

# From Zero to Drone Hero

Enhancing Critical Infrastructure Security with User-Centered Drone Interface Considerations

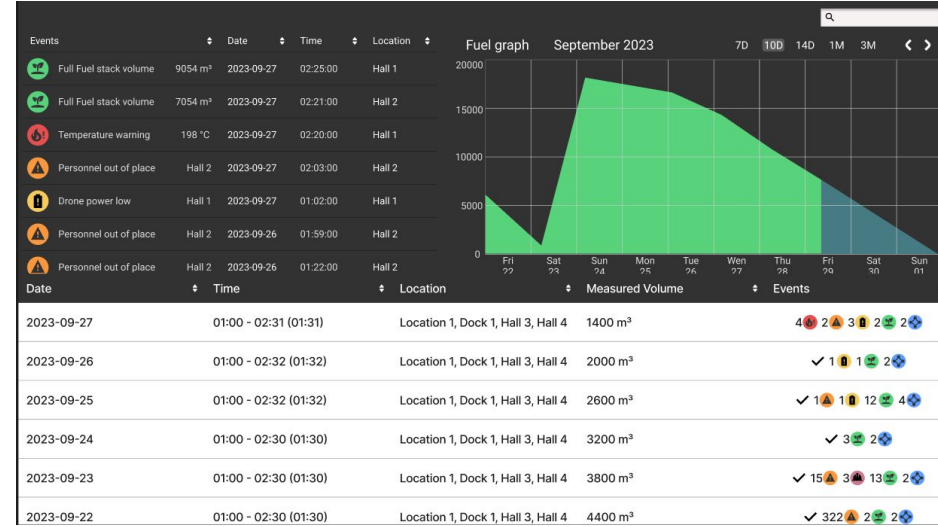










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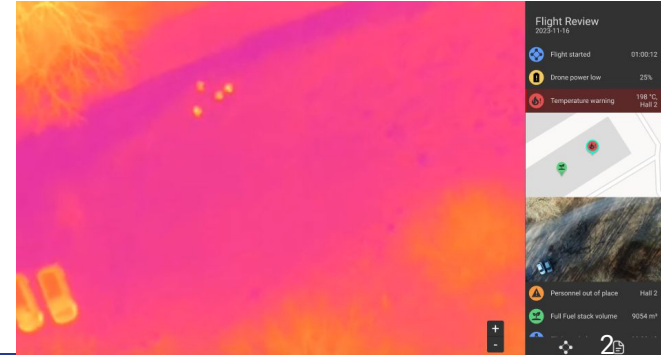
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# Earlier work

- Collaboration with Robotto to create a Design Baseline
- Focused on a review tool for potential drone missions



 Flight started	01:00:12	 Flight ended	02:30:12
 Drone power low	25%	 Temperature warning	198 °C, Hall 2
 Personnel out of place	Hall 2	 Full Fuel stack volume	9054 m³
 Personnel hazard	Hall 2	 Single Fuel stack volume	63 m³



# Challenges in security



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# Pilot study

- Participants: 1 HOFOR
- Current state of monitoring
  - Site operation is primary
  - Security is secondary
  - “Automatic” movement based CCTV
    - 300+ cameras
  - Singular CCTV monitoring screen
  - Multiple sensor monitoring screens
  - Personal patrolling

# Possible scenarios for drone usage:

- Standard work environment
  - Standard task list of a specific business, e.g., biomass monitoring
- Discovering issues
  - Alert vs imagery
  - location -> map
- Reacting to issues
  - Recommendation system
  - Drone as first responder
- Resolving issue
  - Escorting
  - Reporting

# Study 1: Exploring challenges & Drone use



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# Study 1 setup

- Interview
  - Workshop
  - Miro board
- Procedure
- Participants
  - 2 HOFOR

# Scenarios

- Person without helmet
- Person spottet in water ->
- Intruding drones

## Scenarie: Person set i vandet nær forbudt område - Nuværende løsninger

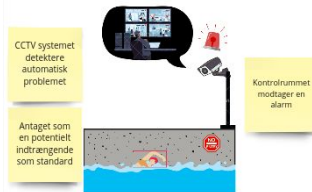
### Intro

I denne situation er en person blevet spottet svømmende i eller tæt ved forbudt område

### Task prompt

Step 1: Beskriv hvilke opgaver du har i denne situation  
Step 2: Træk de enkelte post-it notes til det relevante billede  
Step 3: Lav eventuelt manglende post-it notes

### Problem detektion



Hvordan bliver det opdaget?

Hvor stor er sikkerhedsrisikoen?

Hvor ofte sker det?

### Videregivelse af oplysninger

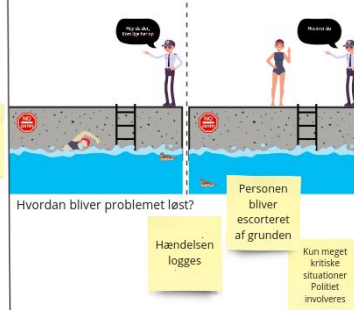


Hvem bliver kontaktet?

Hvem overtager opgaven?

Hvordan bliver incidentet opsporet?

### Problemet løses



## Scenarie: Person set i vandet nær forbudt område - Drone fremtid

### Intro

I denne del undersøger vi hvordan en person der er blevet spottet svømmende i eller tæt ved forbudt område kunne løses i fremtiden med støtte fra droner

### Task prompt

Step 1: Beskriv ideer til hvordan man fremadrettet kunne bruge droner til at håndtere de opgaver der er i denne situation  
Step 2: Træk de enkelte post-it notes til det relevante billede  
Step 3: Lav eventuelt manglende post-it notes

### Problem detektion



Hvordan kunne det blive opdaget?

### Videregivelse af oplysninger



Hvem/hvad kunne overtage opgaven?

Hvordan kunne incidentet blive opsporet?

### Problemet løses



Hvordan kunne problemet blive løst?

Hvordan kunne den nuværende løsning blive assisteret eller erstattet af en eller flere droner?

Hvilke værktøjer kunne ellers assistere løsningen?



## Inductive thematic analysis



# Results (1)

- Potential of Automated Systems
  - Multiple tasks
- Drones as first responders
  - Avoid leaving control room
  - Confirm fire alarms
- Anti-Drone Measures & Detailed Logging
  - Unsolved problem & accountability

# Results (2)

- **Balancing Operations & Security**
  - Dispatch of operators
- **Inefficiencies in Current Surveillance Systems**
  - Movement based -> false alarms
- **Logistical & Financial Constraints**
  - Dedicated operator not possible

# Study 1 wrap-up

- Storyboard presentation
  - Would have worked better using direct participant control
- Focus on usability forward
  - Command from control room
  - Alleviating dispatching
  - Increased information gain
  - Detailed logging

# Study 2:

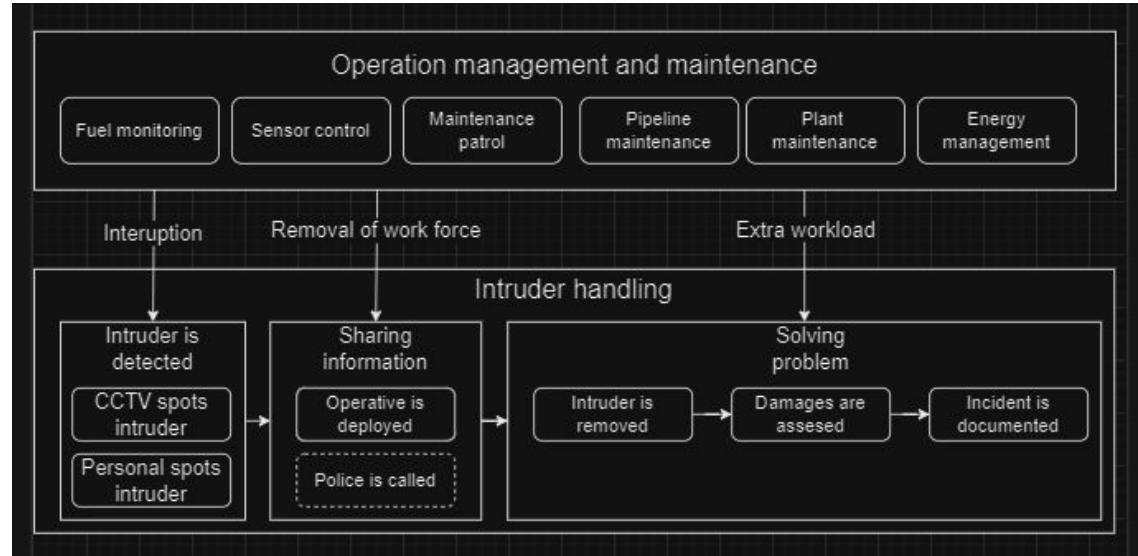
# Drone Control & Display



# Study 2 setup

- Guided interview
- Participants
- Procedure
- Basis

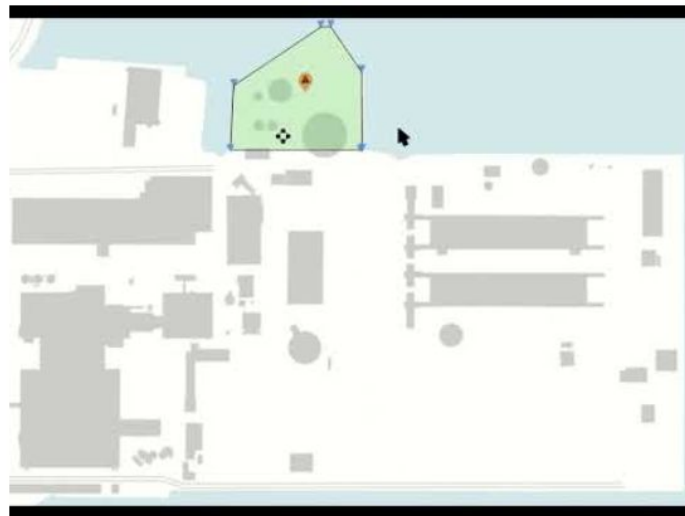
Operational flow



# Questionnaire

- Presented video
- Likert inspired rating
- Discussion prompts

Dronene undersøger et område markeret af brugeren



Dette føles som en intuitiv måde at kontrollere dronen på.

	1	2	3	4	5	6	7	
Meget uenig	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Meget enig

Hvilke fordele/ulemper kunne der være i at markere området med et polygon?

☐ Jeg har diskuteret med interviewet

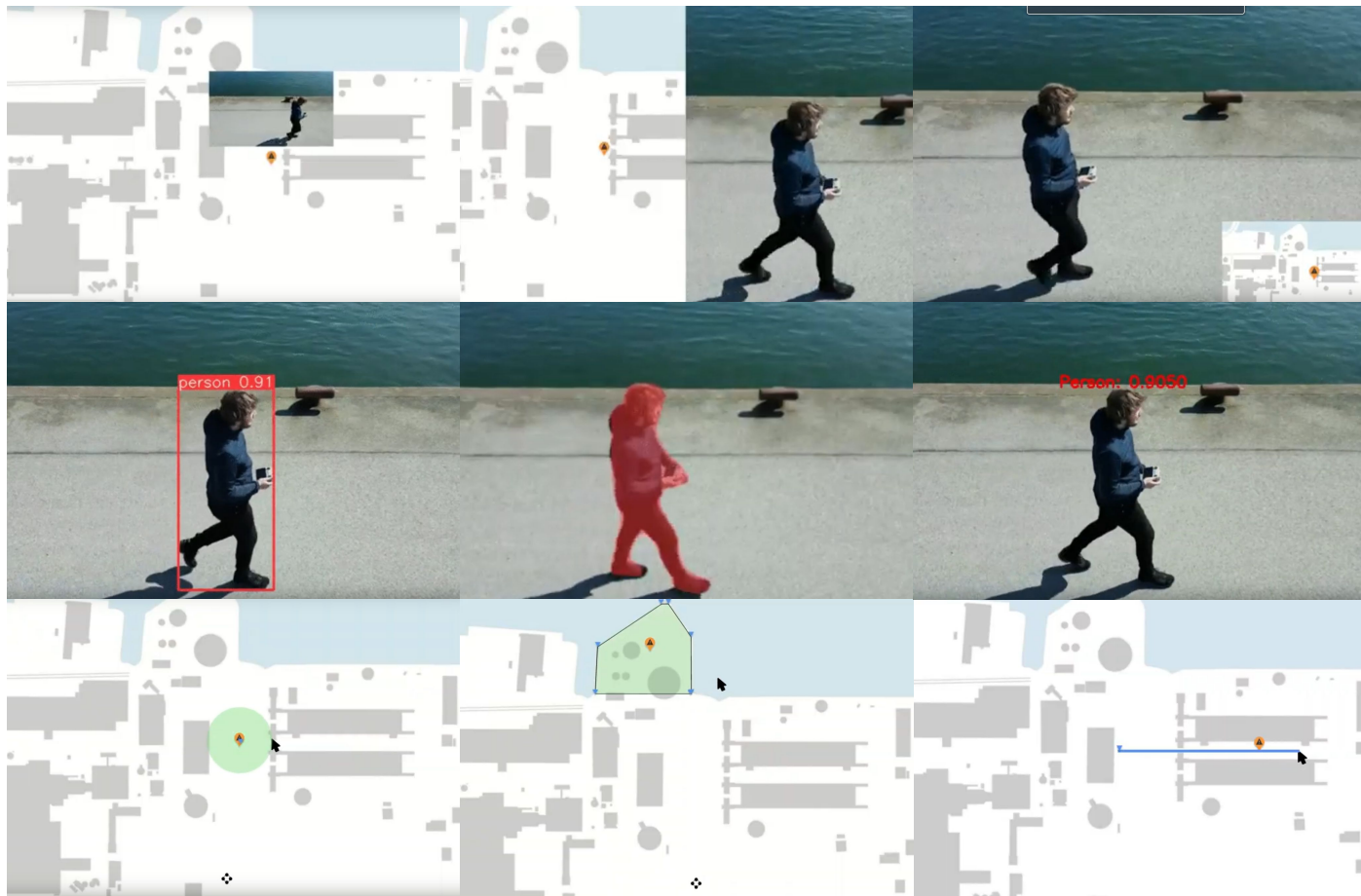
# Categories

- Video & autonomy
  - Logging
  - Degree of autonomy
- Control
  - Maneuvering the drone -> Alleviating dispatching
- Video display & Video detection
  - Logging
  - Increased information gain



# Categories

Few examples



# Findings & Considerations



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# Automation Response

Have a human operator involved when the drone needs to deviate from the standard

- Potential of automated systems
- Responsibility

*"If we automate it and an accident occurs. Then who is responsible?"*

*"I think that will also create some more security among our employees... Someone who sees that the drone has seen something, or when something comes flying around and keeping an eye on them, they know that there are some people behind it in some way."*

*"It (the drone) is in operation in some way, so there should be a matter of priority for the decision-maker, i.e. whoever is responsible"*

# Automation Response

Get context to help the operators make decisions and create documentation.

- Decision-making
- Detailed logging

*“Is it someone drawing (graffiti)... It can also be people who steal something... It also makes a difference if they have weapons with them, it makes a difference to what kind of response you have to send out whether you should call the police directly, or if we can go down ourselves.”*

# Automation Response - Related Work

- Out-of-the-Loop-Syndrome[1]
  - Lack of awareness in the operator when a system operates autonomously due to over reliance on automation
  - The UI must provide sufficient support to allow an operator to quickly re-enter the loop
- The answers agrees with the values to the industry of Cost, Safety, Effectiveness, and Convenience found in What matters in professional drone pilots' practice[2]

“Have a human operator involved when the drone needs to deviate from the standard”

“Get context to help the operators make decisions and create documentation.”

[1] Agrawal, A., Abraham, S. J., Burger, B., Christine, C., Fraser, L., Hoeksema, J. M., ... & Cox, S. (2020, April). The next generation of human-drone partnerships: Co-designing an emergency response system.

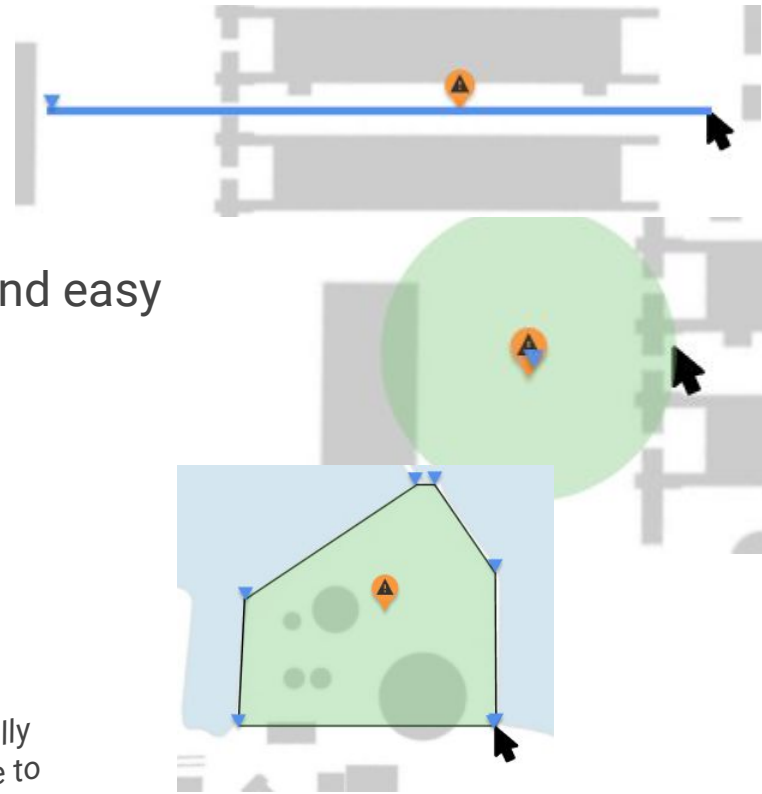
[2] S. Ljungblad, Y. Man, M. A. Bayta s, M. Gamboa, M. Obaid, and M. Fjeld, “What matters in professional drone pilots' practice? an interview study to understand the complexity of their work and inform humandrone interaction research,”

# Direct Control

Make the method of directing the drones flexible and easy to use

*"But I need to be able to say go and see south of this building, if there should be anything there, or We have an alarm at this door, go right over and see what should be there"*

*"If you take the area, you get a relatively large area, and it is really nice if it is a large area you have to cover. Where the route, you will be much more precise."*



# Direct Control - Use Cases

Make the method of directing the drones flexible and easy to use

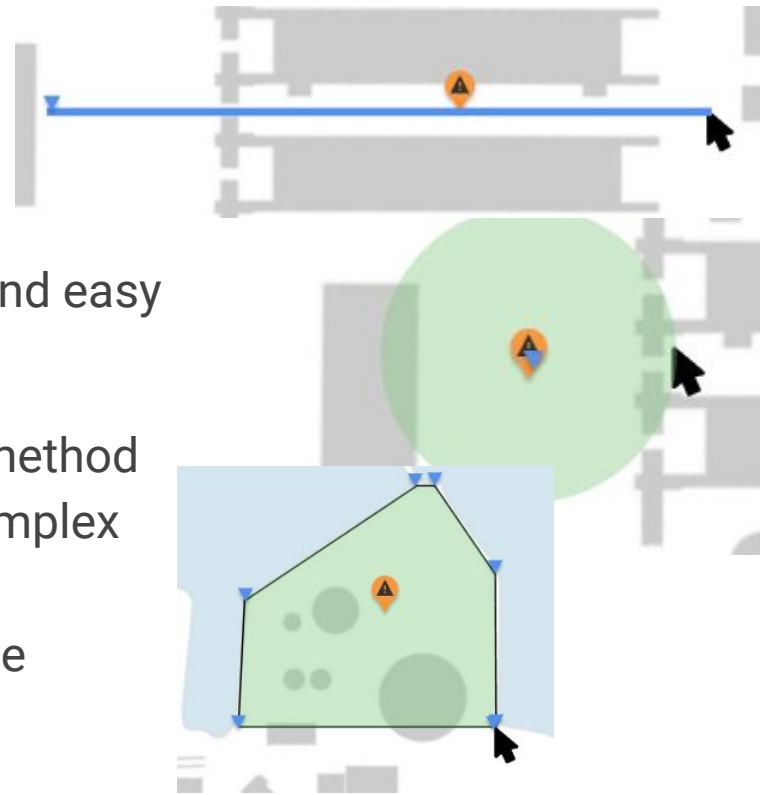
- Add to / Redirect manual or automatic response
- Setup search in area of interest
- Setup patrol areas / routes



# Direct Control - Related Work

Make the method of directing the drones flexible and easy to use

- Beacon control was shown to be an intuitive method for novices to control swarms of drones in complex environments [1]
- The preference of control tool depended on the situation, where Beacon control seemed the preferred method. [2]



[1] Kolling, A., Sycara, K., Nunnally, S., & Lewis, M. (2013). Human swarm interaction: An experimental study of two types of interaction with foraging swarms. *Journal of Human-Robot Interaction*, 2(2).

[2] R. S. B. Andreh Bassam Bahodi Maria-Theresa Oanh Hoang, "User interface design for uav swarms in search and rescue," 2022, 1–17. [Online]. Available: [https://vbn.aau.dk/ws/files/474517368/Master\\_Thesis.pdf](https://vbn.aau.dk/ws/files/474517368/Master_Thesis.pdf).



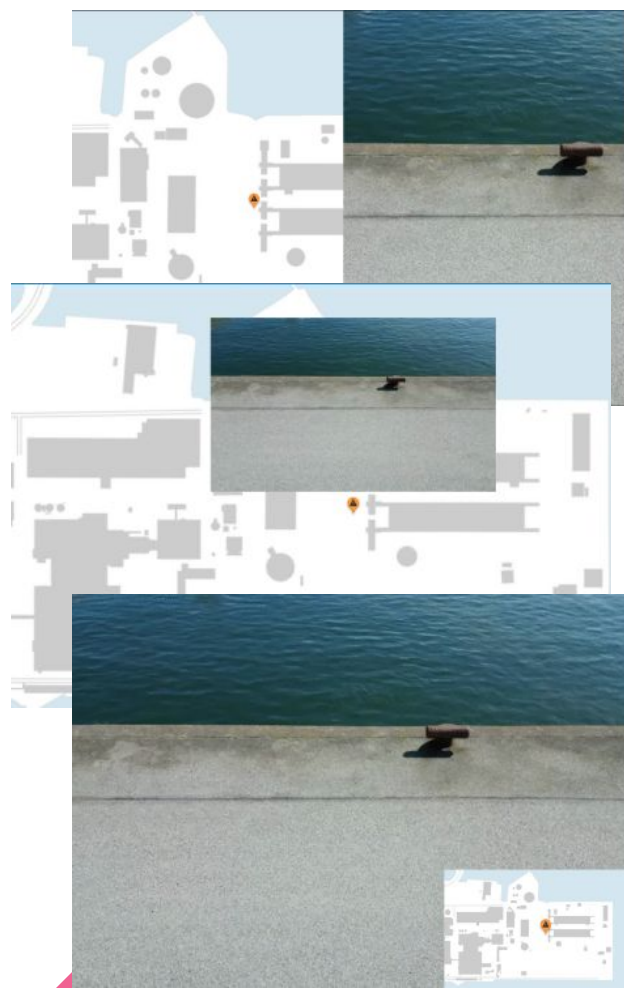
# Video Popup

Do not remove context to show something else

"You just feel more confident in your case when you can see, okay that's what I can see and it's on the map. Then it is much easier to explain it if I have to tell it to my colleague who is on his way out to investigate."

*"It can be a bit difficult based on the other videos (other than minimap) to assess exactly where they (the intruders) stand"*

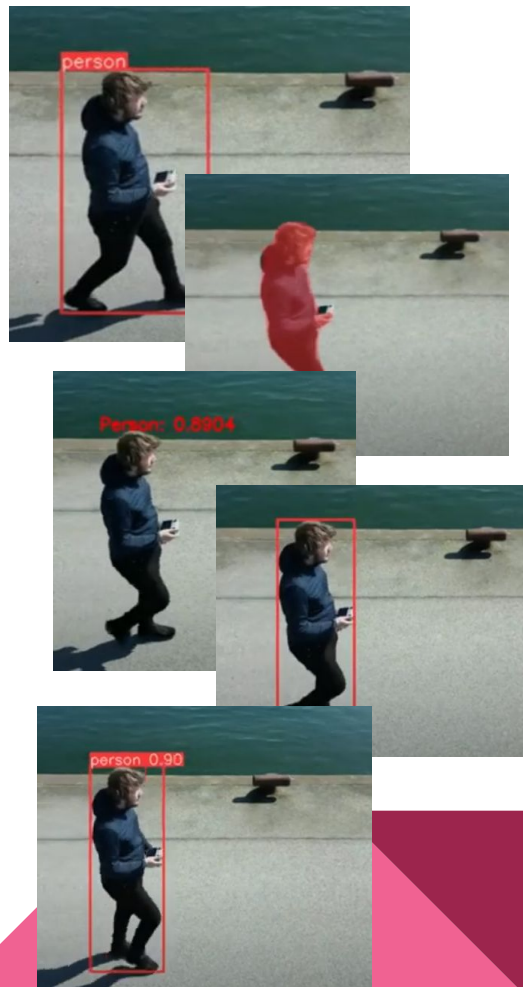
*"The most important thing is to maintain an overview... If there are 2 alarms for example or 2 drones are operating, so you can switch between which video feed you get."*



# Bounding box

Have something that draws the attention to what has been spotted, visually displaying information tied to it

- Lots of ideas but nothing concise
  - Highlight items
  - Highlight toggle
  - Highlight people when in shadow or obscurity
- Requires more focused study



# Addendum - Context Context Context

Remember to include all the context needed, even if it might seem trivial.

- E.g. Route markers and drone paths are helpful indicators on a map. [1]
- Detailed Logging

Do not remove context to show something else

Get context to help the operators make decisions and create documentation.

[1] Agrawal, A., Abraham, S. J., Burger, B., Christine, C., Fraser, L., Hoeksema, J. M., ... & Cox, S. (2020, April). The next generation of human-drone partnerships: Co-designing an emergency response system.

# Project process



# Challenges for the process

- Limited Initial knowledgebase
  - Previous work adjacent to the field.
  - Little knowledge in physical security
- Field is unexplored
  - No existing research on the specific field could be found.
  - Related research comes from different fields.



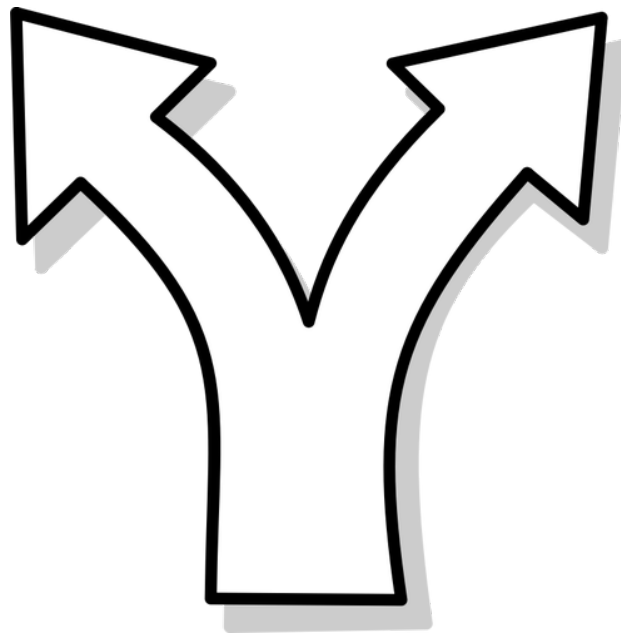
# Research Method

- Why use Participatory research:
  - Experts can make up for the lack of knowledge.
  - Already existing connection to people in the field.



# Alternative Research Approaches

- More specific Participatory Research
  - Participatory Research covers a lot of different methods, with more specific domains.
- Research through design
  - Could be used to create more visual guides.
- Quantitative Study
  - Increase the number of participants, help in specifying problems.

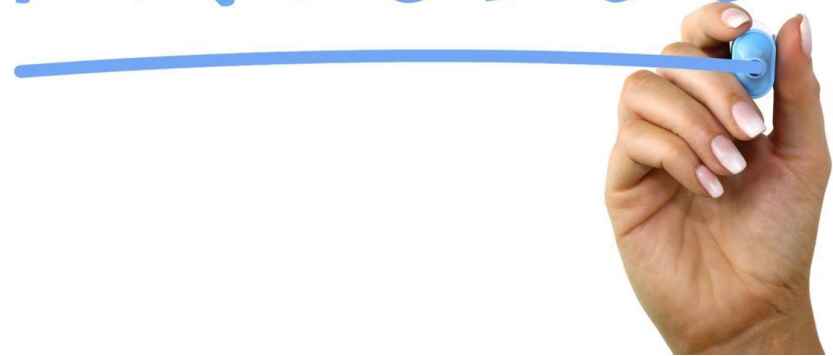


# Research process

- Milestones

- Initial interview
- Scenario interview
- Qualitative analysis
- Mockups creation
- Questionnaire on the selected design space
- Final analysis
- Conclude considerations

PROCESS





# Information gathering methods

- **Semi Structured interviews**
  - Made it possible to create discussion, while being flexible.
- **Storyboarding**
  - Displaying different possibilities for drone security.
- **Guided Interviews**
  - Using a questionnaire to guide participants through questions



# Qualitative Analysis - Inductive thematic analysis

- Working up from the data
  - Little previous research hinders deductive approach.
- Usable on interviews
  - Thematic analysis can be used on individual interviews.



# Analysis possibilities

- Doing deductive thematic analysis
  - Using the considerations as existing ideas and concepts.
- Grounded Theory
  - More rigorous, and needs more data.  
Could Yield an improved result.

# Future work

- Use designers
  - Try and see how the considerations work in real life.
  - Create mockup and prototype to help visualize the considerations.
- Use researchers
  - Studies with different participants
  - Do quantitative studies
  - Improve upon the considerations

