the tasks of the second user tests can be found in Appendix V: Tasks second user test.

7.2. Analysis of second user tests

7.2.1. The difficulty level of both the new and repetition tasks

Figure 41 shows the graph made based on the answers from the second user test. The blue line represents the average response per task. The whiskers on the side visualise the standard deviation per task. As mentioned in paragraph 7.2 not everyone who participated in the first user test had time to participate in the second user test. Therefore, there cannot be made a direct comparison between the graph from the first user tests and the second user tests. However, some assumptions can be made based on the setup of the second user test. As explained earlier, in the second user test there was made use of two types of tasks, new tasks about new functionalities and repetition tasks to determine whether participants still knew certain icons or how to perform certain tasks. The new tasks included amongst other things, a functionality to tag a moment in a video, search this tag but also be able to find a specific moment in a video.

Figure 41 shows that even with newly implemented features the iRoom interface design tasks were on average easy to solve. Based on feedback from the participants and the outcomes visible in the graph can be stated that the overall usability of the iRoom interface design did not decrease due to the implementation of new features.

In Figure 42 a comparison is made between similar tasks participants performed in both the first user test and the second user test. The results are only from the participants who participated in both user tests. Based on the graph and feedback from participants can be concluded that tasks become easier to solve through repetition. The speed with which participants performed certain tasks also showed that they were somewhat familiar with the drone dashboard already. Furthermore, can be concluded that although newly implemented functionalities in the second user test the ability to solve the tasks did not become more difficult due to these changes. Same as for the results of the first user test nothing can be said about the difficulty level of the tasks themselves. On the next page will be elaborated on some tasks and the feedback from the participants.

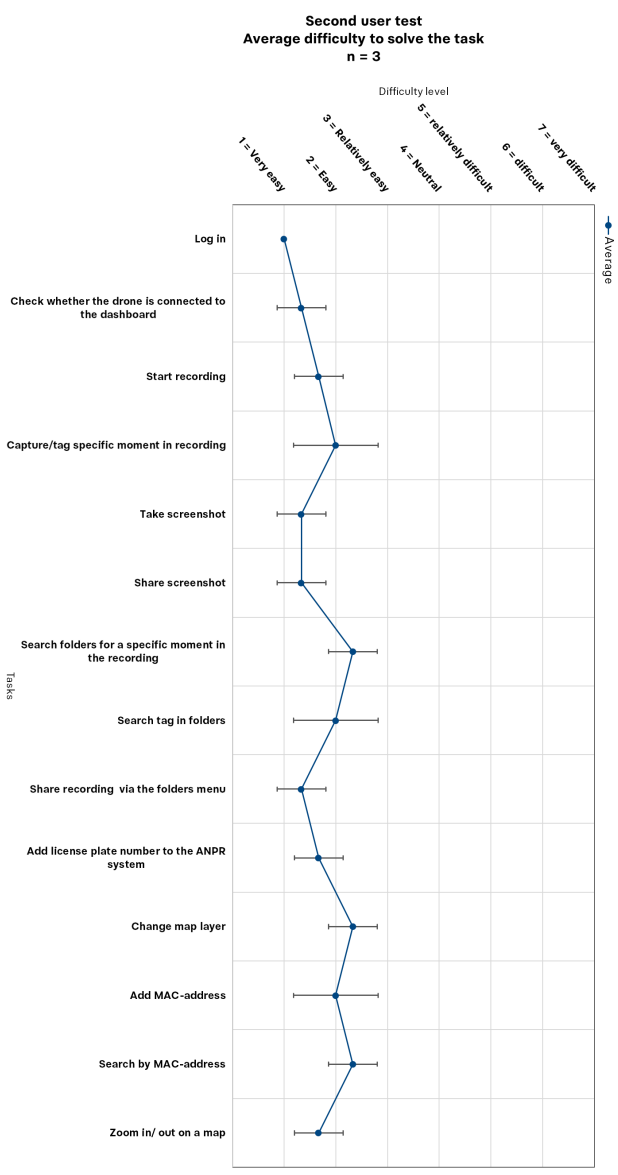

Figure 41 Second user test, average difficulty level per task

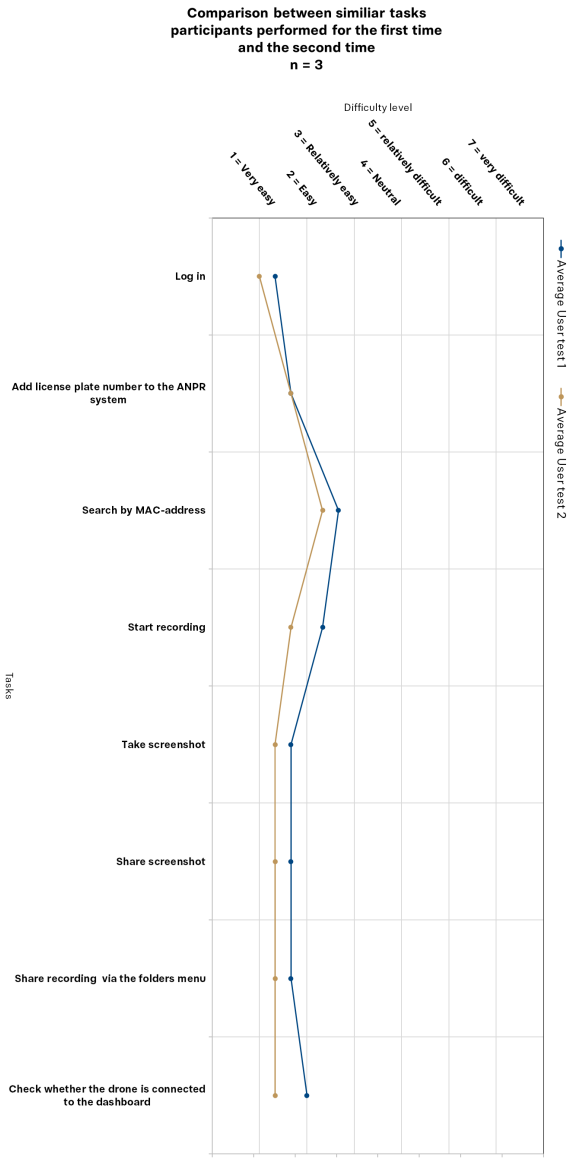

Figure 42 Comparison between similar tasks participants performed in both the first user test and the second user tests

Overall, the tasks were experienced as easy to solve. However, some feedback was given by the participants on how to improve the newly implemented functionalities. Below an overview of some of the feedback given by the participants.

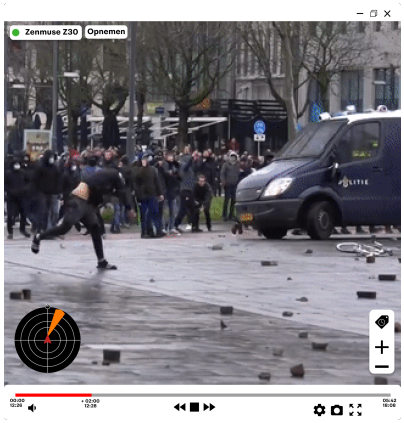

Figure 43 Recording window

Tag functionality

The tag functionality was overall received as a valuable addition to the iRoom interface design. During the user test, the word 'tag' was avoided to prevent the participants from being biased due to a certain association they could make between the word 'tag' and the icon. This way there could be tested whether the icon which accessed the tag functionality was clear. All the participants could find the tag functionality in an instant. The information which could be added to the tag was sufficient and the participants could find the stored tags without help.

One participant mentioned that it could be helpful to group the tags per video. So not just a list of all the tags in all the video but a tag list per video. With the idea that whenever a video is selected on the bottom of the screen the tags of that video will be made visible.

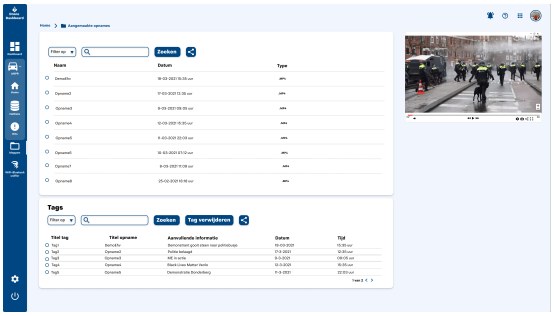

Figure 44 Folder window

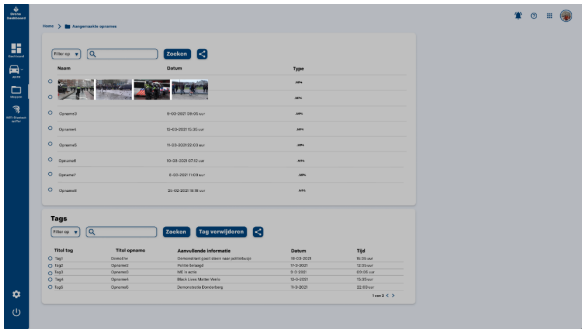

Figure 45 Preview reference videos of a recording

Reference video functionality

All participants agreed that the reference video functionality is a nice addition to the possibilities to find a specific moment in a video.

Wi-Fi Bluetooth sniffer functionality

In the Wi-Fi Bluetooth sniffer window, there was added the functionality to add a MAC address just like the ANPR add license plate functionality. However, there was some confusion about whether the MAC addresses displayed on the right were MAC addresses that were added to the system or MAC addresses which were found by the sniffer. This had to do with the fact that in real life the list of MAC addresses would move down whenever a new MAC address was found. A solution could be to add a MAC address hotlist to display the added MAC addresses. A picture of the Wi-Fi Bluetooth sniffer window can be found in Figure 40.

Apart from a 7-point Likert Scale also a System Usability Score was implemented in the questionnaire after the second user test. The results from the System Usability Scale can be found on the next page.

7.2.2. Usability after implementation of new functionalities

During the first user tests, the System Usability Scale was used to check the overall usability of the iRoom interface design. The same was done in the second user tests. Due to that only three people participated in the second user tests the two outcomes of the SUS cannot be compared. However, the scores of the three people who participated in both the first and the second user test can be compared. Therefore, below the SUS of the first and second user tests with the scores of the people who participated in both user tests. Based on the individual scores and average of the first user test compared to the second user test can be concluded that the overall usability of the iRoom interface design has improved. This is also in line with the results of the graph in Figure 42. However, the reliability of the SUS scores of only three participants is questionable. Nonetheless, can be concluded that the iRoom interface design is a user-friendly, multi-purpose interface that fits the requirements and the wishes of both the users and the clients.

Based on the analysis of the second user test, proposals for improvement and recommendations will be made on how to further improve the iRoom interface design

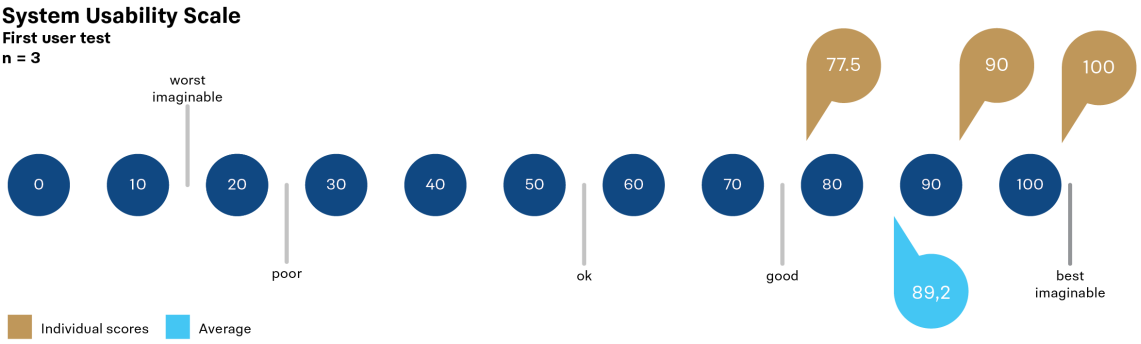

Figure 46 System Usability Score of the first user test selected for those three participants that also participated in the second test

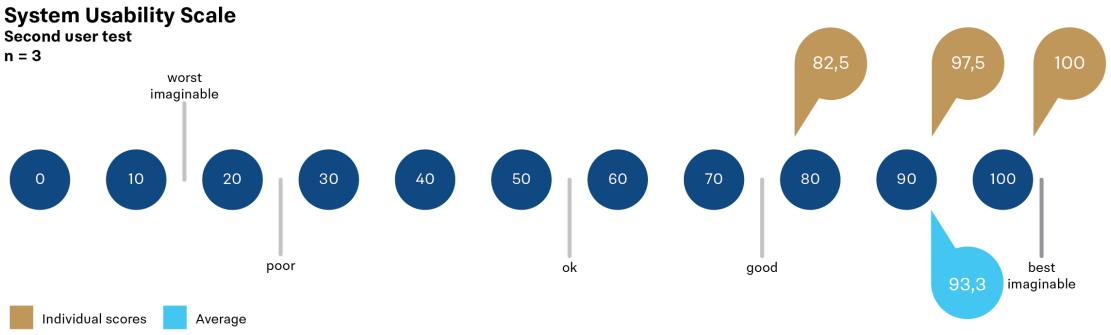

Figure 47 System Usability Score of the second user test with three participants

7.3. Recommendations for the iRoom interface design

The following recommendations are made to improve the iRoom interface design:

- Supported with feedback from participants it is recommended to add a hover function within the iRoom interface design. This way whenever there is hovered over a button a message will appear with a description of what the button does.
- It is recommended to add personalised dashboards which give users the possibility to customize their dashboard and settings to their liking.
- Participants also mentioned that it would be valuable to gather the information which was used during an operation and store this information. Or the option to send this information to someone who is, for instance, required to draw up an official report.
- It is recommended whenever technically possible to add the location of colleagues, events, incoming alerts to the already existing map in the iRoom interface design. This feature was mentioned by iRoom team members and is in line with findings in the drone analysis phase.
- Participants also mentioned that the recording button implemented in the video window should be changed slightly. By doing so there is made a distinction between the red dot used to make visible whether a sensor is online or offline and the red dot used as the recording button.
- In the second user test, there was added the functionality to add a MAC address and receive a message of an alert whenever the MAC address is found. This function still needs improvements. For instance, a separate list of MAC address hits needs to be added to the iRoom interface design.
- Recommended to add a kind of logbook functionality in which all actions within the dashboard are logged. By doing so steps can be traced back and this could be helpful whenever an official report needs to be made.
- The functionality of the 2 minutes which is added to a recording when a recording is started needs to be thoroughly tested. A loop recording of 2 minutes was chosen because of the useful length. Whether this indeed is a useful length of a loop recording should be tested with users whenever the drone dashboard will become operational.
- It is recommended to facilitate a small training for the end-user about how to use the iRoom interface design. This way people can be familiarised with the drone dashboard and have some basic understanding of the different functionalities and sensors which could be used with the iRoom interface design.
- Whenever the drone dashboard will be made operational the usability needs to be closely monitored to catch bugs or other problems at an early stage. A feedback button could also be implemented to give people the possibility to give feedback. This feedback should be stored and analysed to translate the feedback to possible improvements.
- Lastly, from a personal point of view, it is recommended to take aspects like latency, means of communication, bitrate, and supported video formats into consideration whenever the iRoom interface design will be made operational.

All functionalities which are recommended to implement in the iRoom interface design need to be thoroughly tested. This way can be determined whether these functionalities have added value for the iRoom interface design and the people who will be working with the drone dashboard.

8. DISCUSSION & CONCLUSION

This chapter describes the whole process of the thesis assignment, reflects on the limitations and recommendations and what is learned in the duration of the graduation assignment.

The assignment of this thesis was to determine what kind of data can be gathered from a drone and implemented in the iRoom that has added value for the iLab and accordingly develop an interface with which users of the iRoom would effectively and efficiently have access to this data. The aim was to first analyse what kind of data can be gathered by drones and analyse which elements and sensors need to be implemented in the interface. Then conduct user tests to determine the usability of the interface developed in this thesis and iterate on the prototype. Finally, conclusions are drawn based on the outcome of the user tests.

The research results show that the iLab can be supplied with an interface that can be used to pinpoint the required data from the drone by conducting field research and having conversations with people working both inside and outside the police. The implementation of the sensor data in the iRoom can be supplied by determining the perspectives and visions of members of project iRoom and the clients and translating this information into a prototype that can be tested.

The data gathered in the drone analysis suggests that within the police, no operation is the same which means that there must be determined upfront which sensors would have the most added value during the operation. Furthermore, to prevent unnecessary deployment the goal and location of the operation need to be narrowed down. Overall, the deployment of the drone had three main purposes during deployment. To *gather data*, *to observe* or *to validate*. Examples of 'extra' data available during deployment is thermal imaging of an apartment with a deviating heat signature or the extra eyes in the sky during a protest.

The results from the conducted user tests indicate that overall, the iRoom interface design is easy to use. This is based on the outcome of the System Usability Score (SUS) which creates an overall view of subjective assessments of usability. Furthermore, the question about whether the interface does fulfil its purpose can be answered with "yes". The interface does according to the user tests visualize the data gathered by drones clearly and understandably. Additionally, was stated by the participants that the dashboard was user-friendly and well-structured. Some participants wished it could be used right away. Furthermore, can be stated that the use of the iRoom interface design will become easier through repetition. This is based on the outcome of the second user test in which both new tasks were introduced and tasks that were also implemented in the first user test. The speed with which participants performed certain tasks also showed they were somewhat familiar with the drone dashboard already. This is supported by the graph in Figure 42.

Limitations

One of the limitations of the graduation assignment is the small group of participants with which the user interface was tested. Because the sample size of the user tests was small the reliability of both the graphs and standard deviation is questionable. Furthermore, Within the user test, it was assumed that the future employees of the iRoom will receive training or general information regarding the systems they will be working with, including the different aspects of the drone dashboard.

In the user tests, there was tested how easy or difficult it was to solve the tasks and not whether the tasks themselves were easy or difficult. Another limitation is the fact that the implementation of the Wi-Fi Bluetooth sniffer was partly based on facts and partly hypothetical. Whether the implementation of the Wi-Fi Bluetooth sniffer in the iRoom interface design could be translated into a fully functioning prototype is yet to be seen. The same can be said about the rest of the iRoom interface design because there was no technical validation of whether the iRoom interface design could be translated into a fully functioning prototype.

Recommendation

In the course of the graduation assignment, two sets of user tests were performed. The user tests gave insight into whether the functionalities within the iRoom interface design suffice, which changes should be made, or which functionalities should be added. However, whenever possible the user tests should be performed with the real end-user, the people who will be working in the iRoom. Furthermore, there should be taken into consideration whether the people who will be working in the iRoom will be working there full-time or not.

Whenever the drone dashboard will be made operational the usability needs to be closely monitored to catch bugs or other problems at an early stage. A feedback button could also be implemented in the dashboard to give people the opportunity to leave feedback. This feedback should be stored and analysed to translate the feedback to possible improvements. To be able to communicate with the drone team from within the iRoom there must be investigated what manners of communication there are. Lastly, it is recommended to take aspects like latency, bitrate, and supported video formats into consideration. An overview of all the iRoom interface design recommendations can be found on page 52.

As mentioned in the introduction it is of vital importance to the police to keep up with new development and use these new technologies to their advantage. The iRoom interface design makes drone data accessible for both the people working in the iRoom and their colleagues on the streets. The finalized prototype provides an effective first iteration which can be used during further development of the iRoom interface design. More extensively, it could serve as an example of what the future of the iRoom could hold and what drones could mean for the future of policing.

8. TABLE LIST

9. FIGURE LIST

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11. APPENDIX

Appendix i: Plan of Approach

Plan of Approach

Adeline Thevissen – August 2021

Adeline Thevissen
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Master Thesis
2 July 2021

TABLE OF CONTENTS

ABBREVIATION LIST

Table 9 Abbreviation list

Abbreviation	Meaning
OC	Operational Centre
OMG	Outlaw Motor Gangs
UAR	Unmanned Aerial Vehicle
UAS	Unmanned Aerial System
MoBa	Mobiel Banditisme

1. RESEARCH CONTEXT

Below, a description of the participants in this project and the relation with other ongoing projects at the iLab.

1.1. iLab

The iLab is the innovation lab of the National Police and is in Heerlen. At the iLab is worked on solutions to concur new challenges in the field of safety by using innovative technologies and by collaborating with other companies, other units, and services within the police organization and with educational organizations.

1.2. Project iRoom

The iRoom is going to be a 24/7 intelligence room in which information is received, filtered, and dispatched to the right people as quickly as possible. The iRoom will consist of 15 identical workstations with multiple screens. The information on the screens can be ordered and selected based on the needs of the employee. Additionally, there will be the possibility to stream images from a certain workstation to a central video wall. The information on the video wall can also be changed and ordered by the director. Daily, 6 to 8 people will be working in the iRoom, but this can change based on needs and incoming alerts. The iRoom will be situated near the Operational Centre (OC) of Maastricht with which will be communicated during events, high impact incidents etc. The communication between the Operational Centre and the iRoom is mostly via phone, mail, Dragonforce [7]and in person. Currently, there is a small version of the iRoom available at the iLab for testing purposes.

1.3. Project Drones

Project Drones is about the added value of the use of drones during events or operations. Several types of sensors can be placed below a drone and can, for instance, gather information on the number of people present at an event and how close those people are together. The connection between project Drones and project iRoom is the visualisation of the data gathered by the drones in the iRoom and the communication between the people in the iRoom and the drone pilot and the payloader. Whether communication between the iRoom and the drone pilot/payloader will be implemented in the interface has yet to be determined based on the added value of this implementation and the use. Additionally, the communication channels in the control room must be determined, their priority, if it is incoming information or outgoing information and the most feasible way of implementing this incoming and outgoing information in the interface design.

1.4. Relation project iRoom and project Drones

The intention is to have the acquired sensor data simultaneously and in real-time entering the iRoom, but also on location within the ongoing operation. In the iRoom, the sensor data will be processed, and relevant information will be directly communicated with the ongoing operation. This way a quick overview is created of all available, relevant information on which after decisions are made information-driven deployment can take place. Based on the aforementioned information the following question arose; What kind of data can be gathered from a drone which has added value for the iLab and how to implement this data in the iRoom to create a user-friendly and efficient interface.

7 Dragonforce is a mobile team collaboration platform which can be used to track personnel in real time, send secure messages and to delegate group members to manage an operation Drakontas (Drakontas).

2. PROJECT ASSIGNMENT

This chapter described the main goal, sub-goals, and main question during the assignment.

2.1. Main goal

1. What kind of data can be gathered from a drone and implemented in the iRoom that has added value for the iLab.
2. Develop an interface with which users of the iRoom would effectively and efficiently have access to this data.

2.2. Sub goals

- Make a selection of use cases that will be focused on during the assignment
- Create an overview of incoming and outgoing information in the control room and the iRoom
- Create scenario's based on older police operations to test the interface with
- Test the scenario's with people

2.3. Main question

To successfully fulfil the requirements of this project all the assignments need to be fulfilled. Therefore, the main question is: How to supply the iLab with an interface that can be used to pinpoint the required data from the drones and the implementation of the sensor data in the iRoom.

2.4. Added value for the iLab and Adeline

Within this assignment, Adeline will be the key participant. By combining both projects, she will be the bridge between the data gathered within the Drones project and how this data will be visualised within the iRoom project. Furthermore, iLab will have not only a set of data gathered from drones but also, a direct way to visualize this data in the most beneficial way for its users. Additionally, Adeline will be able to help the national police by giving them an enhanced version of the iRoom which would give Adeline a feeling that she contributed to a safer Netherlands. Lastly, the iLab would also greatly contribute to the knowledge and skills Adeline possess, simply by working in a highly capable multi-disciplinary team.

3. PRODUCTS

The following products will be delivered either during or when the project is completed.

The deliverables of the project are:

- Thesis
- Presentation
- Interface design
- Overview of data from a drone that has added value for the iRoom

3.1. Thesis

The thesis contains all the research and interviews which are conducted, (design) choices that are made and conclusions that were drawn.

3.2. Presentation

In the presentation will be described the project, why and which decisions were made and a conclusion.

3.3. Interface design

The interface design is the file with both the final design and all preliminary designs created during the assignment.

3.4. Overview of added value per use case for the iRoom

This document contains an overview of the data which can be gathered from a drone and the added value for the iRoom per selected use case.

4. PRELIMINARY RESEARCH

During the preliminary research was investigated what kind of drones the iLab has at their disposal and the sensors which are compatible with these drones. Secondly, the use cases where the UAV (Unmanned Aerial Vehicles) can be used in are described and the division between which sensor can be used in which use case was made. In the thesis will be made a selection of use cases that will be focused on during the project.

4.1. Drones and sensors

The drones currently available at the iLab are the DJI Matrice 210, the DJI Inspire 2 and the DJI Mavic. In the remainder of the project, there will be focused on the implementation of the DJI Matrice 210 in combination with a selection of sensors and the iRoom. The current selection of sensors available at the iLab can be found below with a short description of the functionality of the sensors:

DJI Matrice 210 V2
The Matrice 210 V2 is built to withstand the most extreme weather conditions and was designed for inspection purposes. The drone has 17-inch propellors and has a closed frame to make the drone water-resistant. Additionally, the drone supports multiple gimbals on which multiple cameras can be connected like for instance thermal imaging cameras. The drone and can fly up to 35 minutes on one battery. The functionality to place two sensors underneath the drone in combination with the 35 minutes flight time was the reason why the iLab chose to work with the Matrice 210. The Inspire 2 and the Mavic can only fly with one sensor per flight and can stay in the air less than 35 minutes (DJI, 2017a).

Zenmuse Z30 with a zoom lens
The Zenmuse Z30 is a long-range aerial zoom lens for industrial application. It has up to 30x optical zoom which can be used to do detailed inspections while keeping a safe distance from the object/subject. Additionally, the Zenmuse Z30 has up to 6x digital zoom and can take pictures and video's in full HD 1080p resolution and up to 30 frames per second (DJI, 2017c).

Figure 48 Zenmuse Z30 (Skytools, 2020d)

Figure 49 Example of infrared image made with the XT2 (Limited)

Zenmuse XT2 Infrared sensor
Is a highly sensitive thermal sensor that can gather visual and thermal data in one flight with the 4K visual camera + a Tau 2 Thermal Core sensor. Additionally, the temperature can be measured in real-time and the thermal sensor can lock on to the highest temperature in the frame with heat track or other desired objects with quick track. A temperature alarm can be set to a certain temperature to alert the drone pilot of objects exceeding the set maximum temperature. Lastly, the Zenmuse Z30 can also be used in low light conditions (DJI, 2018a).

Zenmuse X7 with 4 lenses
The Zenmuse X7 has a 35 mm sensor for video recording with a video resolution of up to 6k. Additionally, the Zenmuse X7 can be used in all lighting situations and is lightweight and durable. Lastly, the Zenmuse X7 has an ultra-short flange distance which allows a compact lens design and DJI offers 4 lenses that can be combined with the Zenmuse X7 with focal lengths of 16, 24, 35 or 50 mm (DJI, 2017b).

Sniffer
A sniffer is used to locate chemical substances and can also contain these substances for further testing afterwards. The implementation of a chemical sniffer or cannabis sniffer is of this moment not possible. Whether this will be possible during the project or if this will be part of the scope of the project will be described in the thesis.

4.2. Possible Proeftuin use cases

The iLab created a list with possible proeftuin use cases of UAVs see, (Venema, 2019). Below a short description of the possible use cases.

4.2.1. Entertainment areas

The use of UAVs during events could create the advantage of having an overview of a certain area and everything that is happening within that area. This could be helpful during fairs or other places where many people come together like cafés.

4.2.2. Events

During events like the 'City Swim' in Roermond or Solar, a dance event, UAVs could be used to create an effective way of dispersing the police to certain areas and to have an overview of what is happening on the terrain.

4.2.3. Ad-hoc upscaling

Based on the situation the police are reacting to the number of required policemen and the expertise needed on site can change. Ad-hoc upscaling means other units (but also the fire department or ambulance) can be called in to help during an incident.

4.2.4. Cross-border crimes

UAVs could contribute to tackling cross-border crimes between the Netherlands, Belgium, and Germany. Examples of cross-border crimes are drugs, migration, or mobility crime.

4.2.5. Inzet proeftuin MoBa Roermond

Besides the already existing Proeftuin there also exists a Proeftuin called sensing which is operational in Roermond. This Proeftuin focusses on using all kinds of sensors to tackle "Mobiel Banditisme" (MoBa) or mobile banditry in English. The term mobile banditry is used for international travelling criminal groups who are guilty of various crimes such as shop and cargo theft, burglary, swindling and pickpocketing. UAVs could help by tracking down the cars used by those groups and could alert policemen about the exact location of for instance a suspicious vehicle.

4.2.6. Forensic Intelligence on crime scenes

Another Proeftuin called 'forensic intelligence' at the iLab is researching the use of sensors when investigating a crime scene. An element of the Proeftuin is investigating the added value of the use of UAVs on a crime scene. The goal would be to live-stream the crime scene into the iRoom and use this data to combine the process of 'intelligence-oriented scenario thinking' with the forensic activities on the crime scene itself.

4.2.7. Collaboration with the defence department

The former military airbase “De Peel” is part of the police force Limburg. ‘De Peel’ can be used as a location to practice with the UAVs. Additionally, ‘De Peel’ is the centre for Unmanned Aerial Systems (UAS) and UAV in the defence department.

4.2.8. Illegal outdoor cultivation of hemp

The illegal outdoor cultivation of hemp mostly takes place in the middle and northern part of Limburg. Flying above rural agricultural areas in the middle and the northern parts of Limburg could help stop these illegal activities and creates a way to practice and develop skills when flying with the UAVs.

4.2.9. Drug waste dumping

Drug waste dumping takes places regularly in Limburg and every dump location is being regarded as a crime scene. With the use of UAVs, there could be made visible whether there are vulnerable traces of toxic substances on the crime scene before entering.

4.2.10. Project national holiday resorts

This project is part of an integrated project about housing, labour migrants and Outlaw Motor Gangs (OMG) concerning various forms of (undermining) crime. The goal of the project is to combat crime and gain more insight into the types of residence plus to make people visible who try to stay invisible and anonymous.

4.3. Sensor implementation per Proeftuin use case

Based on the Proeftuin use cases and the available sensors a selection was made of which sensors could be used in which use case. All use cases are matched with another use case because of corresponding drone use cases or corresponding use of sensors.

Entertainment areas & Events

- Zenmuse Z30 with a zoom lens
- Zenmuse X7 with 3 lenses
- (Zenmuse XT2 Infrared sensor)
- Sniffer

The Zenmuse Z30 or the Zenmuse Z7 could be useful when an overview of an event is required. The Zenmuse XT2 could be beneficial when a festival continues during the evening and a sniffer can be used to locate synthetic drugs or other unwanted chemicals.

Ad-hoc upscaling & Cross border crimes

- Zenmuse Z30 with a zoom lens
- Zenmuse X7 with 3 lenses
- Zenmuse XT2 Infrared sensor
- Sniffer

During Ad-hoc upscaling and border crossing criminal activities, both the Zenmuse Z30 and the Zenmuse X7 can be used to follow cars or to film a house from above where possible criminal activities take place. This way the police can gather information about the exits, the buildings, and people in the vicinity of the target building. The Zenmuse ZT2 can be used to map the number of people in a house or car and to track cars or people who fled. The sniffer could be useful to locate possible chemical substances before entering a house.

Inzet Proeftuin MoBa Roermond & Project national holiday resorts

- Zenmuse Z30 with a zoom lens
- Zenmuse X7 with 3 lenses
- Zenmuse XT2 Infrared sensor

Both the Zenmuse Z30 and the X7 can be used to track cars and people and to gather intel before raiding a place on a national holiday resort or to catch burglars in the act. The Zenmuse XT2 can be used to determine the number of people in a car or in a house and to track people when entering/leaving buildings or cars during the night.

Forensic Intelligence on crime scenes & Collaboration with the defence department

- Zenmuse Z30 with a zoom lens
- Zenmuse X7 with 3 lenses
- Zenmuse XT2 Infrared sensor
- Sniffer

Livestreaming the crime scene to the iRoom could be done with both the Zenmuse Z320 and the Zenmuse X7 and practicing this could be done on the former military air base “De Peel”. The Zenmuse XT2 could be used to determine the temperature of the diseased and could help with determining the time of death. The sniffer could be used to scan for chemical substances or synthetic drugs before entering the crime scene.

Illegal outdoor cultivation of hemp & Drug waste dumping

- Zenmuse Z30 with a zoom lens
- Zenmuse X7 with 3 lenses
- Zenmuse XT2 Infrared sensor
- Sniffer

As already mentioned in paragraph 2.2 flying above rural agricultural areas in the middle and northern part of Limburg, with the Zenmuse Z30 or the Zenmuse X7, could help stop illegal outdoor cultivation of hemp and could help locate drug waste. The Zenmuse XT2 could be helpful when the criminals are still on site and can be used to track them even during the night. The sniffer could be used to locate the chemical drugs and track, for instance, vulnerable traces or toxic substances before entering a crime scene.

5. PLANNING

5.1. Rough planning

In Figure 3 the rough planning during the graduation assignment. The planning was divided into 4 phases: research, concept development, iterations, and final concept.

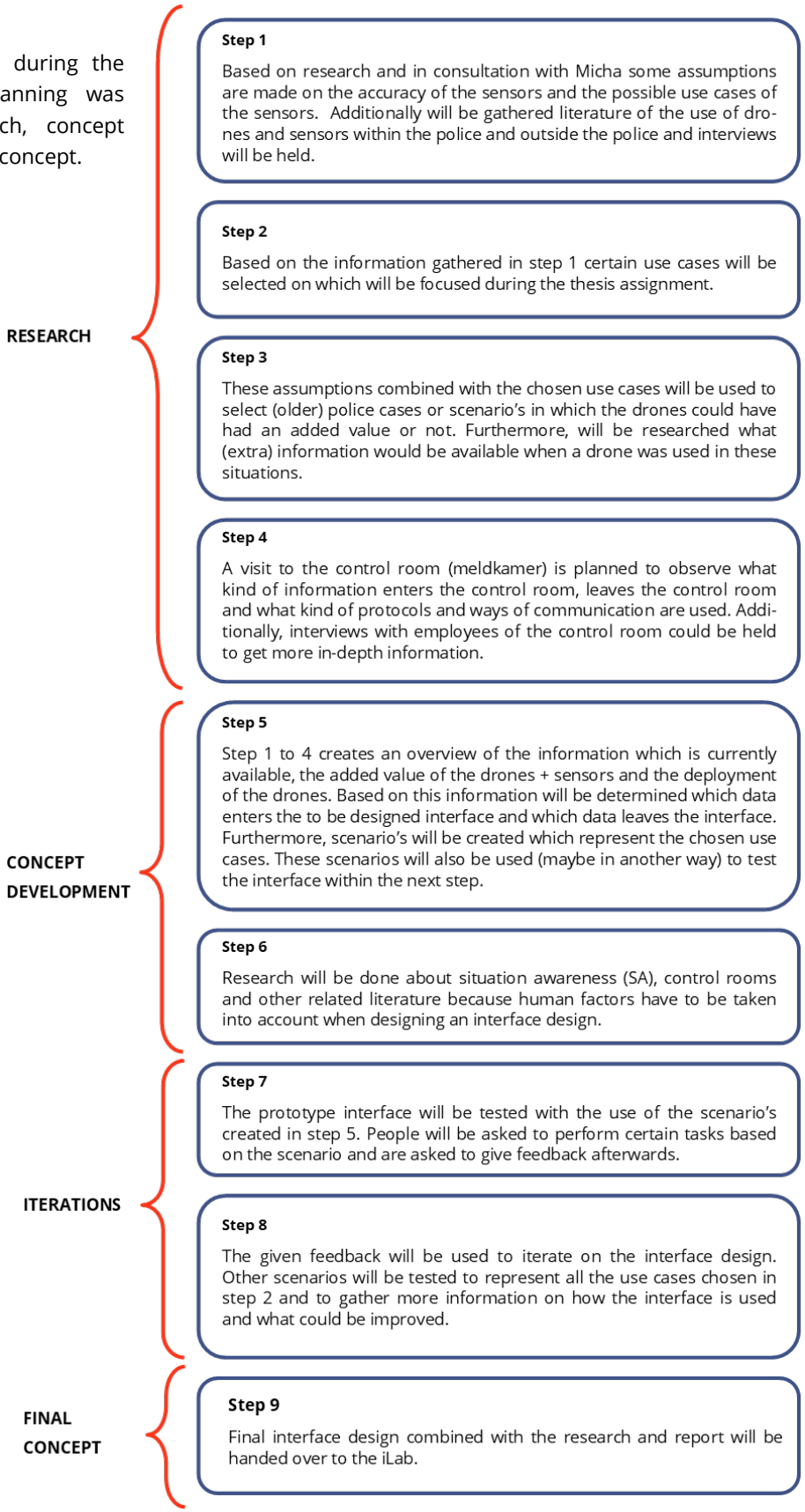

Figure 50 Rough planning during the graduation assignment

5.2. Detailed planning

Table 10 Planning graduation project

Week	Activity 1	Activity 2
46	Research	Plan of approach
47	Select use cases	
48	Research	Finalize Plan of approach
49	Research	
50	Scope data that can be gathered by the drone	
51	Research	
52	Research	Visit control room
53	Research	
1 & 2	Determine added value based on real-life police cases + interviews	
3	Research	
4	Research	
5	Create scenario's	
6	Research	
7	Research	
8 & 9	Create overview input/output interface	
10	Conceptualisation	
11	Conceptualisation	
12	Conceptualisation	Concept choice
13	Conduct usability tests	
14	Evaluation	Evaluate feedback
15	Iteration	
16	Iteration	
17	Iteration	
18	Conduct usability tests	
19	Evaluation	Evaluate feedback
20	Development final concept	
21	Development final concept	
22	Development final concept	
23	Development final concept	
24	Evaluating feedback	
25	Defining final concept	
26	Defining final concept	
27	Evaluation	
28	Documentation	
29	Documentation	
30	Documentation	

6. FIGURE LIST

7. TABLE LIST

8. REFERENCES

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Appendix II: Pictures low-fidelity prototype

Figure 51 Low-fidelity prototype camera element

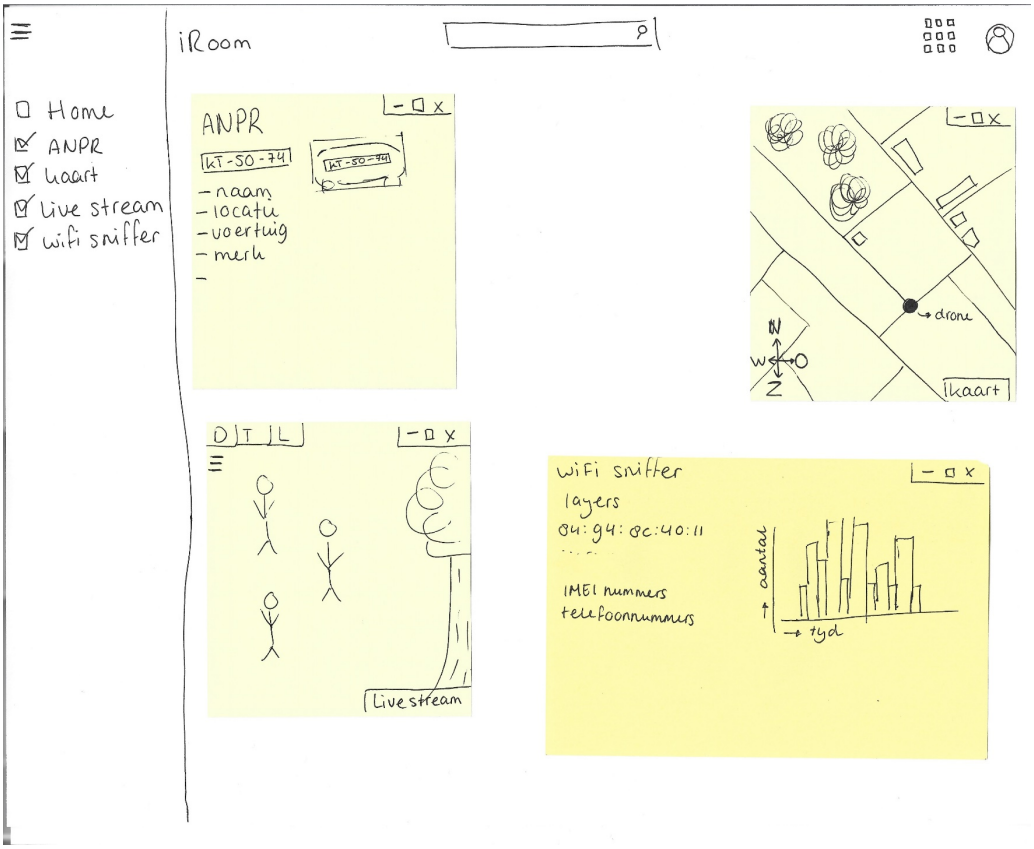

Figure 52 Low-fidelity prototype dashboard element

Appendix III: Picture's prototype

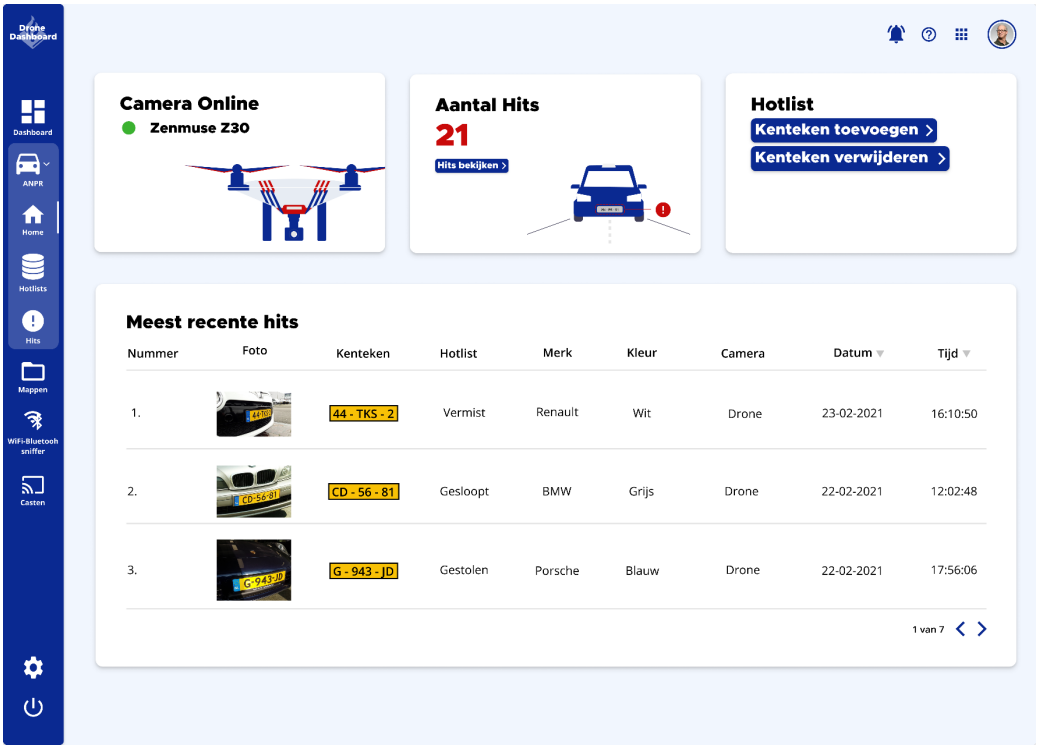

Figure 53 ANPR system prototype

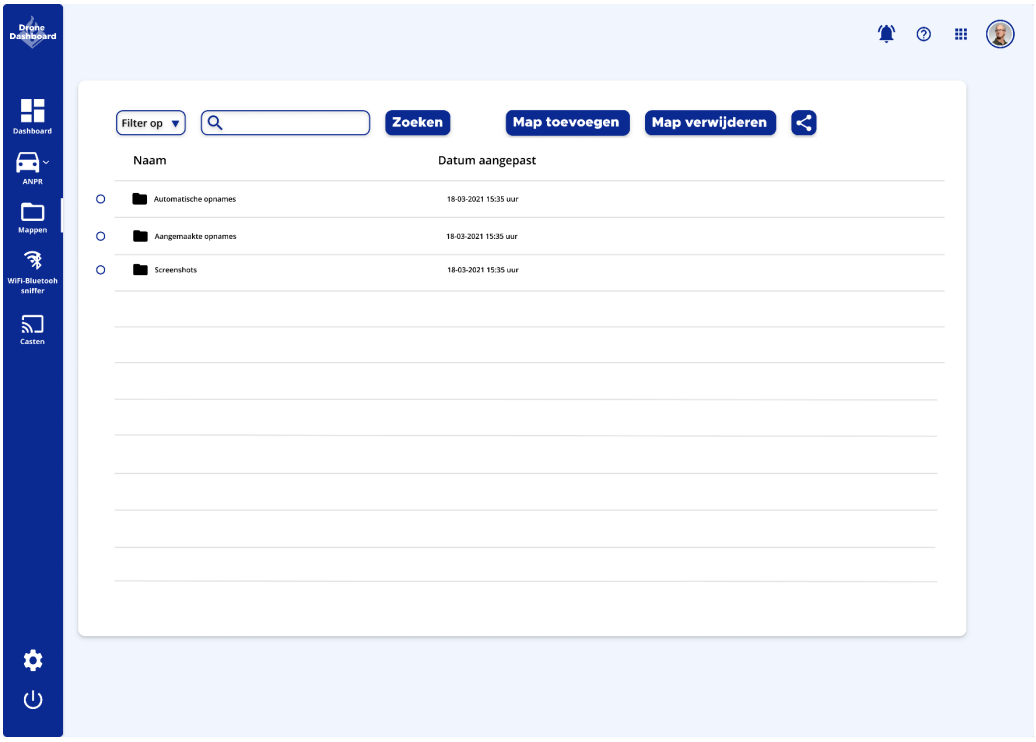

Figure 54 File system prototype

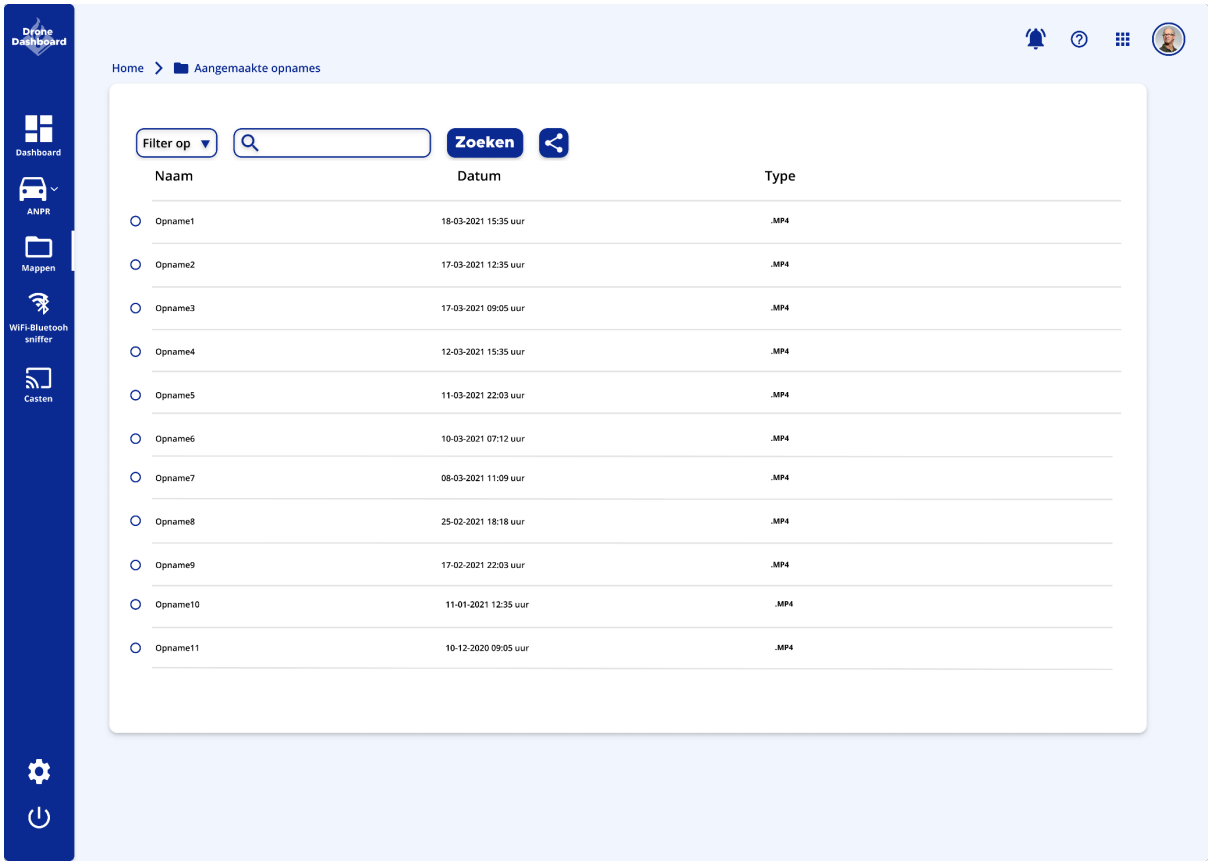

Figure 55 Created recordings frame prototype

Appendix IV: Tasks user tests

Doel: Uitvinden of het drone dashboard gebruiksvriendelijk is en of/hoe dit verbeterd kan worden.

Vooraf aangeven:

- Gebruik geen pijltjestoetsen of de spatiebalk anders verspringt de openstaande pagina van het prototype
- Je kan niet typen of slepen in het prototype
- Je mag vragen stellen, kan zijn dat ik ze niet beantwoord omdat ik anders het antwoord al geef
- Je mag meteen iets aangeven als je het opvalt maar ook bewaren voor na de test
- Vragen om de vragen hardop te lezen, worden gedeeld in de chat
- Informatie over de casus wordt ook gedeeld via de chat/whatsapp
- Geef nadat ik de taak gegeven heb vooral aan hoe je te werk zou gaan, je gedachtegang e.d. Zo kan ik een beeld krijgen van wat je zou gaan doen en waarom. Begin daarna met het daadwerkelijk uitvoeren van de taak.
- Drone dashboard alleen voor de data verzameld door drones
- **Is bekend wat Dragonforce is?**

Casus 1: Vermissing

Dia 4 → Intro
Dia 5 → Melding komt binnen

Er komt een melding binnen van een vermist persoon. Deze melding is door de meldkamer opgepakt maar wordt doorgestuurd naar de iRoom omdat er verschillende instanties bij betrokken zijn. Je collega's hebben de informatie van de meldkamer op de videowall gepresenteerd.

Dia 6 → in de iRoom
Dia 7 → Beschikbare informatie

Als iRoom medewerker ben je verantwoordelijk voor alle data wat verzameld wordt door drones en gepresenteerd wordt in het drone dashboard.

Open het link, groot beeld maken, gestures uitzetten

1. Log in op het drone dashboard

   Dia 8 → Droneteam met Z30 en Wi-Fi Bluetooth sniffer
   Basisteam Heerlen wordt geïnformeerd over de vermissing

2. Aan de hand van de beschikbare informatie op de videowall en wat je voor je ziet op het drone dashboard, wat zou je als eerste gaan doen?

3. Marc van het droneteam heeft de drone verbonden met het drone dashboard en vraagt of bij jou de drone ook verbonden is.

4. Het kenteken van de dame is bekend, zorgen dat er een hit binnenkomt als de drone het kenteken registreert

5. Een van de droneteam leden ziet een auto die van de vermiste dame zou kunnen zijn en vraagt aan jou of je zou kunnen meekijken of het inderdaad deze auto is.

   Dia 9 → Hit!

Een collega in de iRoom heeft met de provider van de dame gebeld en zo het IMEI-nummer en MAC-adres van de telefoon van de dame achterhaald.

IMEI-nummer:
2409093757394723
MAC-adres:
84:a6:c8:2b:3e:7d

6. Zoek d.m.v. deze informatie (het MAC adres) uit waar de telefoon van de vermiste persoon zich bevindt.

   Dia 11 → Dame op het bankje

7. Een collega (in de iRoom) vraagt of je het kaartje met de locatie van de drone zou kunnen weergeven in satelliet weergave. Zo kan ze makkelijker zien waar het Pancratius plein zich bevindt.

   Op R duwen op het toetsenbord of rechtsonder op restart duwen → Pauze?

Handelingen

- Inloggen
- Camera verbonden ja/nee
- Kenteken toevoegen
- Live beeld openen
- Zoeken op MAC-adres

Casus 2: Hennepplantage

Nieuwe dag

Dia 14 → inzet mogelijke hennepplantage

Vandaag zal er met een drone boven een woonwagenkamp gevlogen worden vanwege meldingen van een mogelijk aanwezige hennepplantage.

Als iRoom medewerker hou je het overzicht tijdens de inzet en ben je verantwoordelijk voor alle data wat verzameld wordt door drones en gepresenteerd wordt in het drone dashboard.

Dia 15 → Beschikbare informatie
Dia 16 → inzet droneteam

1. Tijdens de inzet wordt de Zenmuse XT2 warmtebeeldcamera gebruikt. Zorg dat je het juiste livebeeld ziet.

2. Tom, centralist van het operationeel centrum kijkt via de videowall in de iRoom mee naar de inzet. Hij vraagt of je het kaartje met de locatie van de drone zou kunnen weergeven op de videowall.

3. Wijkagent Maarten is aanwezig op het woonwagenkamp en vraagt of je een link zou kunnen delen zodat hij kan meekijken naar de dronebeelden tijdens de inzet

   Zou je nog een andere manier van delen willen hebben i.p.v. Dragonforce?

   Het droneteam begint te vliegen en al snel is op de livebeelden te zien dat het schuurtje bij nummer 7 warmer is en wordt er met toestemming van de OVD binnengetreden.

   Dia 17 → OVD geeft toestemming

   Dia 18 → Kassa!

   Op R duwen op het toetsenbord of rechtsonder op restart duwen

Handelingen

- Live beeld XT2
- Link delen via Dragonforce
- Kaart/locatie beeld
- Scherm casten

Casus 3: Demonstratie

Nieuwe dag

Vandaag vindt er een demonstratie plaats in Venlo van tegenstanders van Zwarte Piet.

Dia 21 → Briefing iRoom

Dia 22 → Beschikbare informatie

Dia 23 → Drone team met Zenmuse Z30

Dia 24 → foto

1. Het is ondertussen druk geworden in het Julianapark en je ziet op het live beeld dat een langharige man de politie voor de zoveelste keer uitdaagt en wordt opgepakt. Voor een mogelijk proces-verbaal wil je dit graag opnemen.

   Wat nu niet van tevoren weet dat er iets gaat gebeuren, er iets gebeurt en dan een opname start. Dan ben je namelijk 'te laat'?

2. Even later zie je dat een man met een zwarte trui en een rood petje een politieagent mishandeld en snel wegrent. De politieleidinggevende vraag om een foto van de man.

   De foto die je zojuist verstuurd hebt naar politie leidinggevende Maarten heeft ervoor gezorgd dat de man kon worden opgepakt. Even later vindt er een tweede confrontatie plaats tussen de pro-Pieten en de politie. De Kick-out Zwarte Piet demonstraten worden door de mobiele eenheid weggestuurd naar stadsbussen, de demonstratie loopt op z'n einde.

   Dia 25 → tijdlijn

3. Na de demonstratie vragen collega's of je de opname die je zojuist gemaakt hebt van de man die is opgepakt (tijdens de demonstratie) zou kunnen delen.

   Op R duwen op het toetsenbord of rechtsonder op restart duwen

Handelingen

- Opname starten
- Screenshot doorsturen
- Opname terugzoeken en delen met collega's

Totaal aantal handelingen

- Opname starten
- Screenshot doorsturen
- Opname terugzoeken en delen met collega's
- Live beeld XT2
- Kaart/locatie beeld
- Link delen via Dragonforce
- Scherm casten
- Opnames delen voor proces verbaal
- Inloggen
- Camera verbonden ja/nee
- Kenteken toevoegen
- Live beeld openen
- Zoeken op MAC-adres

Niet specifiek geteste handelingen die misschien wel plaatsvinden

- Minimaliseren en openen van schermen
- Openen van hotlist, ANPR-dashboard

Appendix V: Tasks second user test

Casus 1: Avondklok rellen in Eindhoven

Mensen zij niet blij met de avondklok en gaan demonstreren in Eindhoven op het 18 september plein.

Informatie iRoom

Het droneteam staat op het dak van de bijenkorf gelegen aan het 18 septemberplein. Ze starten de drone op en proberen verbinding te maken met het drone dashboard.

1. Log in. (H)

2. Paul, dronepiloot, vraagt of je zou kunnen controleren of de drone verbonden is met het drone dashboard. (H)

Zo duidelijker?

Het droneteam en de iRoom is klaar voor de inzet. Ondertussen hebben honderden mensen zich verzameld op het 18 septemberplein. De politie is in opperste paraatheid en de Mobiele Eenheid staat klaar om in te grijpen mocht dit nodig zijn.

3. Je kijkt mee op het livebeeld en ziet dat iemand een steen tegen een politiebusje aangooit. Voor een mogelijk proces-verbaal wil je dit graag opnemen. (H)

   Zien ze dat die +2 min is toegevoegd?

4. Tijdens de opname valt je iets op maar waar je niet meteen op hoeft te acteren. Dit moment in de opname zou je graag vastleggen om het later weer terug te kunnen zoeken. (N)

   Mis je iets aan info daarin?

5. Even later als je de opname al gestopt hebt zie je op het livebeeld dat iemand een auto van ProRail in brand steekt. De collega die naast je zit in de iRoom vraagt of je een foto zou kunnen maken van de man. (H)

6. De collega vraag of je de foto ook meteen zou kunnen delen met de leidinggevende van het basisteam in Eindhoven. (H/N)

Het loopt helemaal uit de hand in Eindhoven en de ME voert meerdere charges uit en zet het waterkanon in. Even na 9 uur in de rust wedergekeerd in Eindhoven. De drone is inmiddels weer geland en het droneteam is aan het opruimen.

7. Nu het wat rustiger is in de iRoom bedenk je je dat er een moment in de inzet was dat je terug wil kijken. Het moment dat die man op die fiets voorbijkomt. Zoek dit moment terug. (H/N)

8. Verder heb je tijdens de inzet een moment vastgelegd waar je later op wilde acteren. Zoek dit moment terug. (N)

9. Deel de video opname met de leidinggevende van het basisteam in Eindhoven. (H)

Casus 2: Vermist meisje

Nieuwe dag in de iRoom

Meisje vermist nadat ze niet thuis is gekomen van school. Melding is opgepakt door de meldkamer en doorgestuurd naar de iRoom. Delen informatie verzameld door de meldkamer.

Informatie iRoom

Een andere collega is ondertussen bezig om informatie te verzamelen over Anne en de vader. Er is een team naar het huis van de vader gestuurd om te kijken of het meisje niet gewoon naar huis is gelopen.

1. Log in. (H)

2. Wat zou je als eerste gaan doen a.d.h.v. de beschikbare informatie?

3. (Het kenteken van de vader is bekend, zorg dat er een hit binnenkomt als de drone het kenteken registreert.) (H)

Anne is niet bij haar vaders huis, wel heeft de buurvrouw aangegeven dat ze de vader vanmorgen campingspullen zag inladen in de auto. De moeder van Anne wordt gevraagd of ze hier meer van weet en geeft aan dat ze een vakantiehuisje hebben op de Meinweg en ze daar van het weekend naartoe zouden gaan.

Het droneteam wordt ingezet in de buurt van het bezoekerscentrum op de Meinweg wat in de buurt is van het vakantiehuisje van de vader. Vanuit daar proberen ze beelden te krijgen van het vakantiehuisje en eventueel de auto van de vader.

4. Een collega vraagt zich af of een van de wegen op de kaart waar de drone zich bevindt verhard is en vraagt of dit zou kunnen checken (H)

HIT!
Een collega heeft ondertussen het MAC-adres en IMEI-nummer van de dochter achterhaald:

IMEI-nummer:
2409093757394723

MAC-adres:
4k:08:65:95:f8:2e

5. Zoek d.m.v. deze informatie (het MAC adres) uit waar de telefoon van Anne zich bevindt.

Gaan ze zoeken op MAC-adres (H) of het MAC-adres toevoegen (N)?

MAC-adres toevoegen → dan HIT geven

Komt een hit binnen op het MAC-adres

6. Collega's op de Meinweg vragen of je een nauwkeurige locatie van de telefoon van Anne zou kunnen doorgeven (inzoomen dus N)

7. Collega in de iRoom vraagt of je de locatie ook meteen zou kunnen doorsturen naar het basisteam terplekken. (N)

Anne blijkt zich in de uitkijktoren op de Meinweg te bevinden met haar vader. De vader wilde alleen even alleen zijn met zijn dochter maar had dit niet gecommuniceerd met de moeder.