Pumps, Pipes and a Four-Legged Robot:

Designing for Human-Robot Teams

2023
Diploma Report
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Title
Pumps, Pipes and a Four-Legged Robot: Designing for Human-Robot Teams

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Discipline
Interaction design

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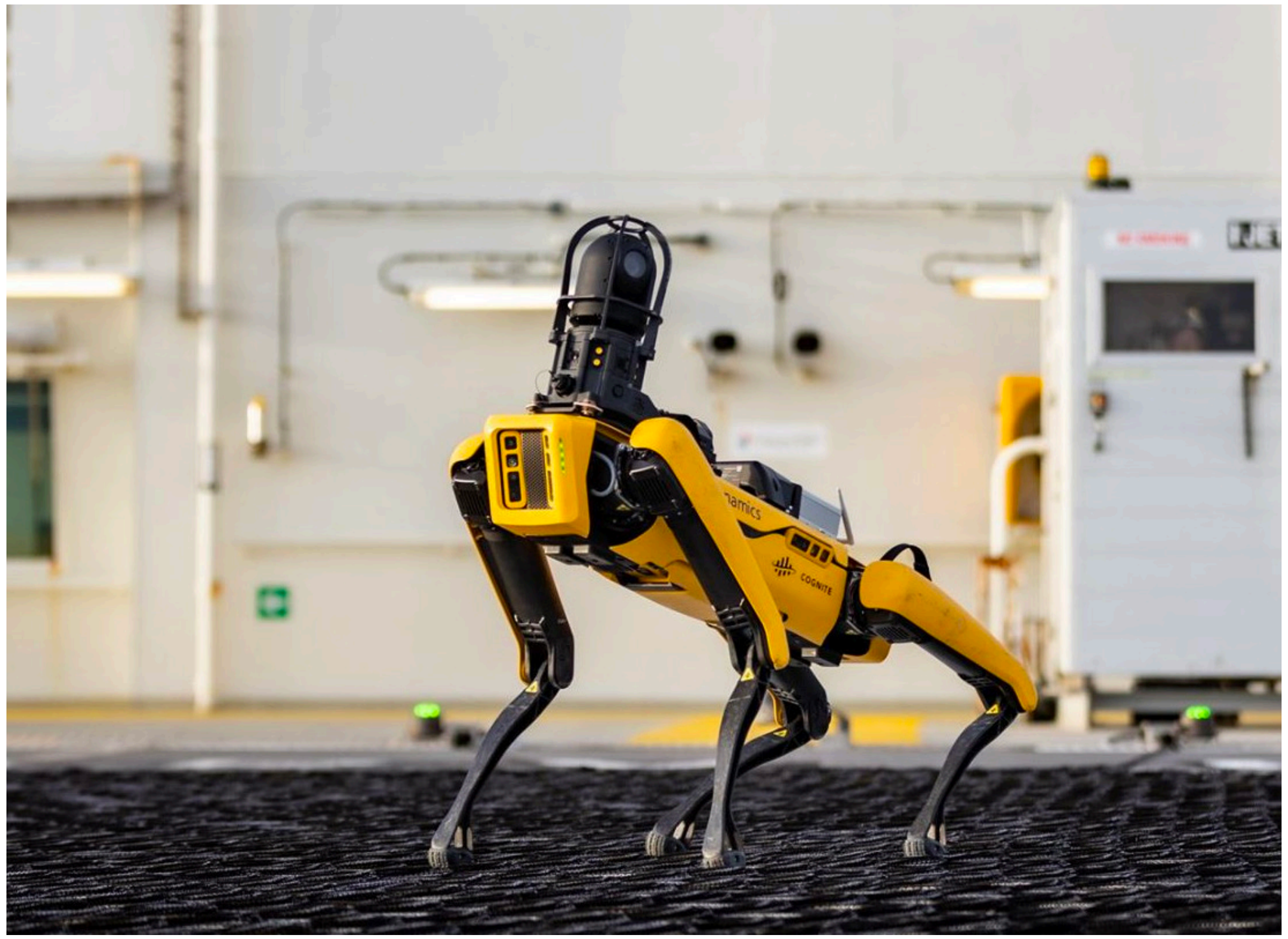


(Fig 1)

Figure 1. Spot robot being deployed offshore.
From Cognite. (2022).

ABSTRACT

The fourth industrial revolution has the potential to enable integration of robots to solve various jobs within heavy asset industries such as manufacturing and processing, to create a safer and more efficient work place. One of the jobs potentially fit for robot integration is in asset performance management (APM), and routine monitoring of equipment such as pumps, pipes and gauges.

But in order to fulfil the potential of this integration there are many unsolved challenges related to the trust, transparency and reliability in the interactions between humans and robots.

This diploma project will therefore explore how interaction design can contribute to the collaboration between humans and robots when planning, executing and monitoring autonomous inspection of equipment. The exploration will be done in InRobot, an industrial application currently under development by the Norwegian software company Cognite.

TABLE OF CONTENTS


BACKGROUND
RESEARCH
DEVELOPMENT
DESIGN
REFLECTION

(Spot doing coffee spill detection)

MOTIVATION

My first encounter with an industrial four legged robot was in the kitchen area of the Cognite offices during a design internship the summer of 2022. As I walked into the kitchen I saw an engineer and a Boston Dynamics Spot robot looking for coffee spill on the floor. It was a test using the Robot to discover for example oil spillage using machine learning. I was very intrigued by how the engineer was collaborating with the robot through digital interactions on a tablet. The engineer was not controlling the robots every move, they were collaborating, trying to discover coffee stains, together. From both a design and a personal point of view this seemed like a very interesting and fun area to explore, which eventually led to this diploma project.

COLLABORATOR

My collaborator in this diploma project is Cognite, a Norwegian SaaS company working with contextualizing industrial data. This collaboration has opened the door to expertise, knowledge and hardware otherwise difficult to acquire as a student working with robotics and heavy asset industries.

Within Cognite I've collaborated with the InRobot team, consisting of: back-, frontend developers and robot scientists. Throughout the entire diploma project I have been included as a part of the team by being invited to everything from standups and field trips, to socials and sprint planning. This cross disciplinary collaboration with a product development team has been important for the design to evolve holistically and realistically.

Cognite also has a strong design team consisting of over twenty designers. Throughout the project I've been fortunate to share designs in weekly design reviews and through casual meetings, which has been a great way to test and validate my development. The designers at Cognite also have experience and insights from working with heavy asset industries that I've been fortunate to build on.

I have spent most of my time working on location at the company offices in Fornebu, which has lowered the bar for sharing and learning from other employees while strengthening the validation of the design and insights.

(Fig 2)

Figure 2. The Cognite logo. From Cognite. (n.d.).

(Fig 3)

Figure 3. Blue equipment pump. From Superior Pumps. (n.d.)

CONTEXT

All over the world there are factories, plants, facilities and platforms that produce a wide range of products from consumer goods to heavy equipment and machinery. Even though these heavy asset industries might produce different things, they have many things in common, like equipment. Pipes, pumps, generators and valves or some variation of this. But its not only the amount, or type of equipment that varies. Depending on what the facility is producing there is also differences in the exposure to toxic materials, noise levels, trip hazards and moving parts. To optimize the performance, reliability and safety of the equipment in these heavy asset industries there is usually someone or something on the floor monitoring the equipment, making sure everything is running smoothly, and that is the context of this diploma.

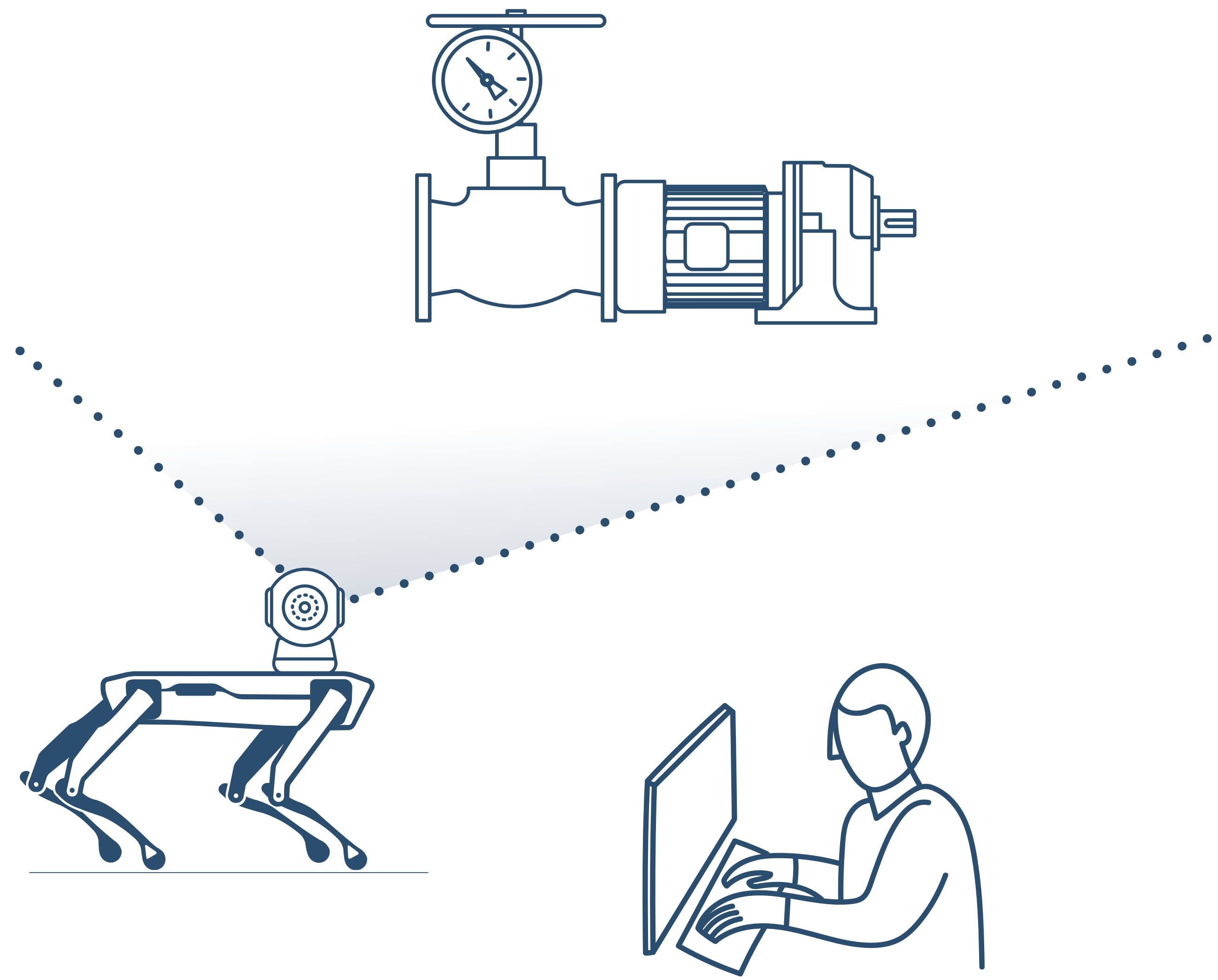
INROBOT APPLICATION

InRobot is a desktop application currently being developed by the InRobot team at Cognite. The goal of the application is to enable autonomous equipment monitoring in industrial facilities using robotics and potentially drones. The core functionality is focused on setting up inspection rounds by selecting locations and equipment in a 3D model, then selecting actions like taking a thermal image or record a video of the selected equipment. After planning an inspection round in InRobot, the users should be able to schedule and run the inspection round before finally reviewing the data from the inspection remotely to assess the equipment.

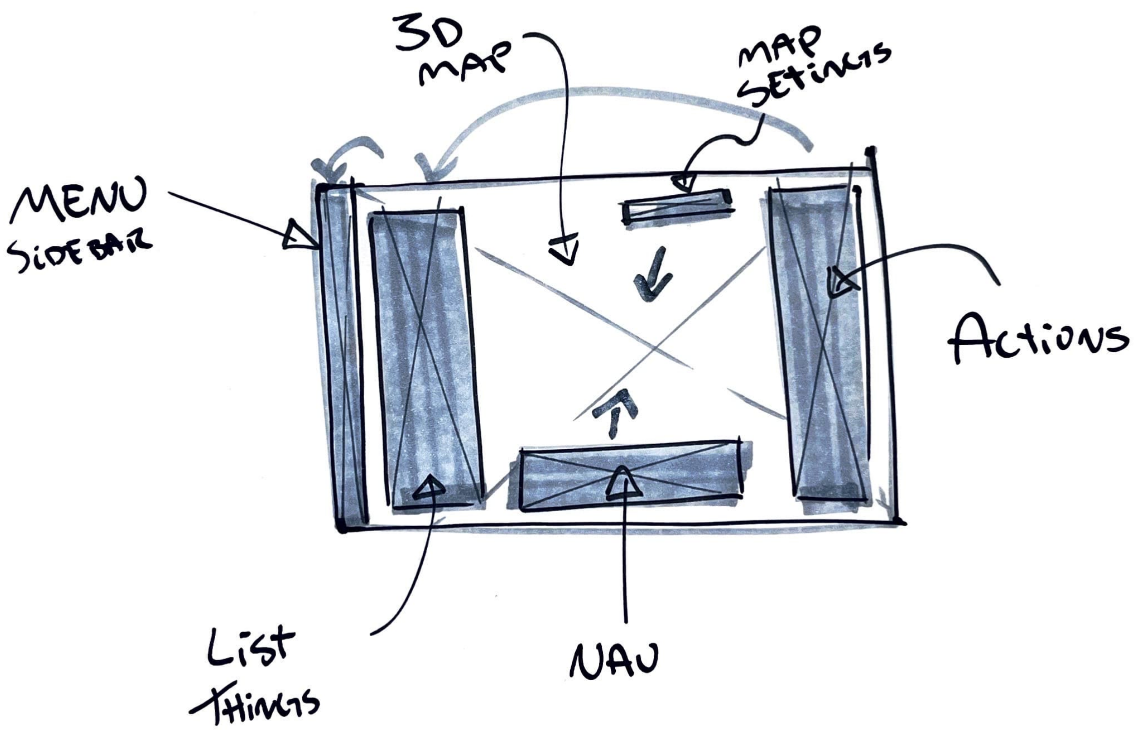
The application is under development and is not publicly available, and therefore only have a few early adopters. The InRobot team has had limited design resources when developing the application so far, which has led to the application missing overarching holistic ideas of the user interface and user experience.

THE USERS

The main user in this project is the process operator, who is responsible for overseeing industrial processes to ensure they operate safely and efficiently. The specifics of their role may vary depending on industries, but one of their key jobs is to monitor equipment and report anomalies to prevent accidents and equipment failure.



(Illustration of InRobot)



(Layout flow sketch)

DELIVERY, GOALS AND RISK

My main delivery for this diploma project is screen based interactions and flows for assigning, planning and executing autonomous, industrial equipment monitoring with a legged robot. The delivery should be professional and showcase my skills as a designer, while also creating value for the team I'm collaborating with. I will not focus on the design of the robot itself, only take its needs and requirements into account.

My goal is to present a professional and holistic project where the process and decisions leading up to the designs are grounded in insights, testing and iterations. In a larger perspective the goal is also to explore valuable use cases and future possibilities for robotics.

Working with robotics and remote equipment monitoring in an heavy asset industries is a risky project because of the complexity of robotics, the domain and time constraints of the project.

DESIGN CONTRIBUTION

Asset performance management and robotics is usually a field populated by engineers and scientists. As a designers I wanted to add value by focusing on the human aspects of the digital interaction. Not only designing for pleasant and efficient experiences, but also taking trust and collaboration between humans and robots into account.

I have contributed to the InRobot application with design, concepts and research of small things like icons and buttons placements, but also larger tasks like overall layouts and flows.

NDA AND PHOTOS

Some names of companies and places have for the sake of a non-disclosure agreement been anonymized. They will therefore only be referred to as a facility, off-shore ship or waste water plant. The same goes for users or people with only a first name.

All images not referenced to a source have been taken by me.

RESEARCH METHODS

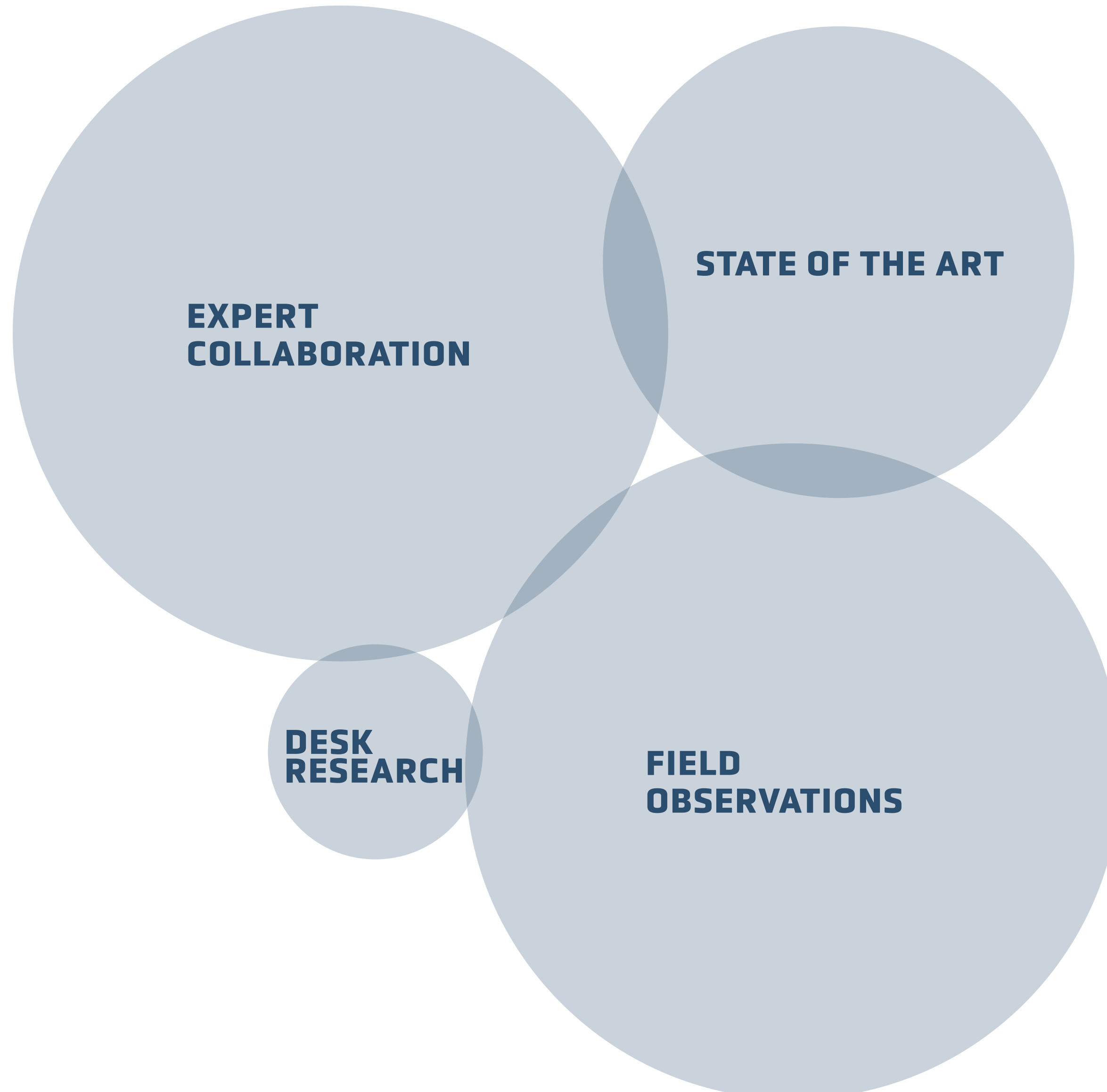
My three main research methods has been expert collaboration, field observation and state of the art research.

I've been fortunate to have a continuous expert collaboration with robotics engineers, computer scientists, engineers from oil- and gas sector and experienced designers. In addition to structured interviews, the knowledge sharing has largely happened over a coffee, in workshops and meetings.

Field observations has been an important method for learning more about users, their work environment and needs. Being able to be out in the field testing the application and robots has played big part in understanding both where the application can bring value to the user, and the challenges related to it. In addition to going on field trips in person, I've also been given material and insights gathered from other designers on relevant field trips.

Finally, during the development and design of components in the application I've drawn inspiration from researching state of the art applications. Strategy games, route planners and robot vacuum cleaner apps are some examples that all contain elements that are relevant to robotics.

In the following chapter I will go through the insights from the three research methods; expert collaboration, field observations and state of the art.



(Research methods scaled after focus)

- BACKGROUND
- **RESEARCH**
- DEVELOPMENT
- DESIGN
- REFLECTION

EXPERT COLLABORATION

Equipment monitoring is a complex process, and without the expert collaborations it would be difficult to gain an understanding of its inner workings. I've learned not only about the asset performance management domain and robotics, but also about the implementation of UI-design in front- and backend of the application. The research presented in this section is a synthesis of what I've learned from this collaboration

COGNITE

Ana Gheorghe
Software Engineer
Front end

Niek Beckers
Software engineer
Tech lead

Atussa Koushan
Software Engineer
Front end

Kristoffer Solberg
Software engineer
Back end

Elias Bjørne
Product manager

Sara Vinje Aalbu
Software engineer
Back end

Sam Medrington
Designer

Aleksandra
Subject matter exp.

USERS

Rob
Automation engineer
Offshore ship

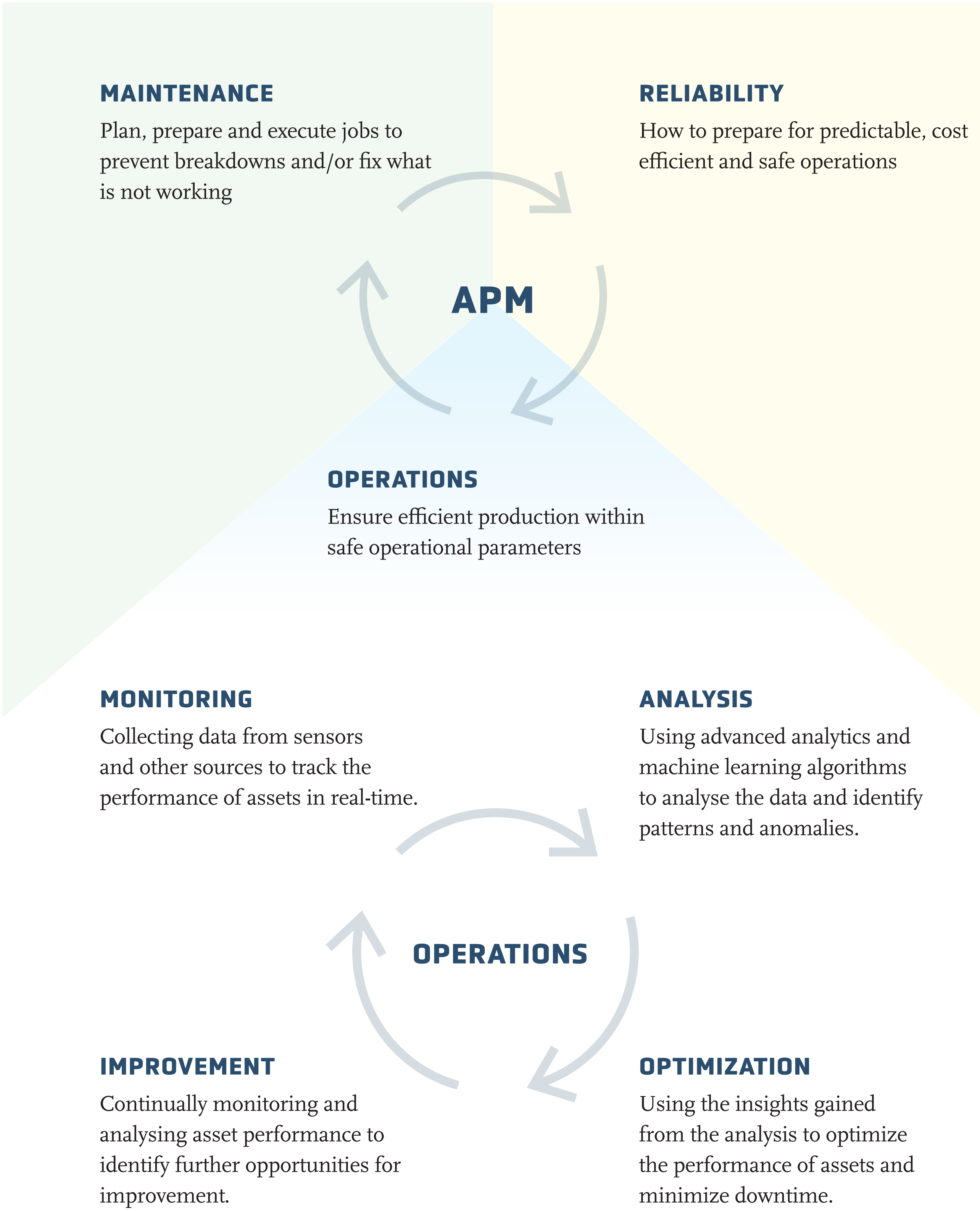
Nel
Chief Geologist
Offshore ship

Steven
Chief Engineer
Offshore ship

Terje
Process operator
Oil refinery

Mosse Sjaastad
Diploma supervisor
AHO

(Expert network)



(APM system illustration)

ASSET PERFORMANCE MANAGEMENT

Asset performance management (APM) is a process focused on optimizing the performance of assets by maximizing the efficiency and availability, while minimizing their downtime and maintenance costs. APM is applied to a wide range assets linked to industrial equipment and machinery in manufacturing and production processes.

APM has three main stages that form a cycle of actions. This project is focusing on the operations steps, monitoring and analysis within operations.

Technological developments such as machine learning, artificial intelligence, sensors and robotics are some of the tools used in operations to monitor assets in real time and identify potential problems before they occur. But in many cases this is still based on paper and Excel sheets.

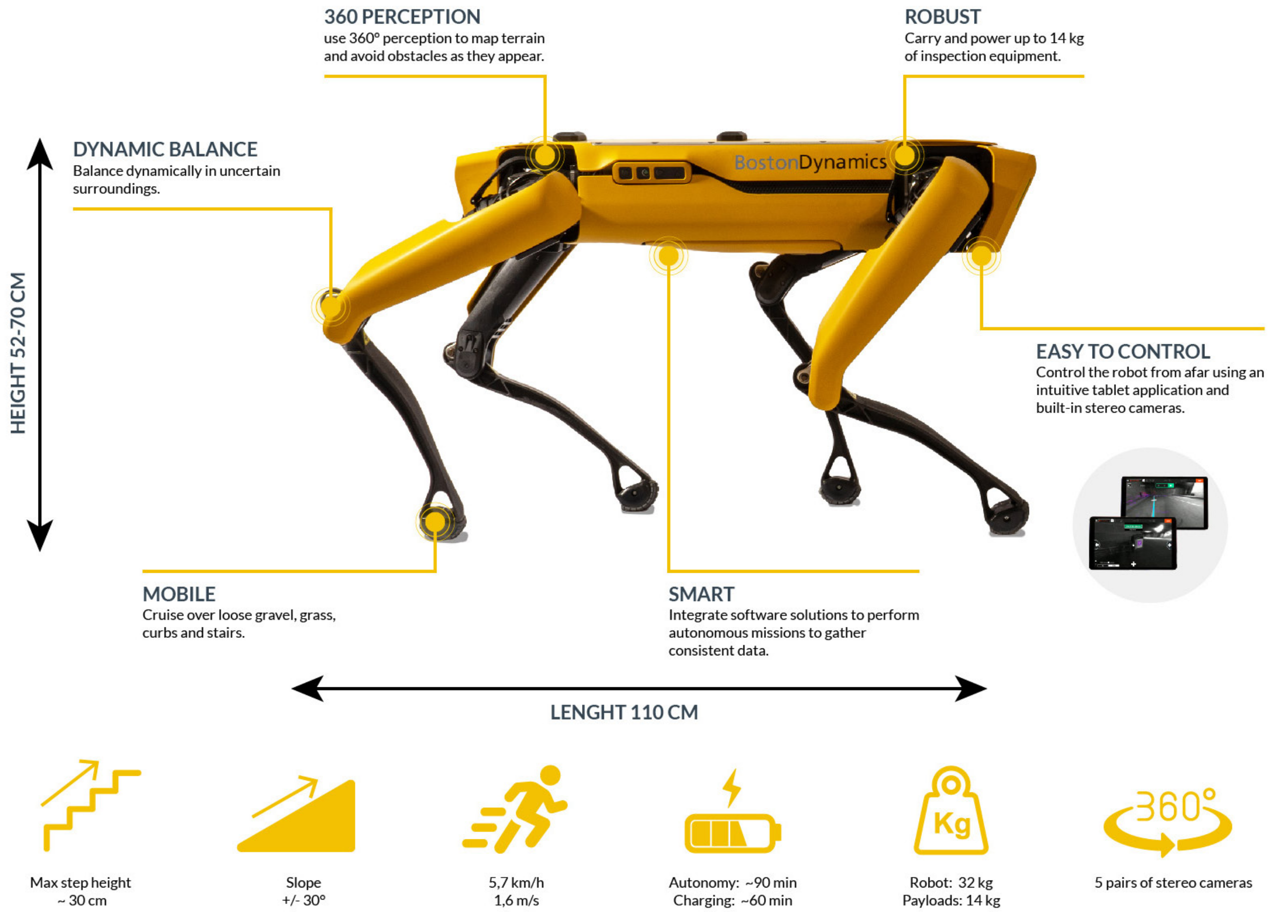
PROCESS OPERATOR

Based on existing research and experience from my collaborators I was able to get a general understanding of the process operator, which created a good foundation for further exploration.

The process operators are the main user in InRobot. His/her main job is to monitor equipment on location. Even though the job title and equipment they monitor may vary depending on if he/she is working in a process facility or on an oil platform, the tasks they solve are similar. Often they will run routine inspection rounds on equipment to detect anomalies to prevent equipment failure that can lead to operation down time, or even worse accident. The equipment they monitor can range from pumps and motors to pipes and gauges, and the frequency of the inspection rounds vary from hourly, daily, weekly, monthly and yearly. Depending on the facility, the number of equipment or inspection points can be in the hundreds. In addition to being a repetitive job, it sometimes requires the operator to work in rough conditions being exposed to loud sounds, high temperatures and large moving equipment.

While running the inspection rounds the data is usually collected on paper or on a tablet that the operator carries with him/her. It is then passed on to the operational lead that has the responsibility of having an overview of the state of the facility or area.

(Process operator in field, image credits: Cognite)



(Fig 4)

Figure 4. Spot specifications. From Intuitive Robots. (2022).

ROBOT

The second main user in InRobot are the robots, in the case of this diploma a Boston Dynamics Spot. A four legged agile moving robot capable of traversing challenging terrain, climb staircases and navigate through tight spaces. A key feature for Spot is the modular design, enabling the robot to carry various payloads such as 360 degrees cameras, gas sensors and pan, tilt and zoom cameras making the robot suitable for different types of inspections. Combined with its ability to move autonomously, this is what differentiates it from using sensors or stationary cameras. Instead of installing numbers of specialized cameras and sensors on equipment.

Although an impressive robot, Spot has requirements and limitations just like humans do that are important to understand when designing for the interaction between the process operator and the robot.

One such requirement is how Spot understands it surroundings. In order to be able to walk autonomously to a specific point in a 3D-map, Spot first needs to familiarize itself with the area. This is usually done by a remotely controlled walk referred to as training, where a person guides the robot on a location using a tablet. Every two meters, the robot saves a waypoint. When Spot has created a network of these waypoints, it's able to autonomously find its way back to a previous visited waypoint. Spot also has limitations like limited battery time of about an hour and the need for a stable network connection.

SOCIAL

INDUSTRIAL

(Range of robots, focus on industrial)

TEAM PLAYERS

Through the expert collaboration I was introduced to the literature on automatic systems and human-robot interaction which brought an interesting perspective and focus on my design work.

Humans have a tendency to anthropomorphize robots, giving them human attributes like 3CPO in Star Wars or Wall-E. Spot on the other hand has more animalistic features, and therefore its natural to zoomorphize, meaning giving it animal-like characteristics, in Spots case a dog or cat. The relationship between dogs and humans is often described as a mutually beneficial one where dogs provide humans with companionship, protection, and assistance, while humans provide dogs with food, shelter, and care. This close relationship has led to dogs being considered "man's best friend».

When comparing the human-robot collaboration with a human-dog relationship it reveals many similarities. According to Jane Malin and her research paper "Preparing for the Unexpected: Making Remote Autonomous agents Capable of Interdependent Teamplay" in order for:

> "any non-trivial level of automation to be successful, the key requirement is to design for fluent, coordinated interaction between the human and machine elements of the system. In other words, automation and intelligent systems must be designed to participate in team play" (Malin, 1991).

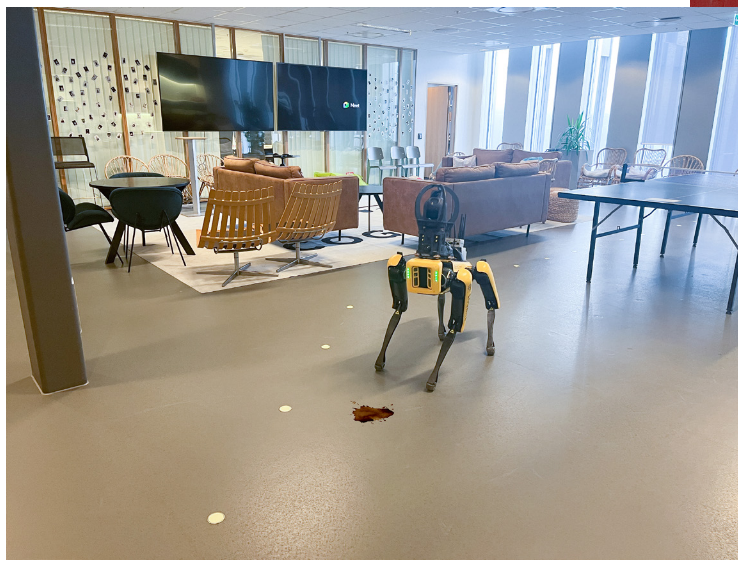
And according to Christoffersen and Woods to achieve this team play:

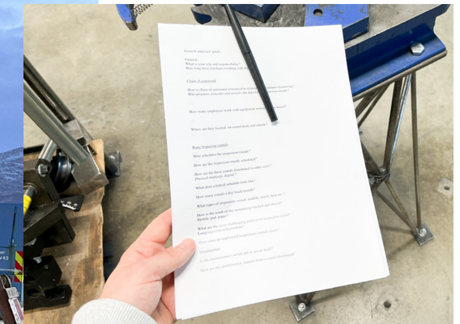
> "there are two fundamental characteristics which need to be designed in from the beginning: observability and directability. In other words, users need to be able to see what the automated agents are doing and what they will do next relative to the state of the process, and users need to be able to re-direct machine activities fluently in instances where they recognize a need to intervene." (Christoffersen & Woods, 2002)

Thinking of the relationship between humans and robots as teams rather than a human controlling a machine has been important for my framing my design work. I see team play as collaborative, coordinated actions where people and machines contribute with complementary skills, working towards a common goal. And for this team play to happen, observability and directability has to been in place.

(Fig 5)

Figure 5. Behind-the-scenes image from Star Wars: Episode IV - A New Hope. From Lucasfilm. (n.d.).





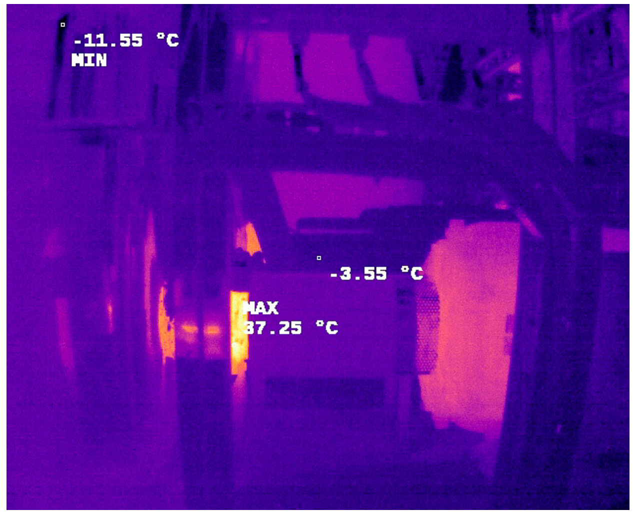
FIELD OBSERVATIONS

One thing is gathering insights from experts and desk research, another thing is going out in the field and experiencing the working conditions and talking to the users in person. I've been fortunate to test and interact with users and Spot in realistic surroundings from the Cognite offices, to testing it on board an off-shore ship. These are some of the key observations and insights from the field observations.

OFFICE TEST

The InRobot team has a Spot robot available at the Cognite offices, enabling us to run continuous testing of the application and robot. This opportunity to interact with both the robot and the application in real life on a regular basis has been a valuable way of seeing the application from a users perspective.

(Remote controlling spot using a tablet)



(IR-image of coffee machine taken by Spot)

REMOTE CONTROLLING

Even though many of us are getting familiar with controlling a robot vacuum cleaner, remote controlling a $100k robot dog in a crowed office space feels different. The 360° camera live feed becomes the only reference to the robots surroundings, and the nature of the cameras makes judging distances very difficult.

CAPABILITIES

The advantage of Spot is its capability of carrying different kinds of equipment, and the variety of data they're able to collect. By attaching a IR-camera we're able to read the heat signature of a coffee cup. With a pant, tilt and zoom camera we can point and zoom onto areas of interest. And with the 360° camera we can capture a full 360° view of a location.

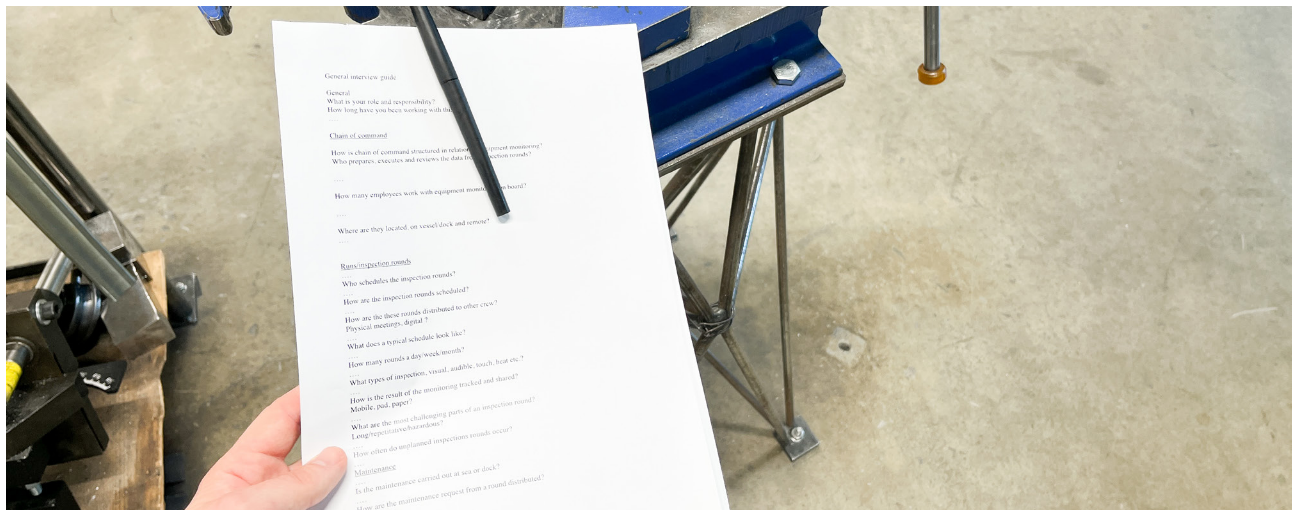
(Spot blocking the door to the coat room)

ROBOT PRESENCE

At the Cognite offices, the presence of a Spot robot is no longer a novelty for employees. Instead of the curiosity and excitement that many people show when encountering Spot for the first time, some find the noise from its cooling fans and mechanical legs disruptive during meetings, and it takes up physical space when charging or moving.

OFFSHORE VESSEL

Working with robotics is exciting, and sometimes it can be easy to design in a vacuum. A field trip to the west coast of Norway and a large off-shore ship was therefore more than welcome. We were able to interact with potential users and test the application over two days.



(Interview guide)

PLANNING AND INTERVIEWS

Prior to departure I wrote a interview guide to come prepared. Since the crew on board was working the whole time while we were there, they were not able to set up and arrange interviews in advance, which meant I didn't know who I would be able to talk to or for how long. The main goal of the interviews was to gain insights on how the crew on-board work in relation to equipment monitoring, and explore the usage of robotics on board the vessel.

During the two days on board I was able to interact with several crew members working in different departments and areas from engineering to maintenance on the ship. Some conversations lasted two minutes, others for half an hour.

(Crew interactions)

AUTOMATION FIELD ENGINEER

The automation field engineer plans maintenance and upgrades for the back deck of the ship while on board during docking periods. They plan how and where to fit new equipment, and how to carry out maintenance tasks before coordinating with technicians. Because the ships is only docked for weeks at the time they work within tight time limits.

Sometimes they do the planning remotely by video-chatting with crew on board, but this is often unreliable and time-consuming due to poor connections.

The engineer I talked to saw big potential using robotics to potentially do this planning remotely using 360° images and video as references.

(Engine room offshore vessel)

CHIEF ENGINEERS

The chief engineers main responsibility is the engine room which is located in the ship hull. Compared to the back deck the engine rooms consists of several smaller rooms, connected by hatches, grated floors, and staircases. The engine rooms are packed with equipment, and this was one of the use-cases we assumed robotics could be a good fit, seen as the crew also did regular inspection rounds.

But seeing the space in person, revealed that is unlikely that a robot or drone would be able to navigate the area without either disturbing the crew working there, or crashing/falling over due to uneven surfaces. Also being a modern ship, a lot of the equipment had censoring technology that could be monitored from the engine room, making the robots role redundant.

(Spot)

GENERAL OBSERVATIONS

Bringing a robot in the field is sure to create attention from the crew. Everyone from the cleaning personnel to captain reacted to Spot when it came walking into their day to day workplace. These reactions were interesting to observe as they ranged from excited to scared. While some crew members walked up to the robot asking it to sit, others turned around and walked the other way.

(Deploying Spot in the field)

(Testing InRobot)

TESTS

While on board we created 3D visual map of the majority of the ship. By creating inspection rounds in the ship, Spot was able to continuously capture 360 images which when compiled creates a «Google Streetview» 3D immersive model of the ship.

Before, during and after these missions we recorded time, battery usage and any pain points or opportunities we saw while using the application out in the field. This opened up for several concepts related to live observability and directability.

WASTE WATER PLANT

This field trip was done by other members of the InRobot team, and the insights presented are based on their research. Over two days the team was testing the InRobot application with Spot, running equipment monitoring tests in an outdoor oil refinery and waste water facility.

(Fig 6)

PROCESS OPERATOR

During the field trip the team was able to learn details about the process operators. His/her main job it is to do routine inspection on the equipment at the facility. Every two hours the process operators would go on inspections rounds lasting up to 1.5 hours.

At the part of the oil refinery the process operators were operating they always had to go in teams of two, and wear full protective equipment including masks, goggles and gloves to reduce toxic and noise exposure, as well as the risk of any physical injuries.

Figure 6. Police officers at the Kingwood wastewater treatment plant. From Houston Chronicle. (2019).

(Inspection round paper)

INSPECTIONS

When further investigating how the process operators performed their rounds and evaluated the status of the equipment they explained that they listen, touch, look and sometimes smell equipment. Based on their experience and by comparing data the process operators are then able to evaluate the equipments health.

Vannrenseanlegget framstod i all hovedsak som et åpent anlegg og en betydelig kilde til avdamping av VOC og benzen. Anlegget bar preg av å være gammelt og nedslitt og med et stort og løpende vedlikeholdsb[redacted] høyde med dagens industristandard. På [redacted]

Denne delrapporten viste at enkelte arbeidstakere tilhørende ytre anlegg på Mongstad hadde en støyeksponering som oversteg grensen på gjennomsnittlig 85 dB(A) over et 8 timers arbeidsskift. Det kunne ikke under tilsynet fremskaffes nyere måleresultater som

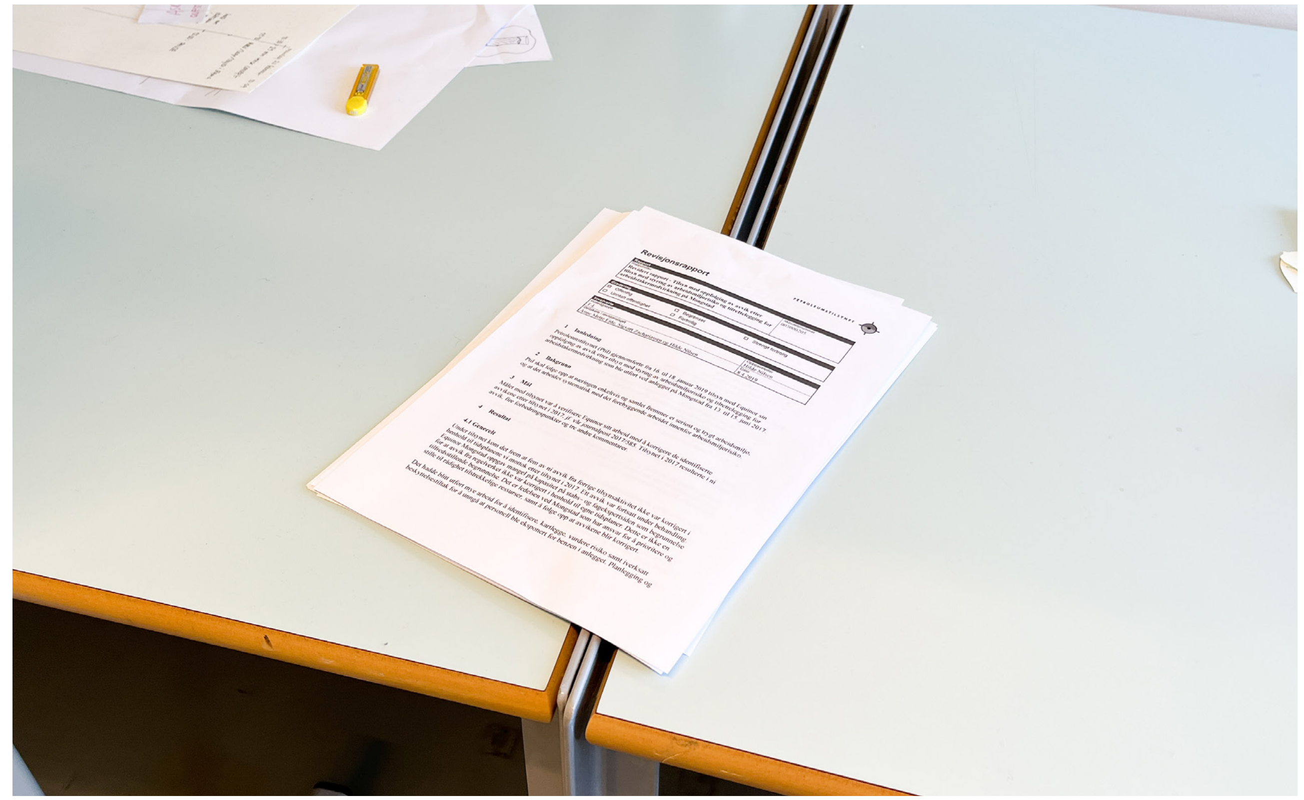
(Fig 7)

MONGSTAD REPORT

When researching the working conditions for process operators in other oil refineries I discovered a report from the Petroleum Safety Order Norway after an inspection at the Equinor Mongstad oil refinery in 2017 in Norway. This report shows the seriousness of the working conditions for some of the process operators.

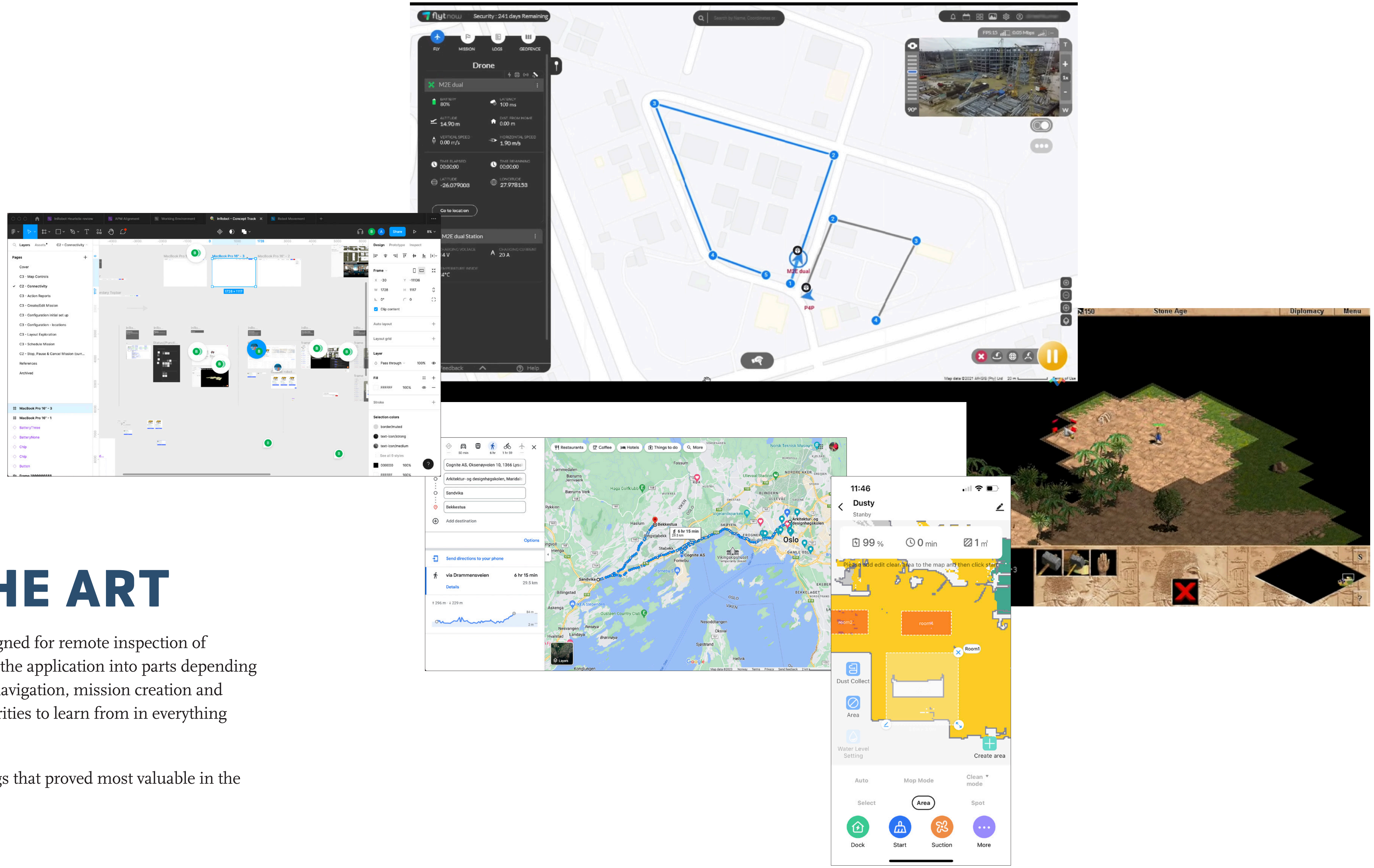
«The water treatment plant appeared essentially as an open plant and a significant source of evaporation of VOCs and benzene. The facility had the impression of being old and run-down and with a large and ongoing need for maintenance. It was a facility that is not up to today's industry standard. At the time of the supervision activity, there were under 8 planning and execution of work which is comprised of 10-15 people for various maintenance tasks in the water treatment plant. This requires that many employees may be exposed.» (Petroleumstilsynet, 2019)

Figure 7. Screenshot from tilsynsrapport. From Petroleumstilsynet. (2019).



(PTIL report)

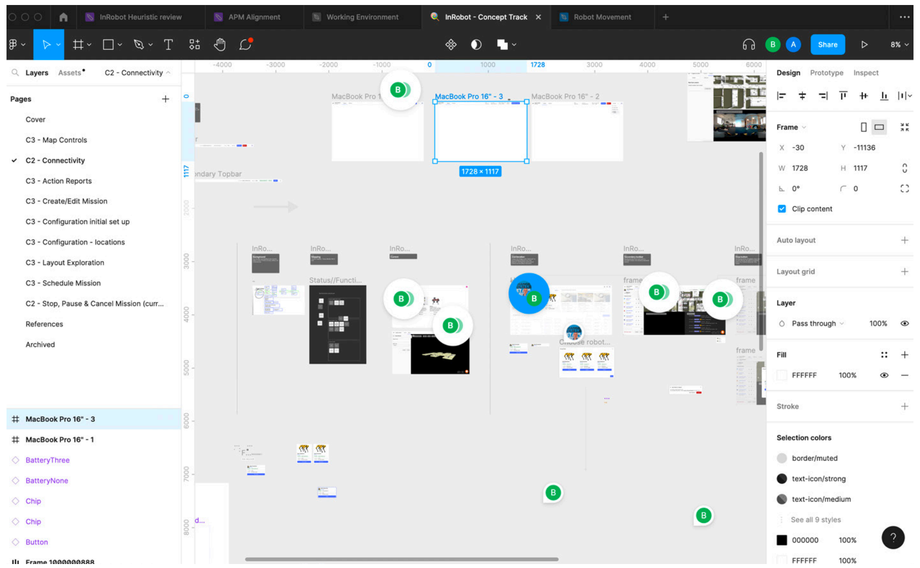
Benzene is classified as carcinogenic by the International Agency for Research on Cancer (IARC); meaning it has the potential to cause cancer. In addition a previous measurement of noise levels at the facility showed that some workers were exposed to noise levels over the limit of 85dB average on a 8 hour shift.



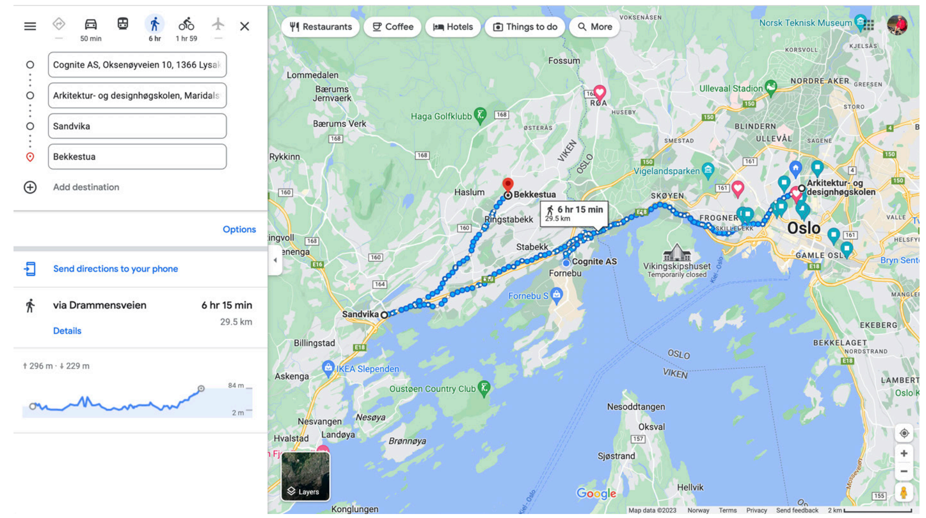
STATE OF THE ART

There are not that many applications designed for remote inspection of equipment using robot. But by separating the application into parts depending on their functions like for example; map navigation, mission creation and route planning it was easier to find similarities to learn from in everything from strategy games to Figma.

The research presented here is the findings that proved most valuable in the development process.



(Screenshot Figma)



(Screenshot Google maps)

GENERAL LAYOUT AND FLOW

Having one main work area in the centre of the screen accompanied by action toolbars and side panels is an established pattern in many applications from Photo Shop to Excel. Another example is Figma, which is used by many designers. Figma has a very consistent pattern in the main work page. Central and always visible is the workspace where the design is done. The left side panel is related to the content, hierarchy and grouping, while the rights side panels shows actions related to the selected element. This gives the user overview and quick navigation of elements on the left, while giving very detailed actions on the right removing the need for moving back and forth between pages and tabs.

I used this as inspiration for the main workflow in InRobot, using both a left and right side panel.

MISSION CREATION

Isolating the event of creating an inspection round has many similarities to planning a trip in Google maps. The users sets a starting point, a means of transportation and searches for relevant places they want to go, thereby building their route. Once set, the user gets a visual representation of the route, estimated time usage and an option to start which is relevant feedback for the user.

Google map is one of the most used map applications in the world and has many established patterns, therefore learning about the UI components and flows of building up a trip became valuable in creating a mission in InRobot.

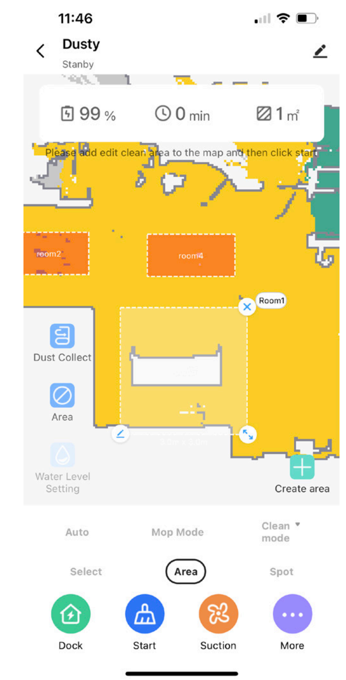
(Fig 8)

REMOTE LIVE FEEDBACK HUD

When observing the robot moving around in the 3D model, it's hard not to think about strategy games such as the classic Age Of Empires. Strategy games has solved many of the key challenges InRobot is facing with giving clear feedback and control of what is going on in the design of the heads up display (HUD).

Using this screenshot as an example, The Egyptian woodcutter status card, actions panel, mini map and top bar status field are all elements that contribute to giving the player an understanding of what's going on. When comparing strategy games over time, not much has changed indicating that the patterns have stuck. I found this to be a great example of observability and directability.

Figure 8. Screenshot from the video "Age of Empires 1 Gameplay" by SergiuHellDragoonHQ(2022) at 00:35.



(Screenshot SmartLife app)

VACUUM CLEANER

The use of robot vacuum cleaners and lawn mowers has become more common, and many people are used to managing, controlling and scheduling these robots. Looking at the SmartLife app for example reveals several ways of giving the user an overview of where the robot is, and what its doing. Also here there are several examples of observability through the 2D map and the status top bar. While the bottom part of the screen is reserved for directability with actions like dock and start. These buttons also have different states depending on what the robot is doing. Start will change to stop, once pressed for example.

RESEARCH SYNTHESIS

My research has focused on understanding asset performance management (APM) in heavy asset industries, and how robotics can contribute and fit into equipment monitoring. It has also focused on defining the process operators user needs and searched for inspiration on how to shape the application.

I adopted three primary research methods: expert collaboration, field observation, and state-of-the-art research.

Through the expert collaboration with Cognite, I was able to work closely with robotics engineers, computer scientists, engineers from the oil and gas sector, and experienced designers. I learned about APM, robots, the process operators and researched human-machine collaboration.

During the field observations I was able to experience the work environment of the users, and do semi-structured interviews with automation engineers and machine room operators to get a better understanding of their needs and requirements. I was also able to build on research and field observations done by the team.

Finally I've researched state of the art application and games from Google Maps to Age Of Empires to draw inspiration and learn about their conventions.

KEY INSIGHTS

1 APM

Is the process of optimizing performance and safety of equipment. Usually done by process operators and sensors and cameras.

2 PROCESS OPERATOR

The person responsible for inspecting equipment. They look, feel, listen and smell equipment to assess it state. Sometimes a dangerous job.

3 SPOT

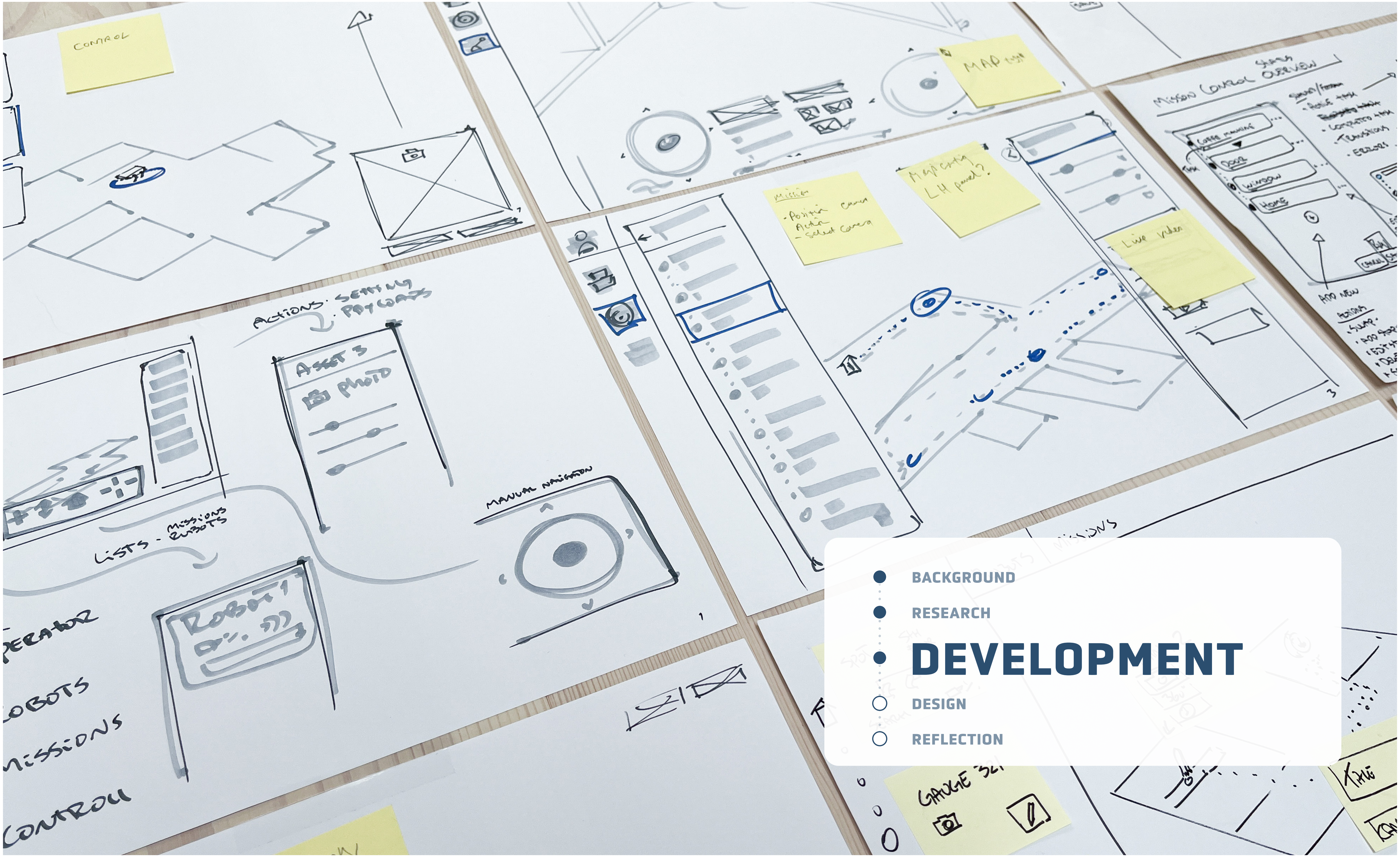
A four legged industrial robot capable of carrying different sensors and camera. Although an autonomous agile robot, Spot has its limitations in terms of battery time, connectivity and location awareness .

4 TEAM PLAYERS

The key to designing human-robot teams is to design for fluent coordinated interaction, observability and directability.

5 AGE OF EMPIRES

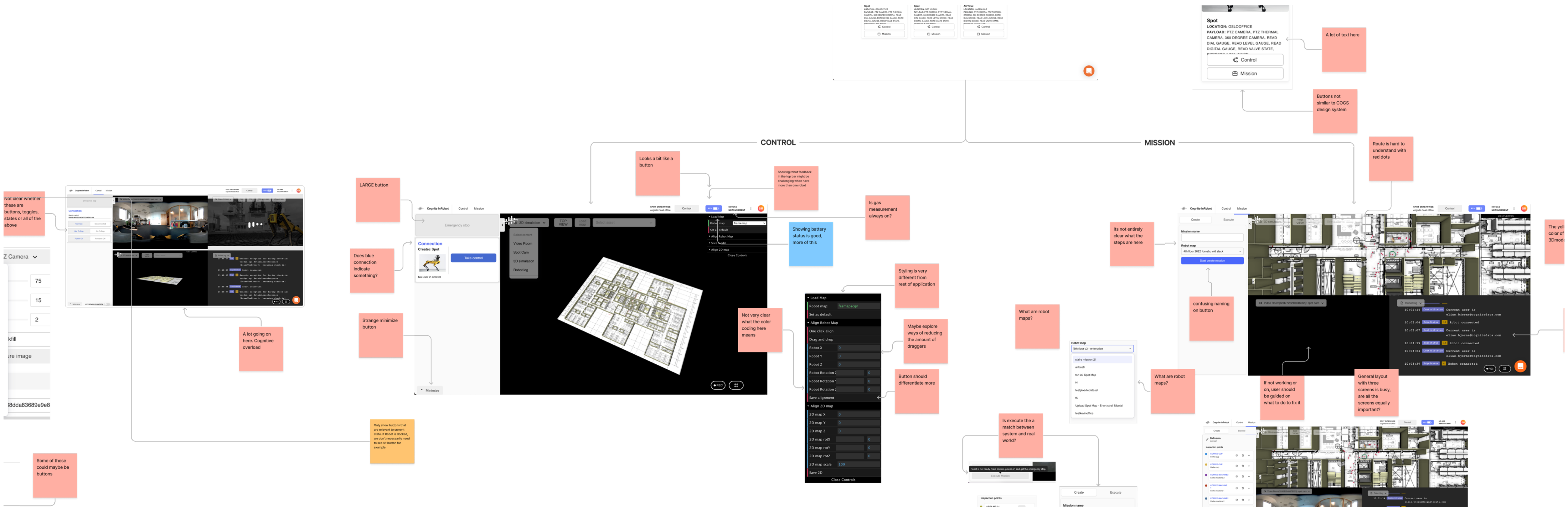
Even though there's not many applications designed for autonomous, remote inspections with robots there are many application that have established patterns and conventions that InRobot can learn from. Like gaming, route planning in maps and robot house hold appliances.



- BACKGROUND
- RESEARCH

DEVELOPMENT

- DESIGN
- REFLECTION

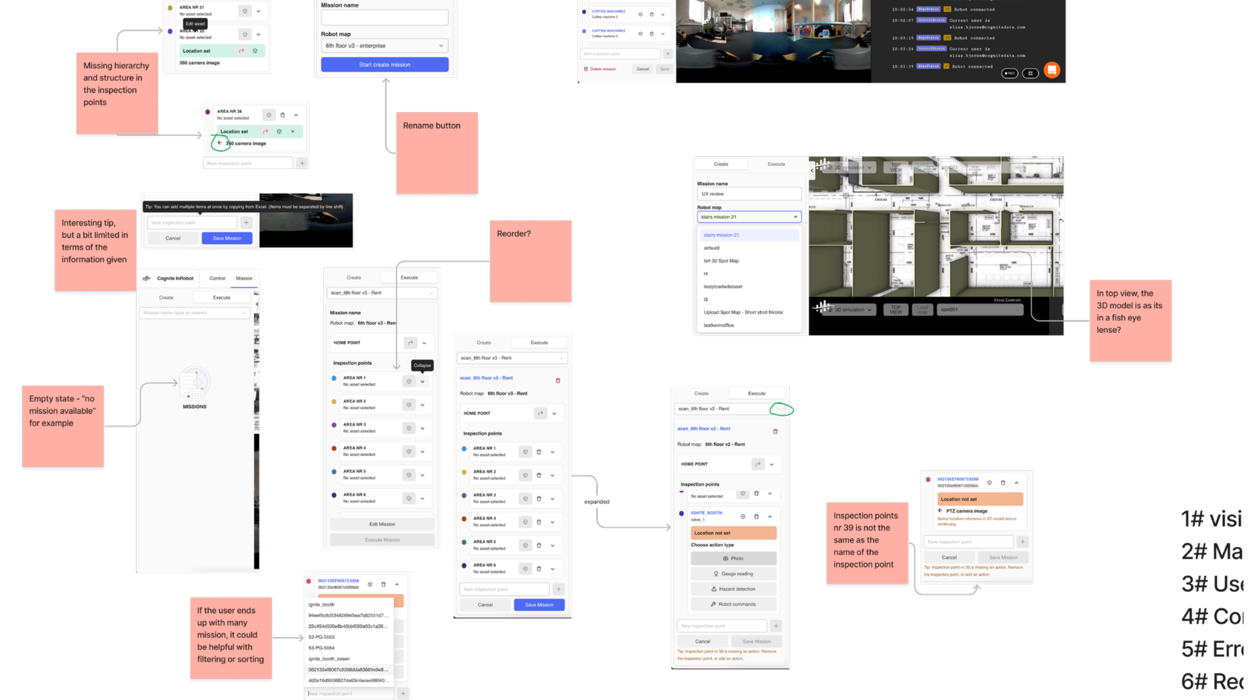


DEVELOPMENT

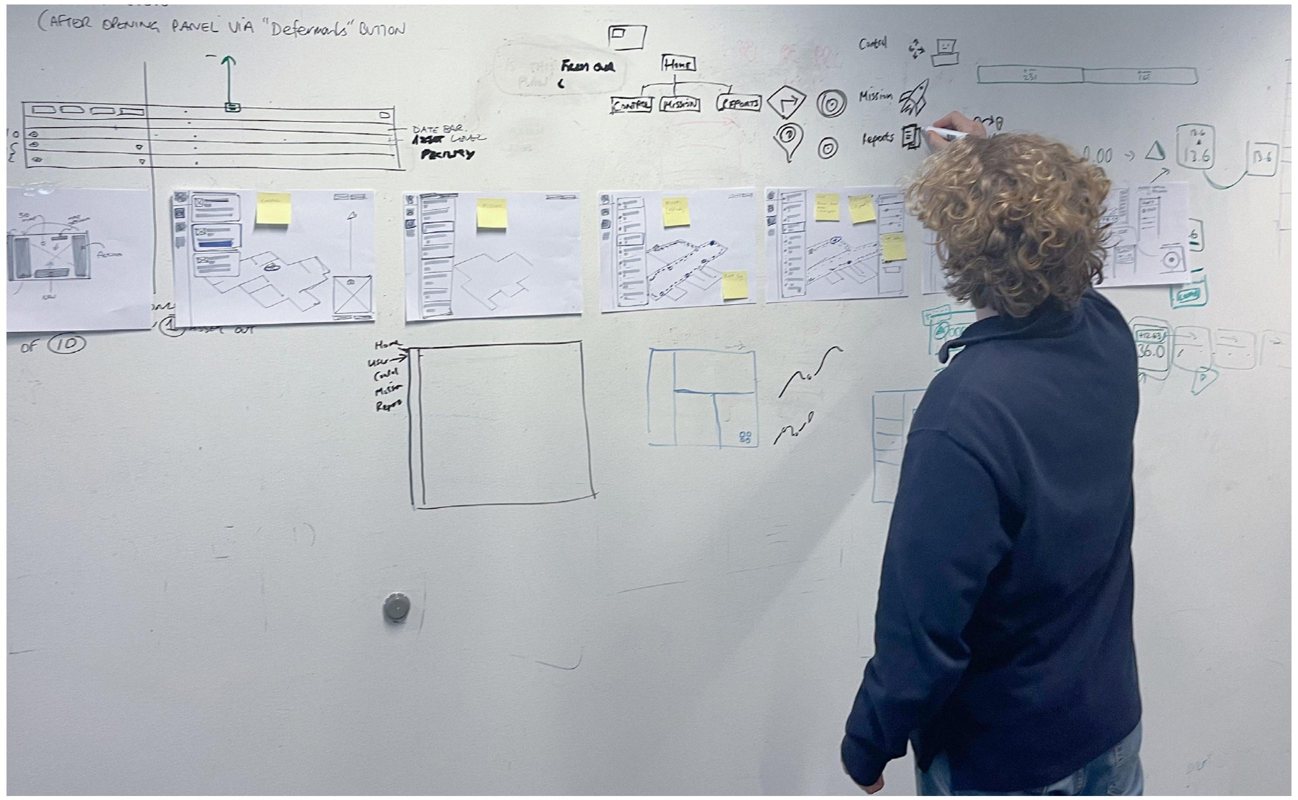
The development phase will show the methods and tools I have used to conceptualize and iterate designs, with the research as the foundation.

HEURISTIC

When I started collaborating with the InRobot team much of the core functionality was implemented. You could for example plan and execute a mission, and remote control the robot in the application which was very impressive. But after having some time to test the application, it became clear that the focus had been on building a proof of concept for showcasing the possibilities in the application, rather than a user-centred experience. In order to capture my initial thoughts I did a Heuristic review, which built a good foundation for learning more about the product, and it pointed out some clear design tasks that I wanted to work on. I used Nielsen Normans Groups heuristic framework, while focusing on observability and directability.



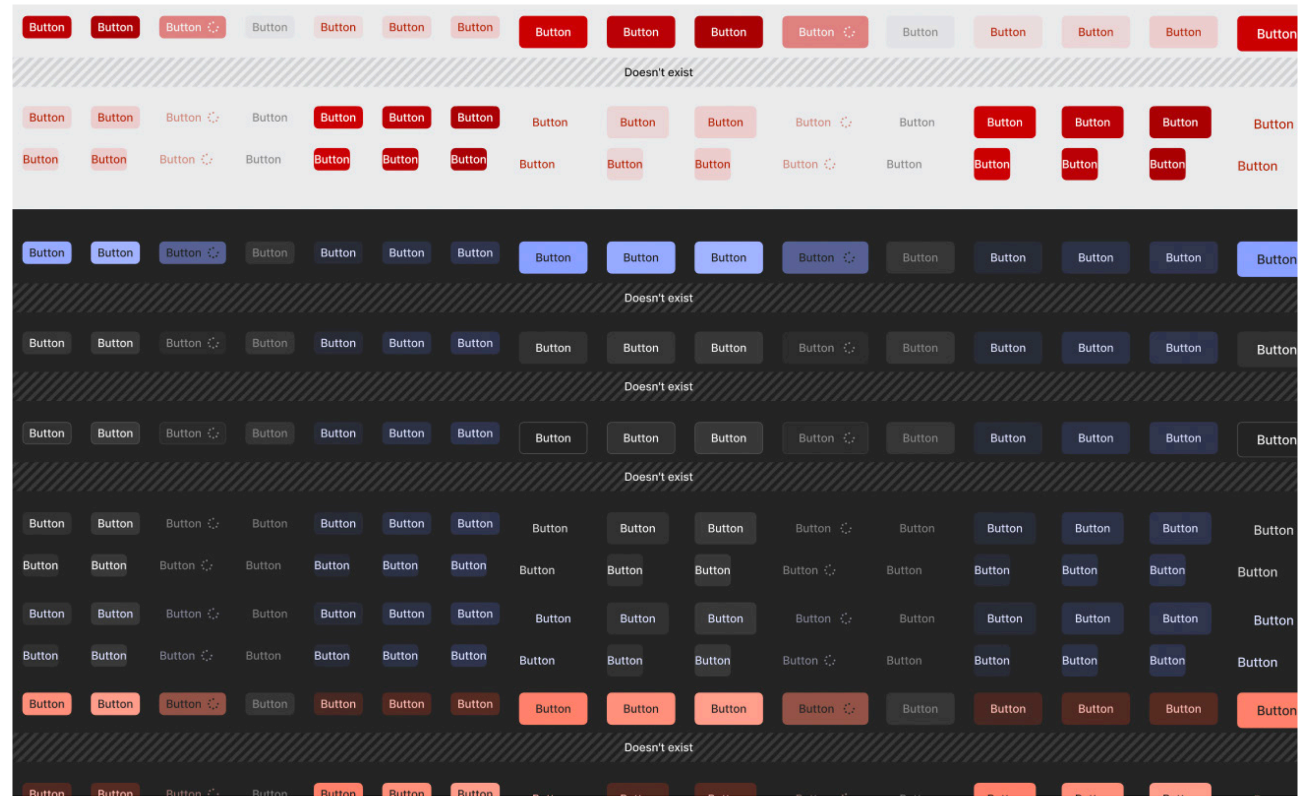
(Screenshot heuristic Figma)



(Visualizing and discussing backlog tasks)

BACKLOG

After capturing my first impression of the current application, I was introduced to the backlog of InRobot. Not having a designer on the team they had several design related tasks that needed attention after feedback from early adopters and testing the application. Many of these matched with my findings in the heuristic like missing feedback on robot, odd button placements and lack of consistency. Getting familiar with the backlog and the background of the tasks was a helpful way of getting a deeper understanding of the needs and features of the application.



(Screenshot buttons in COGS)

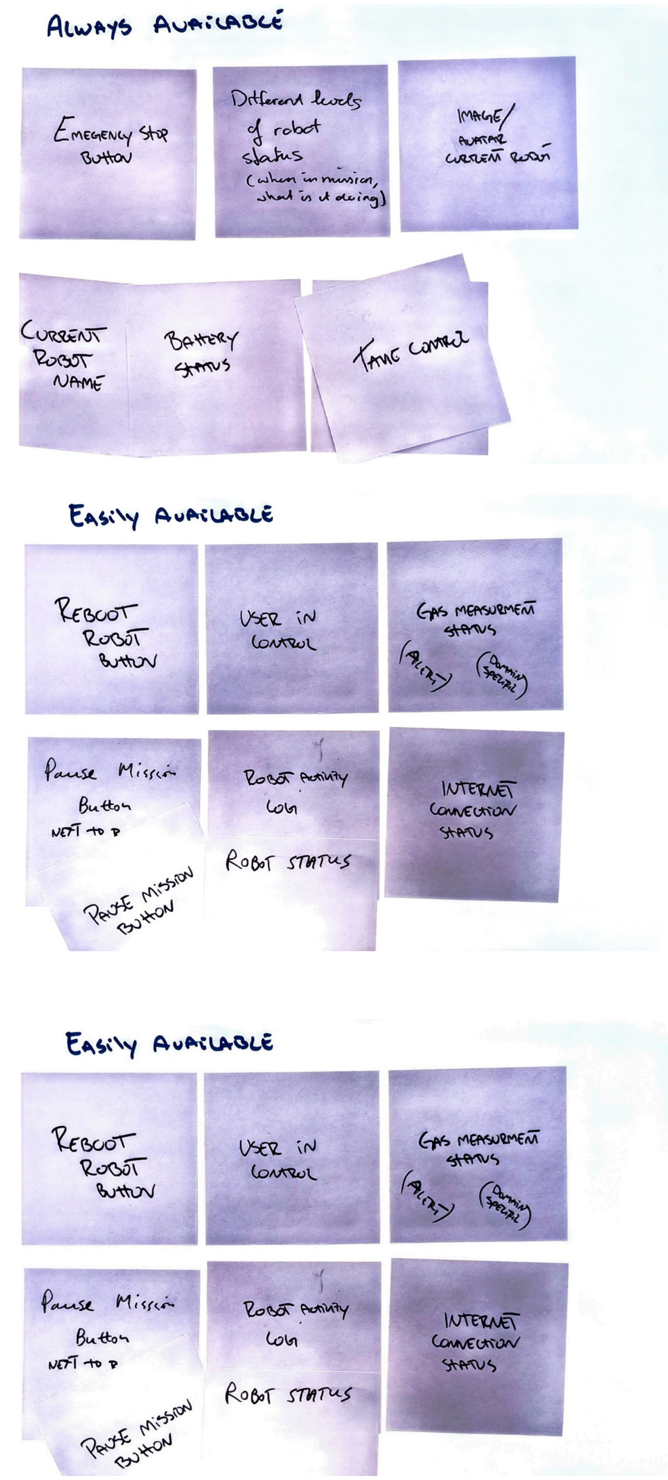
DESIGN SYSTEM AND FIGMA

When building prototypes I have used Figma together with Cognite's design system called COGS. Although a good design system, InRobot require many bespoke components that I have built using the design system as bricks. This work flow enabled me to work faster, while also keeping my designs relevant to Cognite.

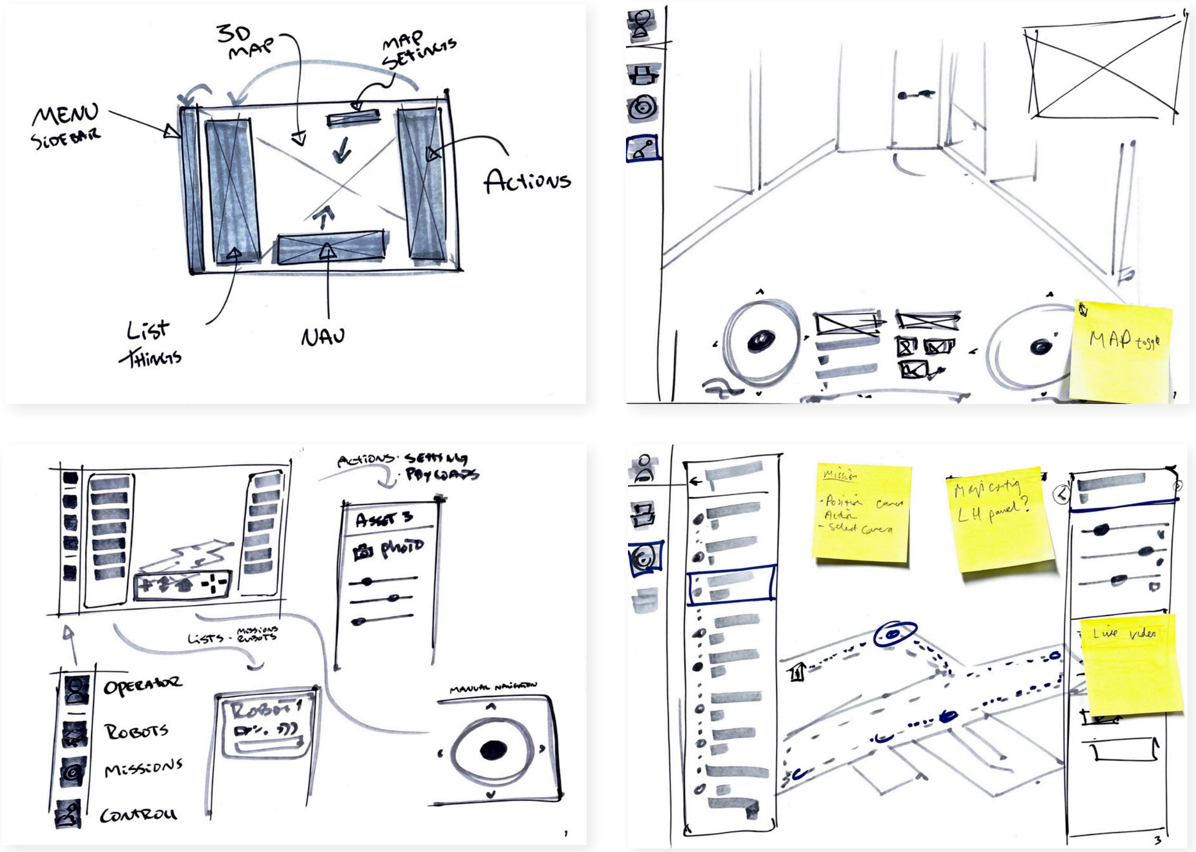
(Mapping workshop with InRobot team)

WORKSHOPS

To learn and collaborate with the InRobot team, I hosted and participated in workshops. Some were simple prioritization exercises with the goal of having a shared understanding of the visual prioritization of components, others were more complex like for example mapping flows for inspection round planning.



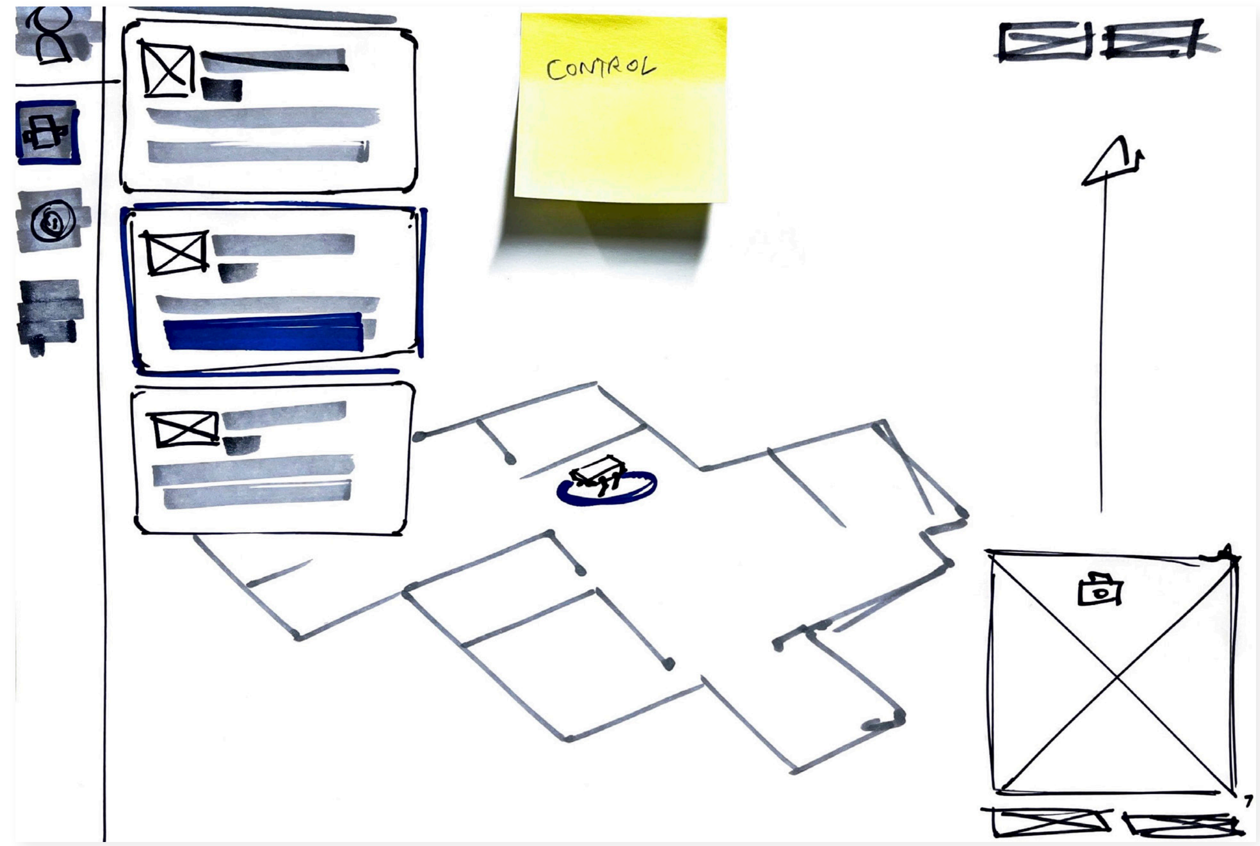
(Priotirty of functions, workshop with team)



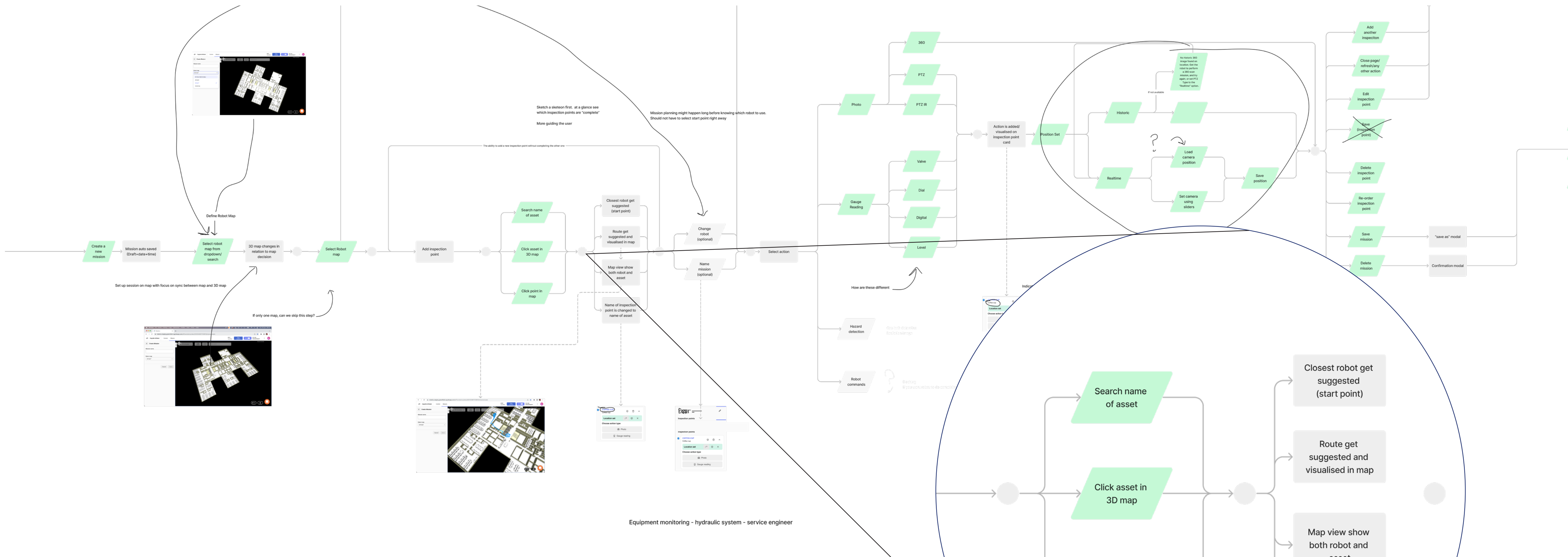
(outtake from sketches)

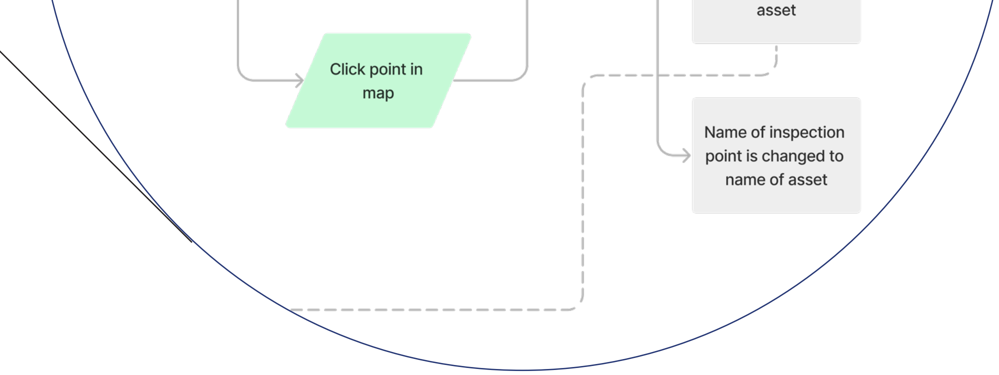
PAPER SKETCHES

Throughout the diploma project I've used paper sketches as a way to communicate and iterate on ideas quickly. The simplicity and roughness of the sketches has helped steer the conversation with others towards general functionality and layout, without going into too much details. I also found adding post-it notes as overlays was an efficient way of iterating on the sketches.



(outtake from sketches)

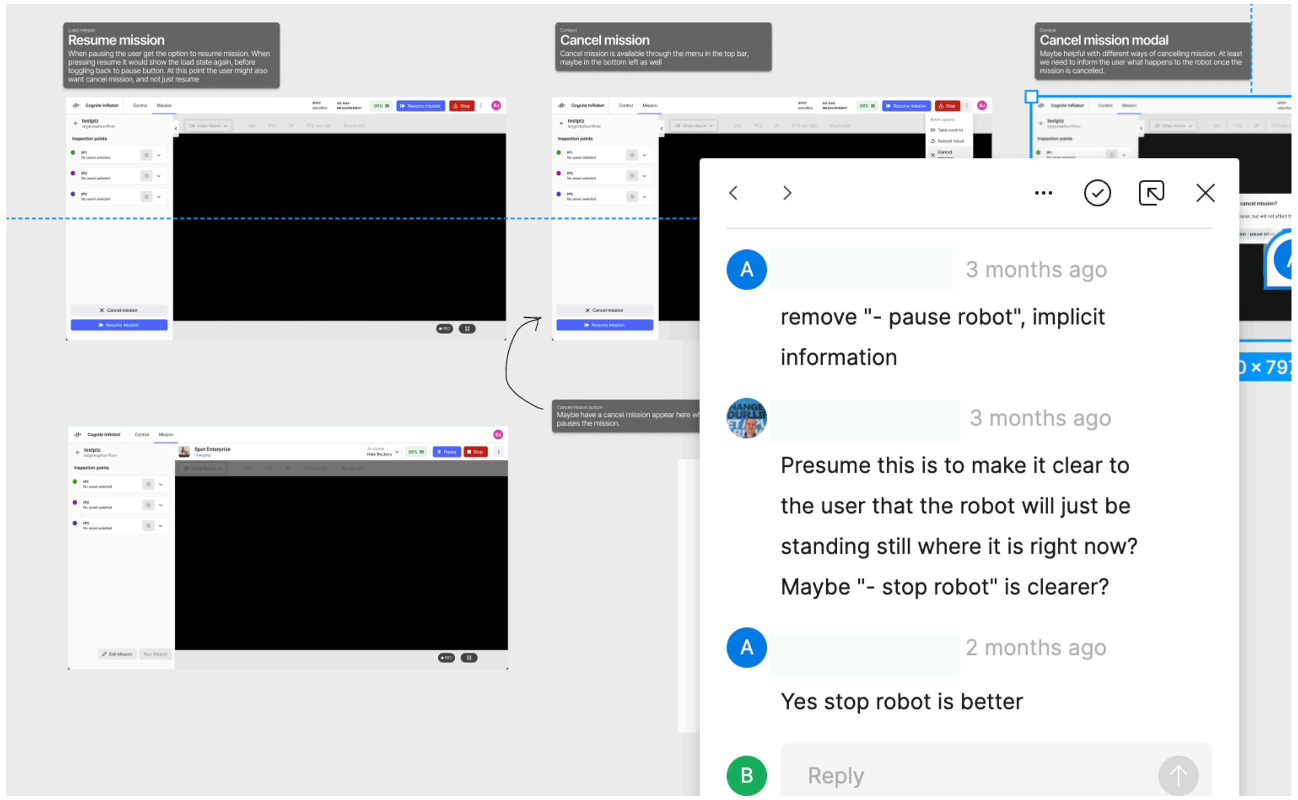




(Example of flowchart development in Figma)

FLOW CHARTS

Flow charts is another tool I've used extensively, both to get a better understanding of the connections and systems, but also as a way of iterating ideas together with the rest of the InRobot team. In situations where I was specifically interested in getting feedback on a flow, and not the UI itself, this proved to be a good way of focusing the discussion away from visual elements. Sometimes these were digital charts, other times paper based.



(Design feedback in Figma)

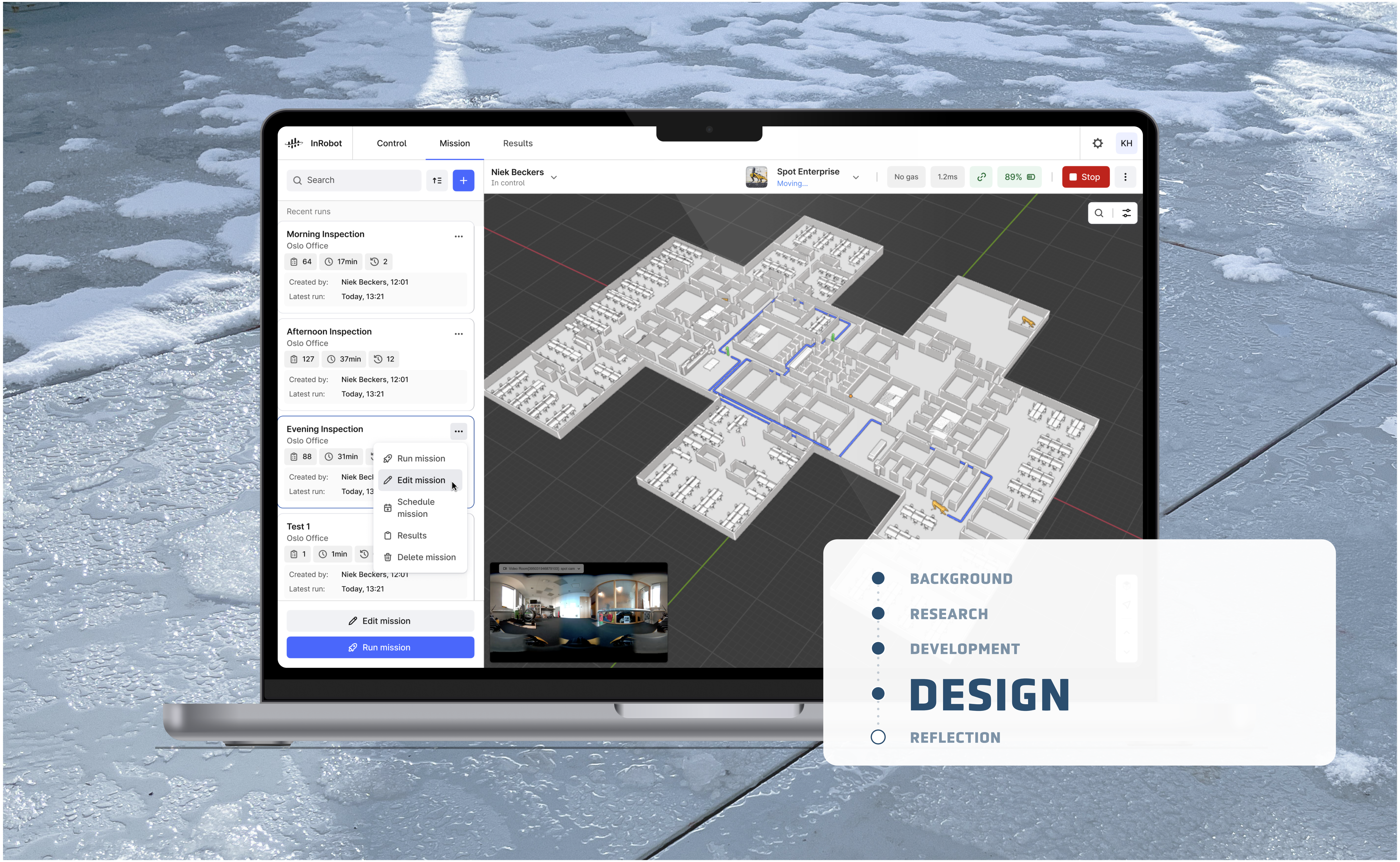
DESIGN COLLABORATION

Collaborating with Cognite and working from their offices has enabled me to work closely with some of the internal designers on a regular basis. I have shared designs in design critique sessions, and presented prototypes for other product teams, as well as one on one meetings. This has been a natural part of my work flow, and it has given the project a realism even to the extent where parts of my designs were implemented during the project. This means I've been able to get continuous validation and feedback.

(InRobot team in the field)

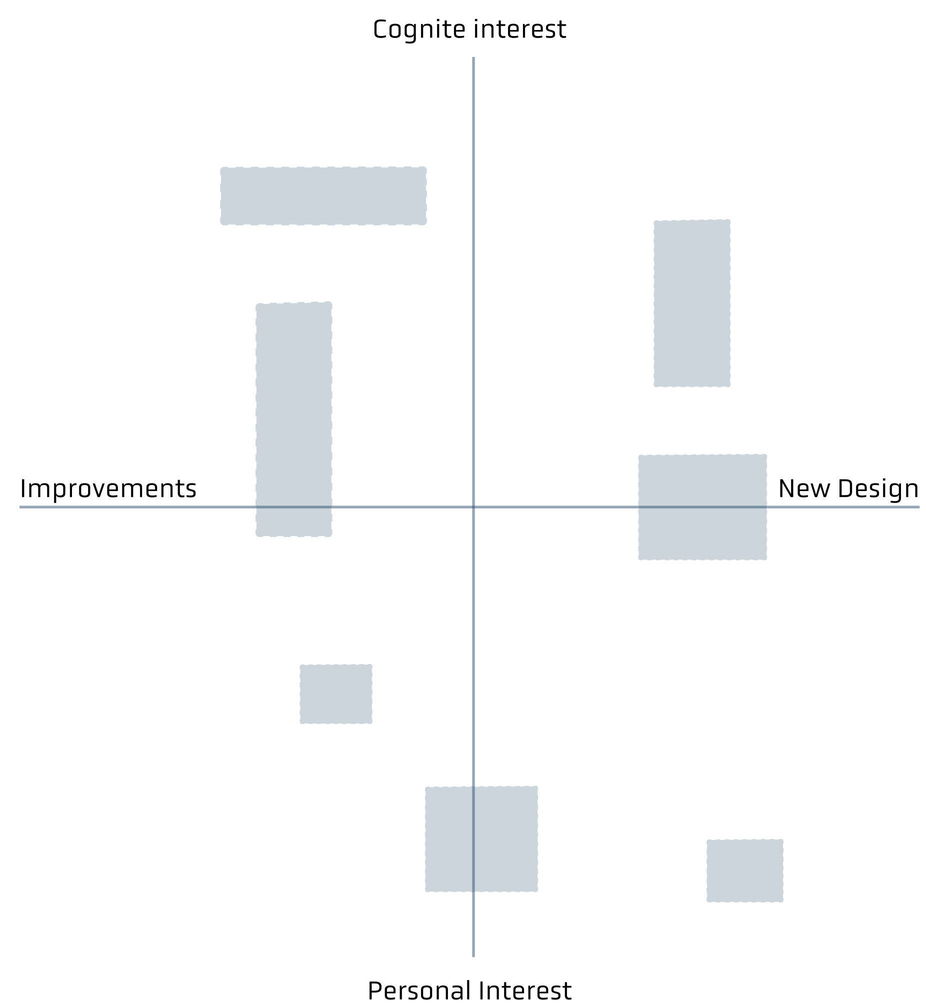
INROBOT TEAM

The InRobot team operate with a scrum framework which is an agile project management framework composed of a backlog of tasks, daily standups, sprints and retro meetings. Even though I've been working on my own tasks I've still been able to take part in the standup meetings to share progress, ask any questions and get help with blockers. In this way I've been able to get validation on my development from front-, backend developers and robot scientists.

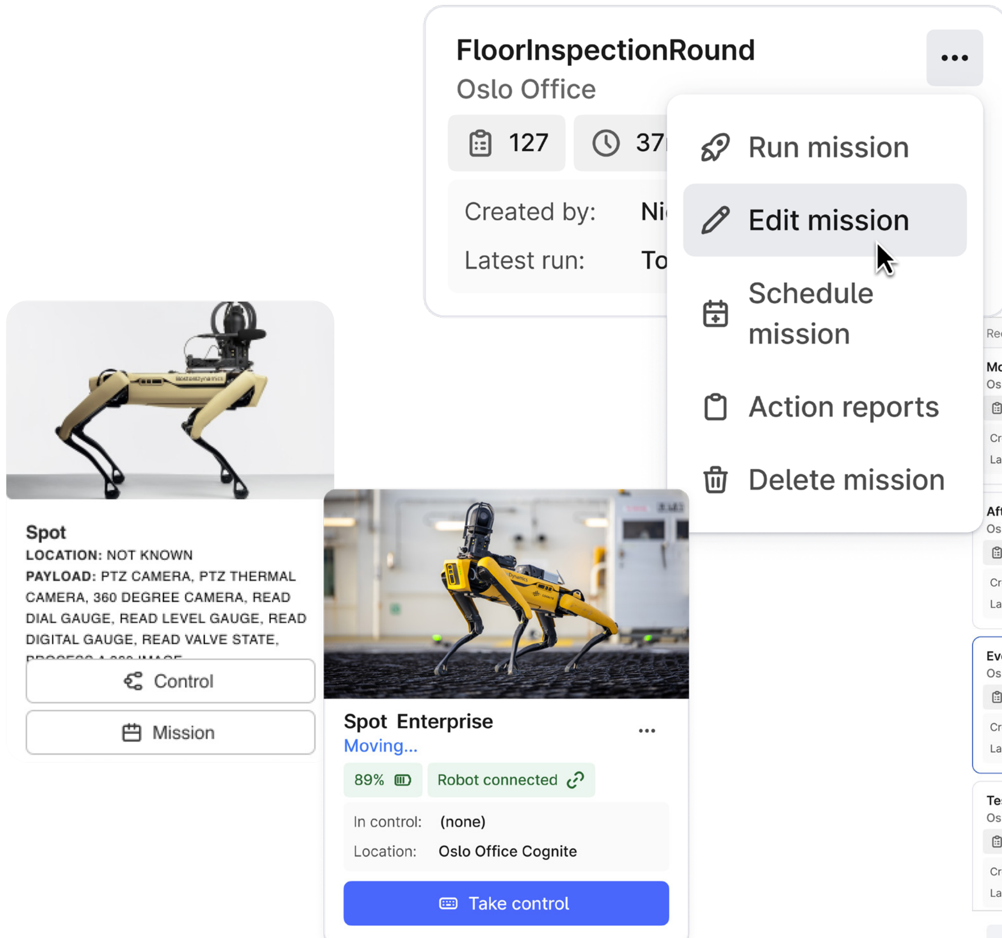

InRobot
Control
Mission
Results
KH
Search
Niek Beckers
In control
Spot Enterprise
Moving...
No gas
1.2ms
89%
Stop
Recent runs
Morning Inspection
Oslo Office
64
17min
2
Created by:
Niek Beckers, 12:01
Latest run:
Today, 13:21
Afternoon Inspection
Oslo Office
127
37min
12
Created by:
Niek Beckers, 12:01
Latest run:
Today, 13:21
Evening Inspection
Oslo Office
88
31min
Created by:
Latest run:
Run mission
Edit mission
Schedule mission
Results
Delete mission
Test 1
Oslo Office
1
1min
Created by:
Niek Beckers, 12:01
Latest run:
Today, 13:21
Edit mission
Run mission
BACKGROUND
RESEARCH
DEVELOPMENT
DESIGN
REFLECTION

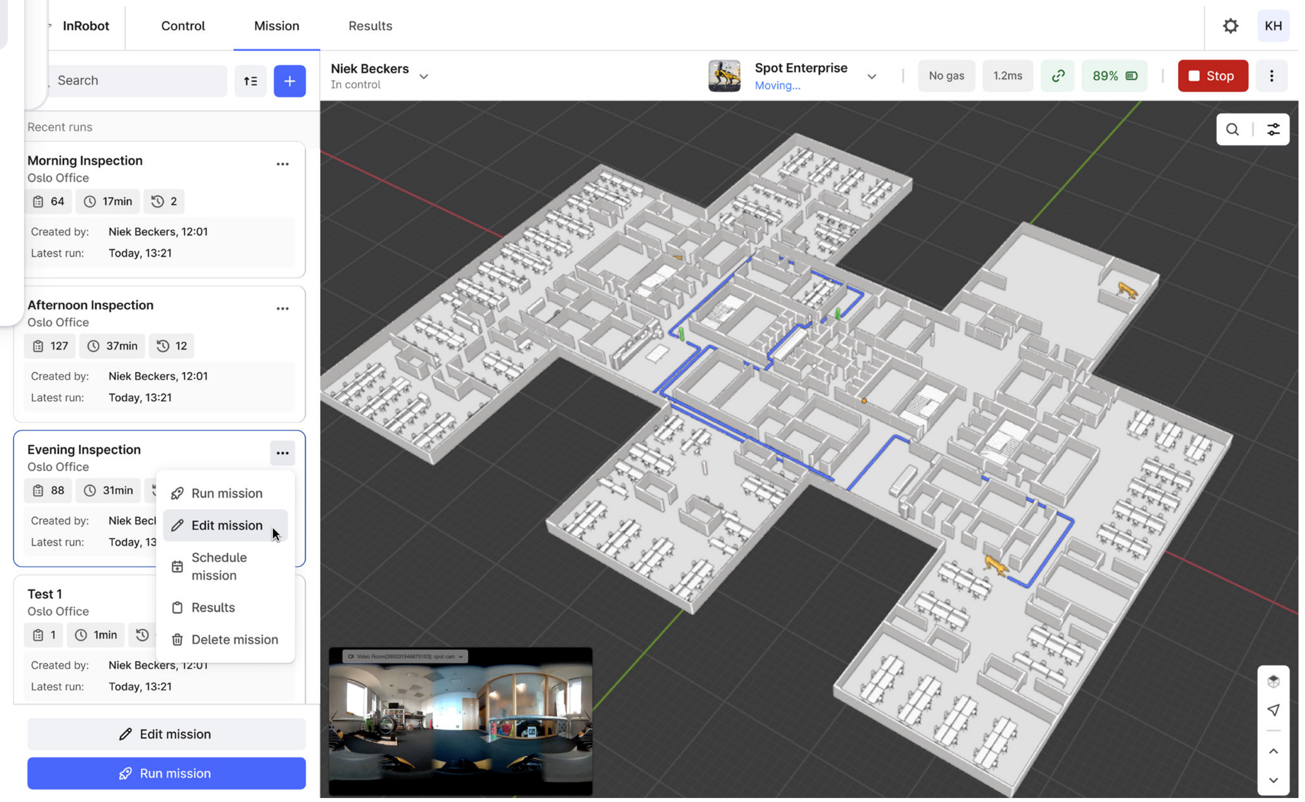
DESIGN DELIVERY

Throughout the project I've worked on designs for many parts of InRobot, from the over all layout and flow, down to button placements and icons. Some of the design I've worked on was improvements the InRobot team needed to solve, which was a great opportunity for me to solve realistic design tasks and get some of my designs implemented along the way. But I've also had the freedom to explore new concepts and design in directions that I though were interesting. To provide some context I've therefore divided the designs deliverables into improvements and new concept design.



(Illustration of the design delivery)

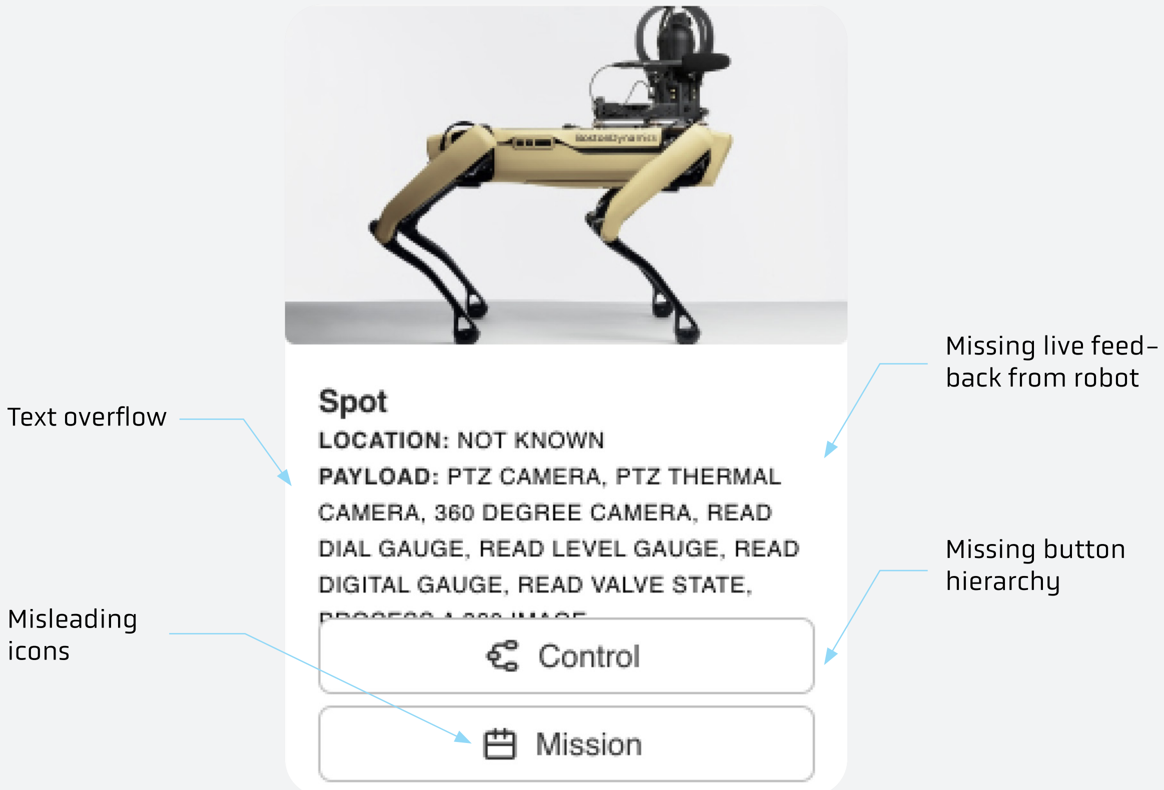




IMPROVEMENTS

These designs focus on improving existing components in InRobot, based on insights from the backlog, heuristic and expert collaboration. The goal was to design more consistent patterns and layouts in the components building observability, direct-ability to support team play.

Spot	Spot	Spot	Spot	Spot
Moving...	Charging	Paused	Docked	Offline

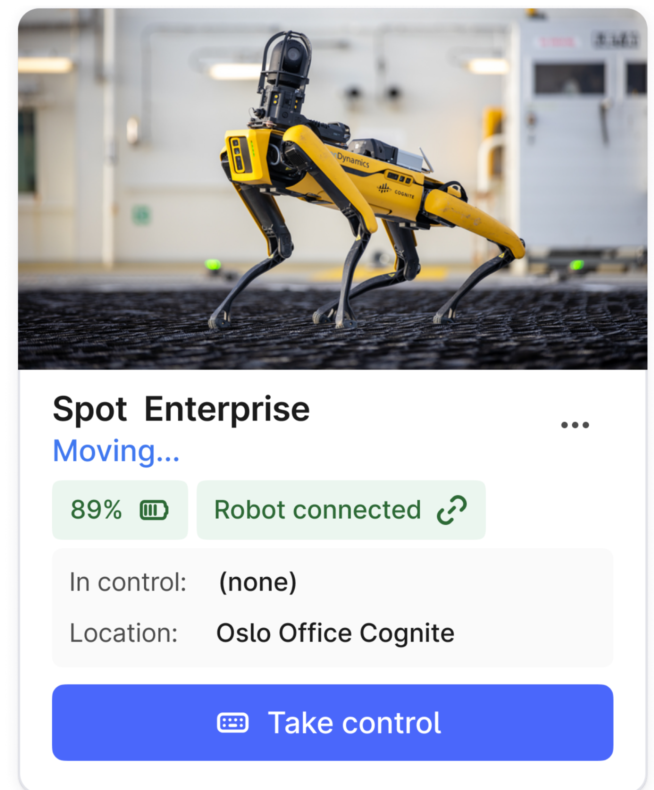


(Original robot card)

ROBOT CARD

ORIGINAL

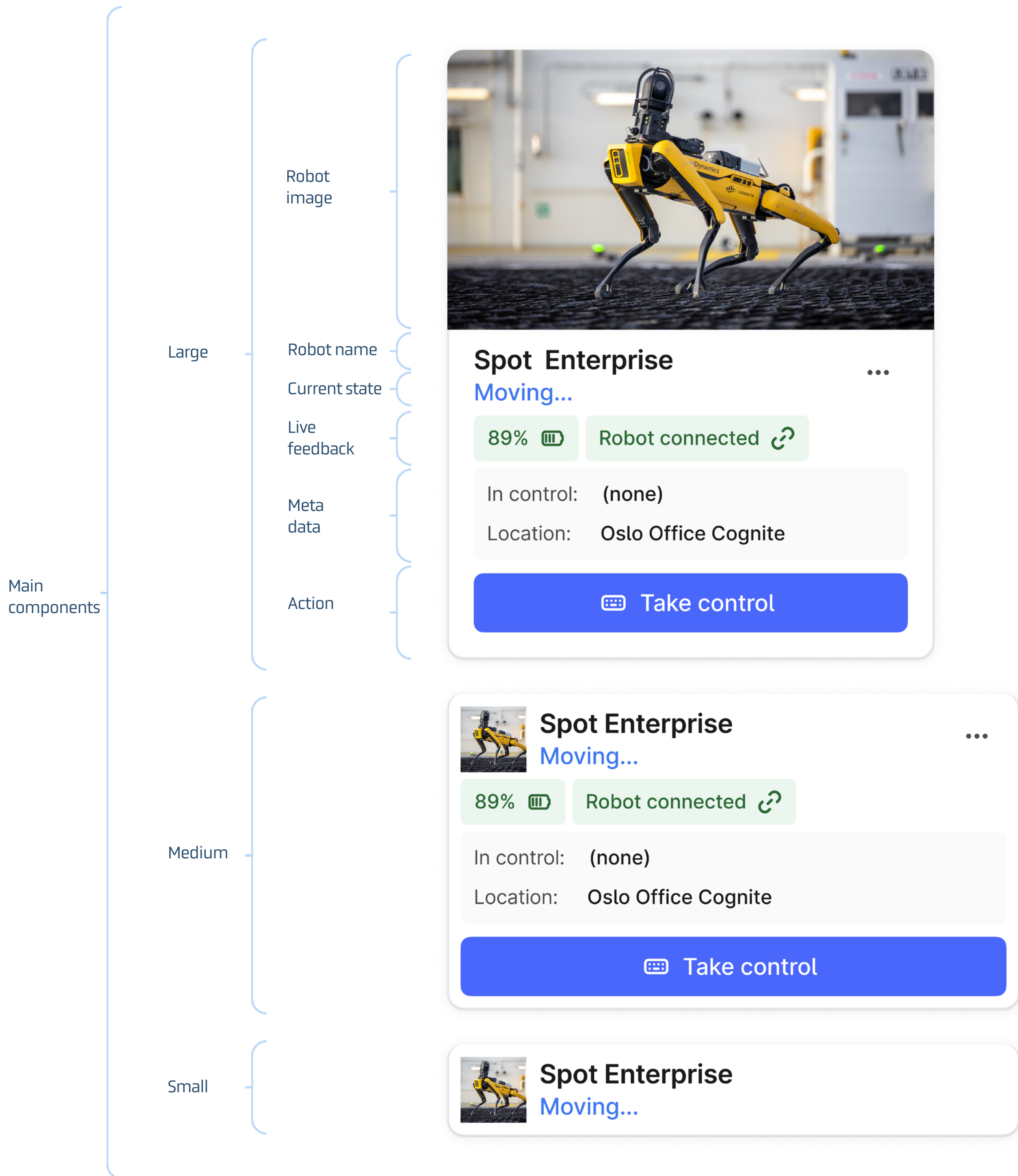
The robot card is a component used mainly in the start page of InRobot, to show various different robots. The original robot card component displayed the name, location, image and payload of a robot. While being a good starting point for a card design, the insights from the heuristic, backlog and desk research highlighted the need and importance of live feedback of what the robot is doing.

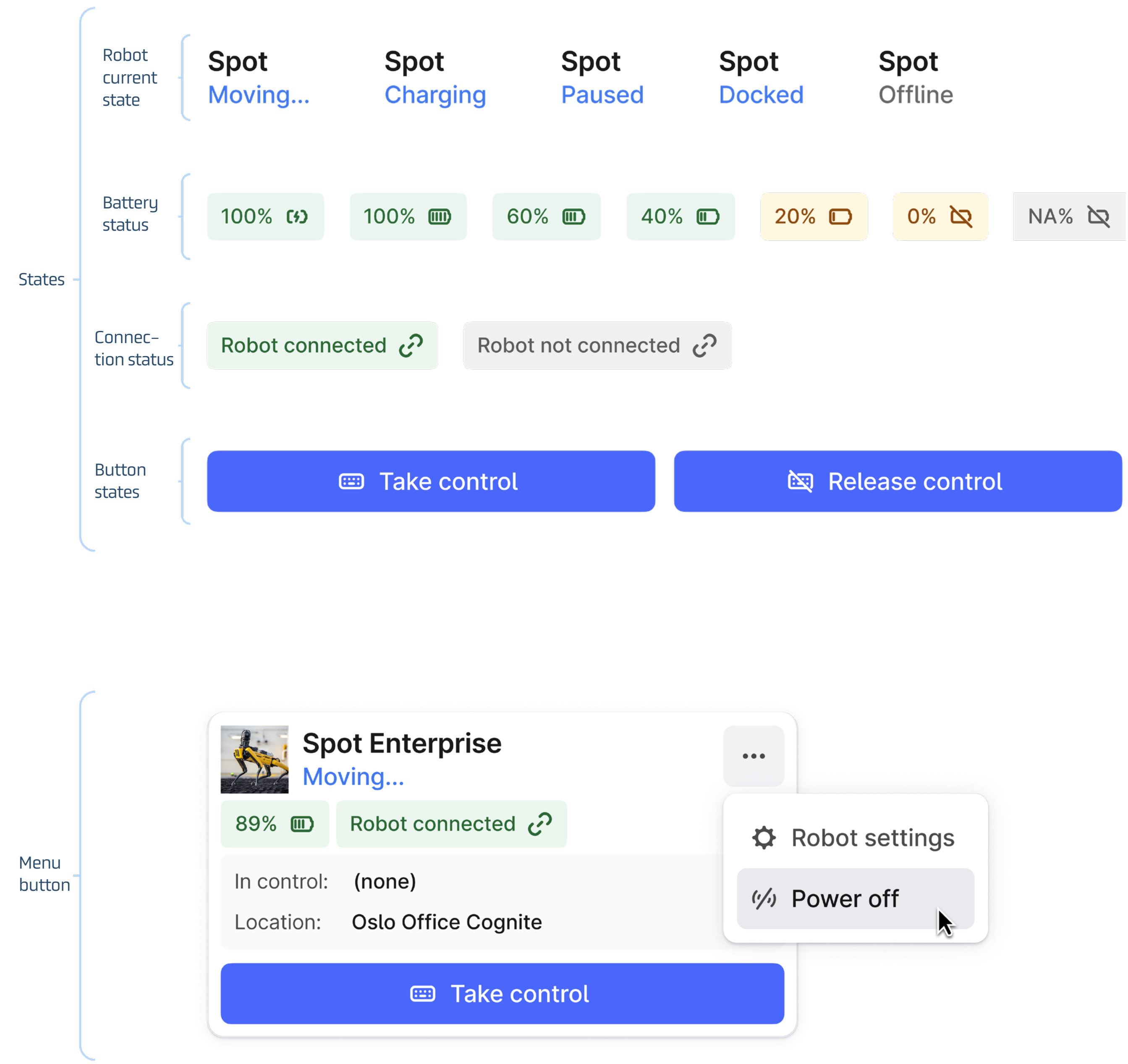


(Improved robot card)

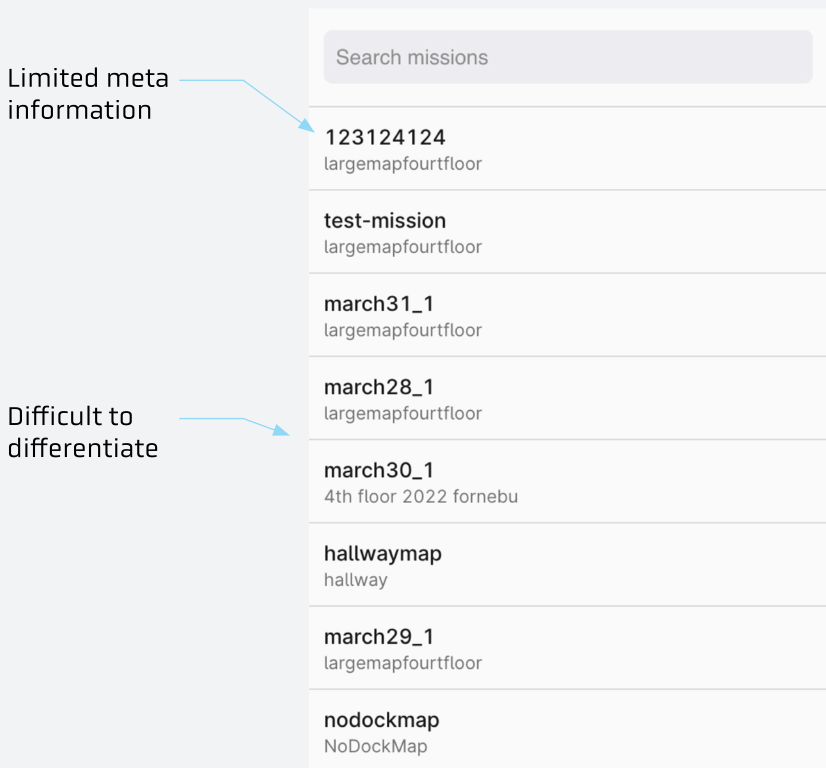
IMPROVED

In the improved version I added more feedback parameters based on what Spot is able to support, like current state, battery status and connection status. I based the hierarchy and prioritizations of statuses and feedback on a prioritization workshop I had with the team. I also created a stricter grid to group relevant information together. The design also has 3 different sizes that can be used as components in other parts of the application, and potentially as dynamic components on smaller size surfaces.





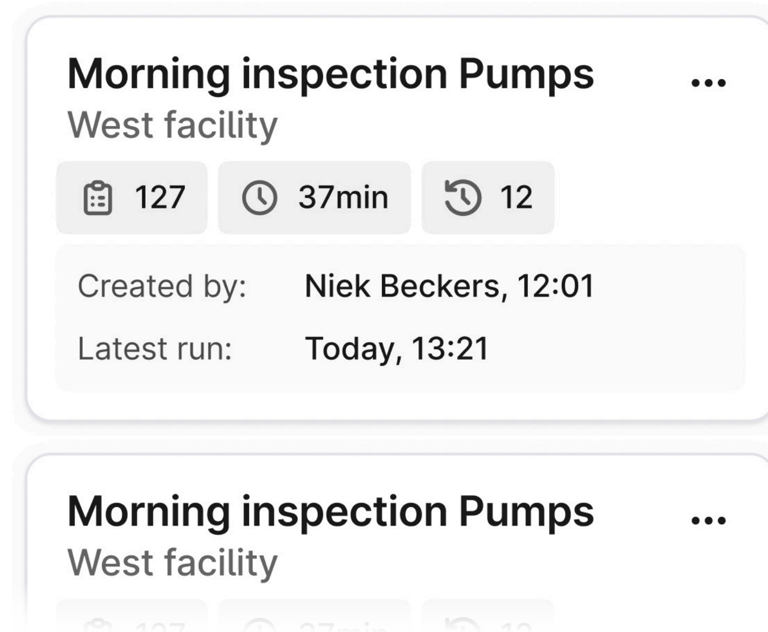
(Robot card component)



(Original mission card)

MISSION CARD
ORIGINAL

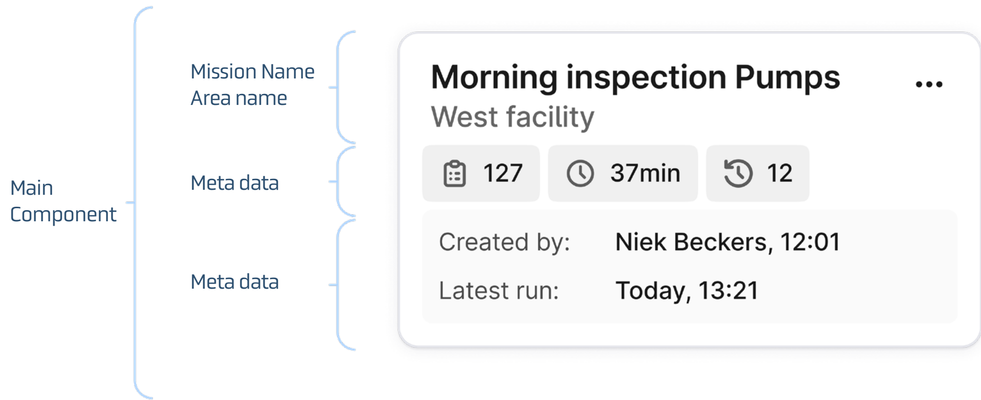
The original way of displaying the missions was in a list with the name and location. In terms of screen real estate it is an efficient way of displaying missions, but it is very limiting in displaying meta data the user could be interested in, for example the size of the mission, or when it was last run.

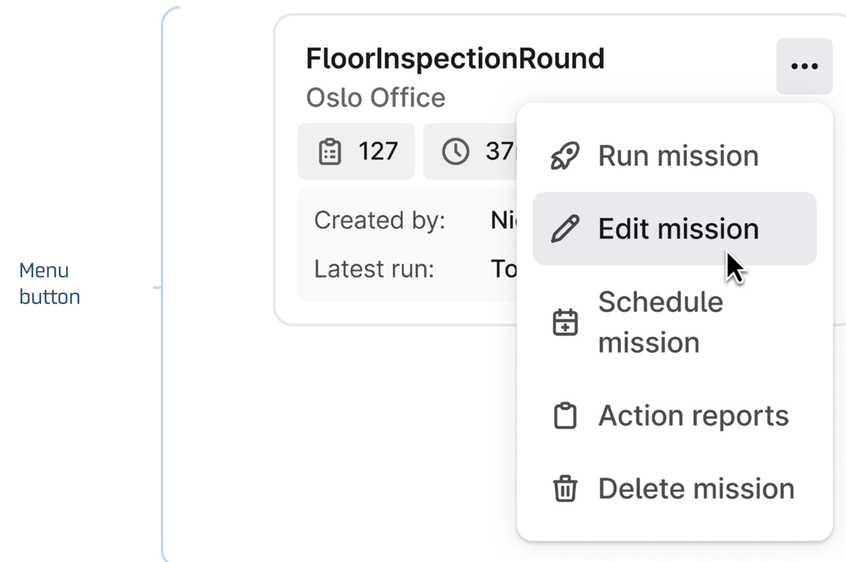


(Improved mission card)

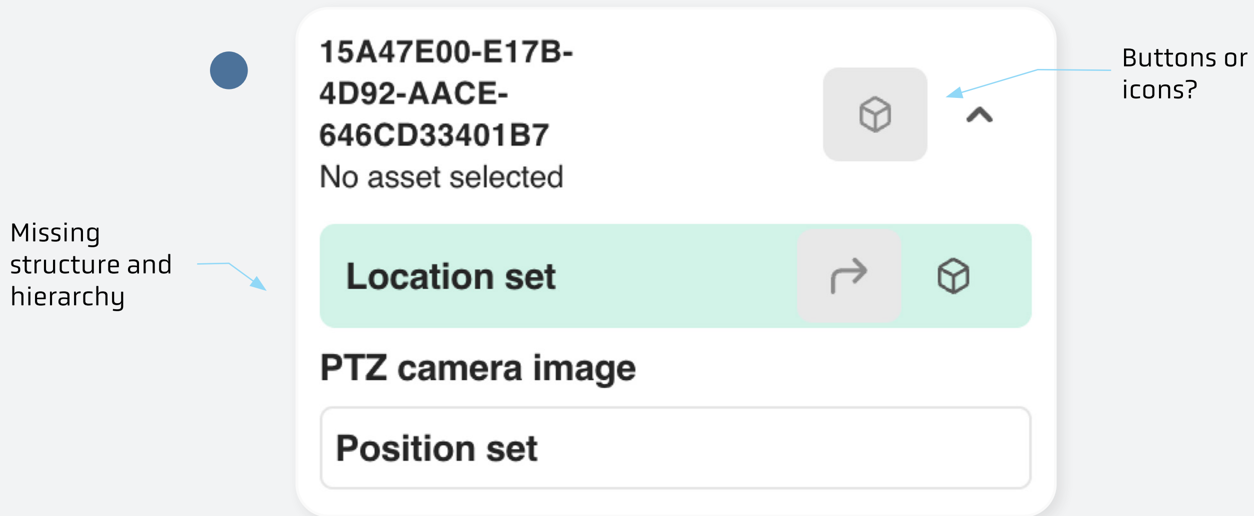
IMPROVED

The improved design has the same framework as the robot card component in terms of layout and the use of icon chips. The component is larger and taking up a more space than the original design, but it is giving more context on the mission, taking inspiration from Google Maps. Additionally having the 3 dot button opens the opportunity to have shortcuts to actions, potentially reducing the amount of steps for a user to complete an action like editing, or scheduling an inspection round.

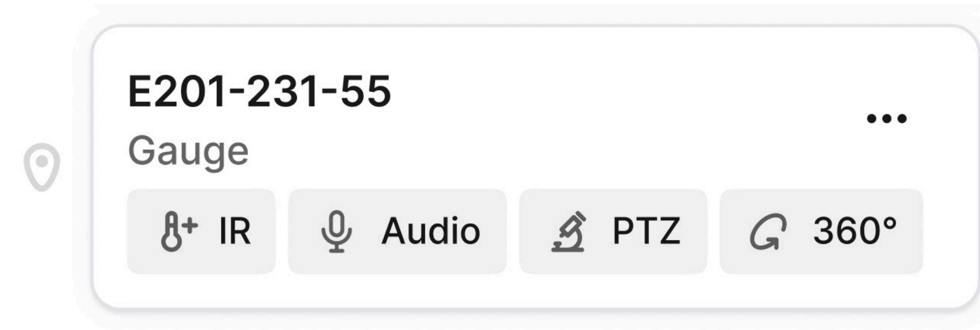




(Mission card component)



(Original inspection card)



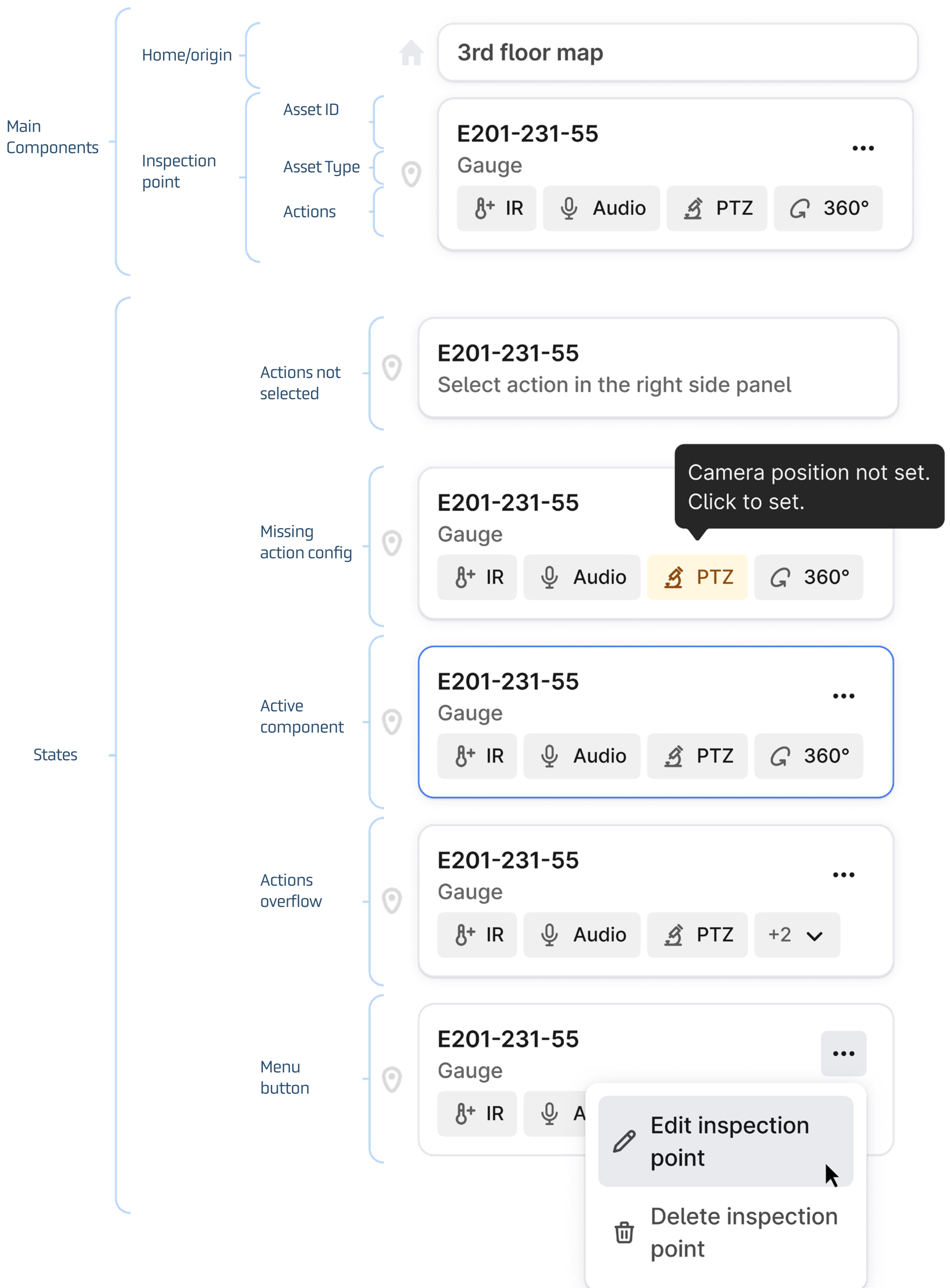
(Improved inspection card)

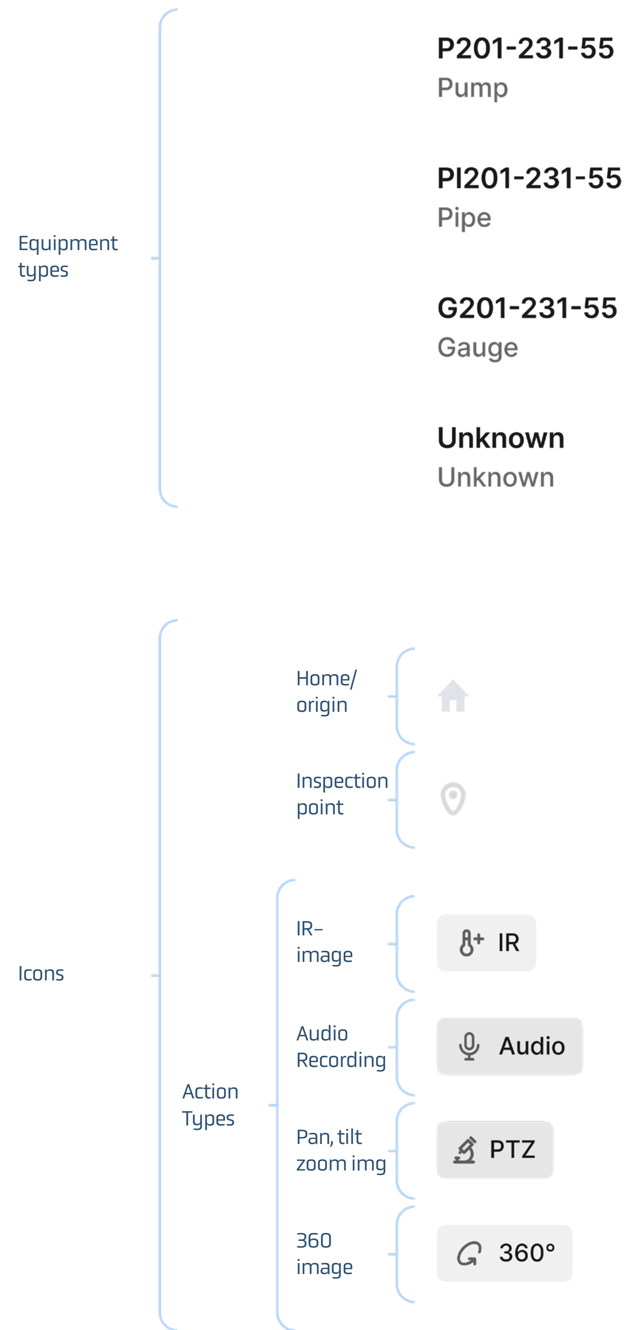
INSPECTION POINT CARD
ORIGINAL

In the original design of the inspection point card, every action performed required a new inspection point card. In the improved design, actions performed on the same asset or location are grouped. So if the user wants to take a 360° image and a thermal image of the same asset the actions are grouped in one inspection points.

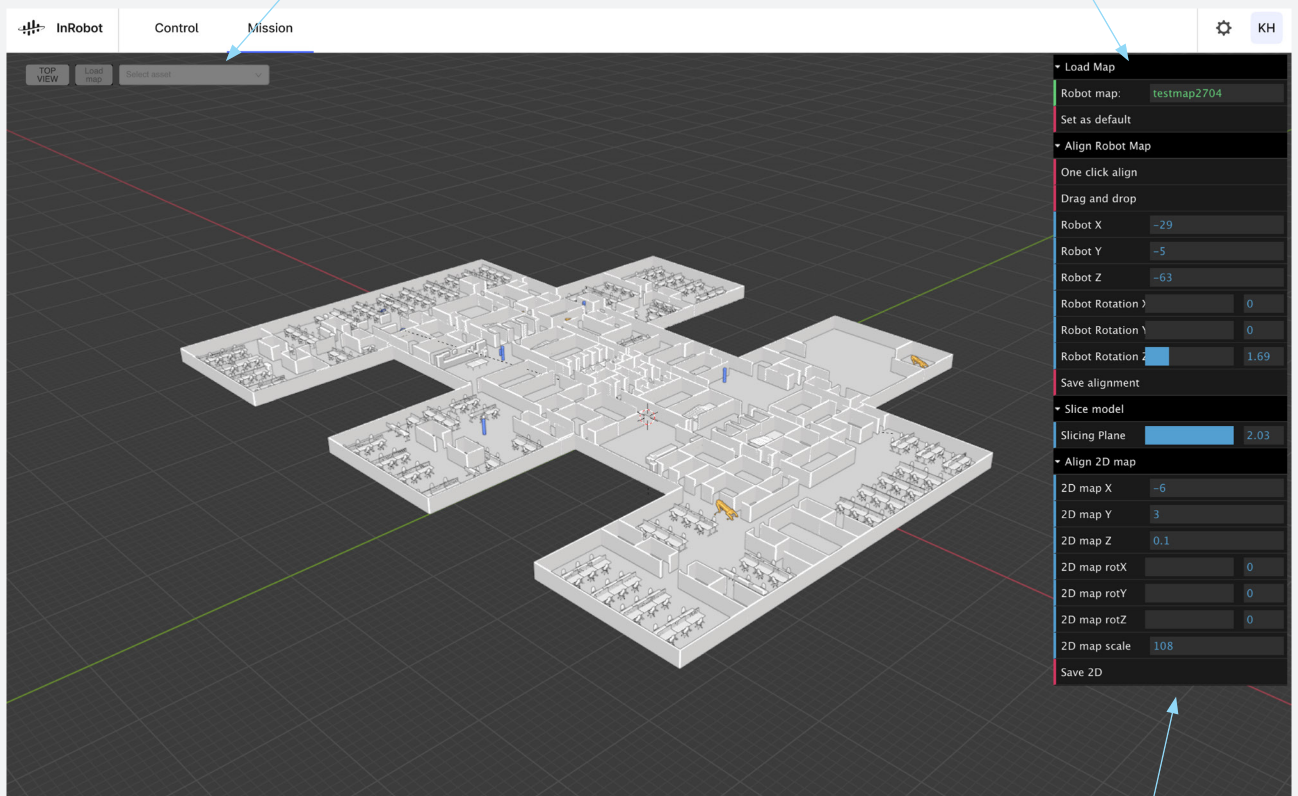
IMPROVED

The improved inspection point card is also based on the framework of the robot card, by using a clear hierarchy and chips to describe the actions related to the inspection point. The additional actions icon opens a menu with space for relevant actions.





(Inspection card component)

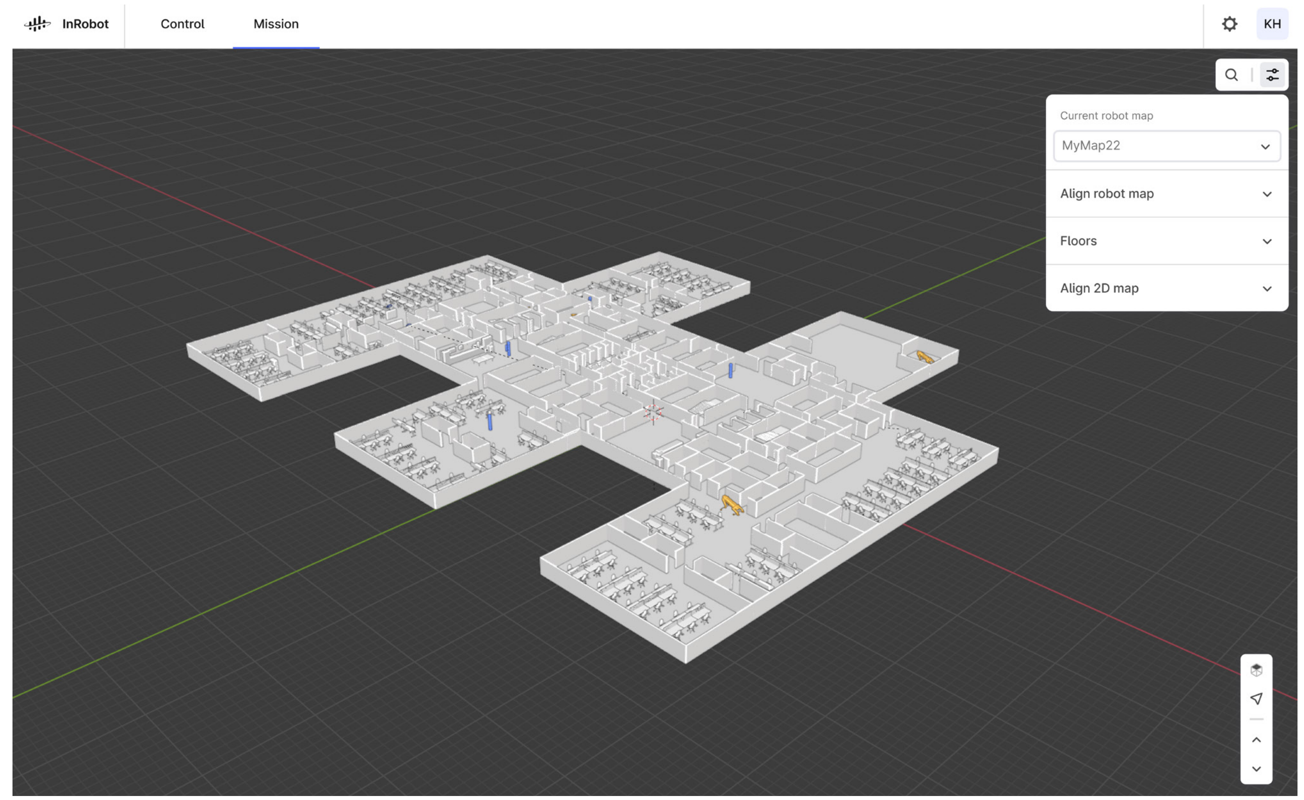


(Original map controls)

MAP CONTROLS

ORIGINAL

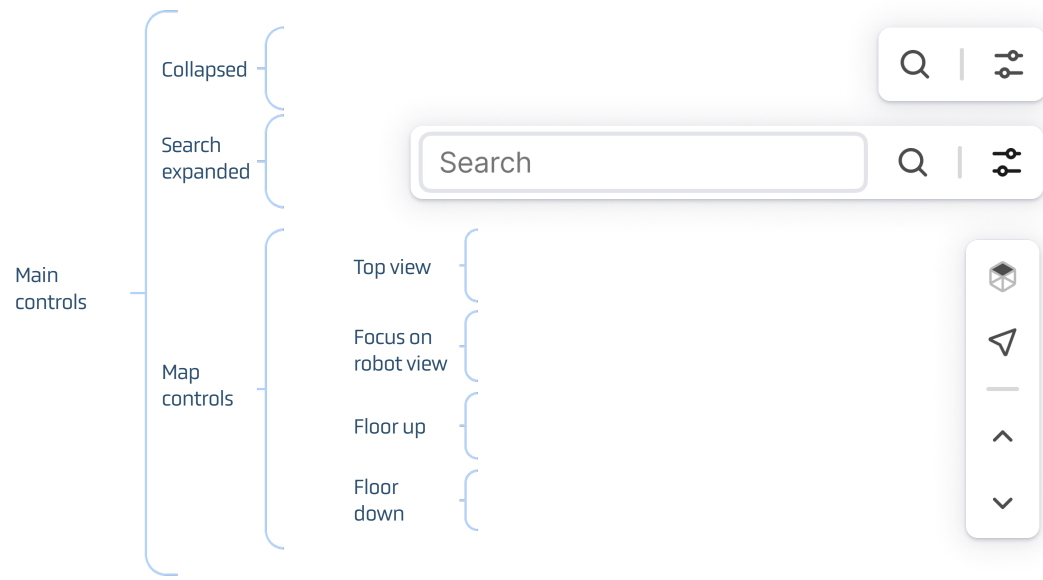
The map controls is a menu related to configuring, navigating and aligning the 3D model with the robot. The original design was not coherent with the rest of the design in InRobot, mainly because of different styling.

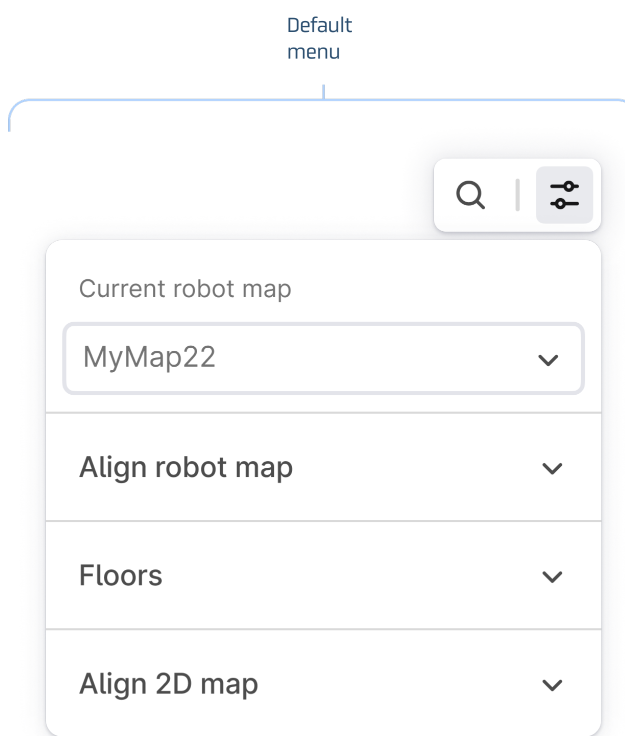


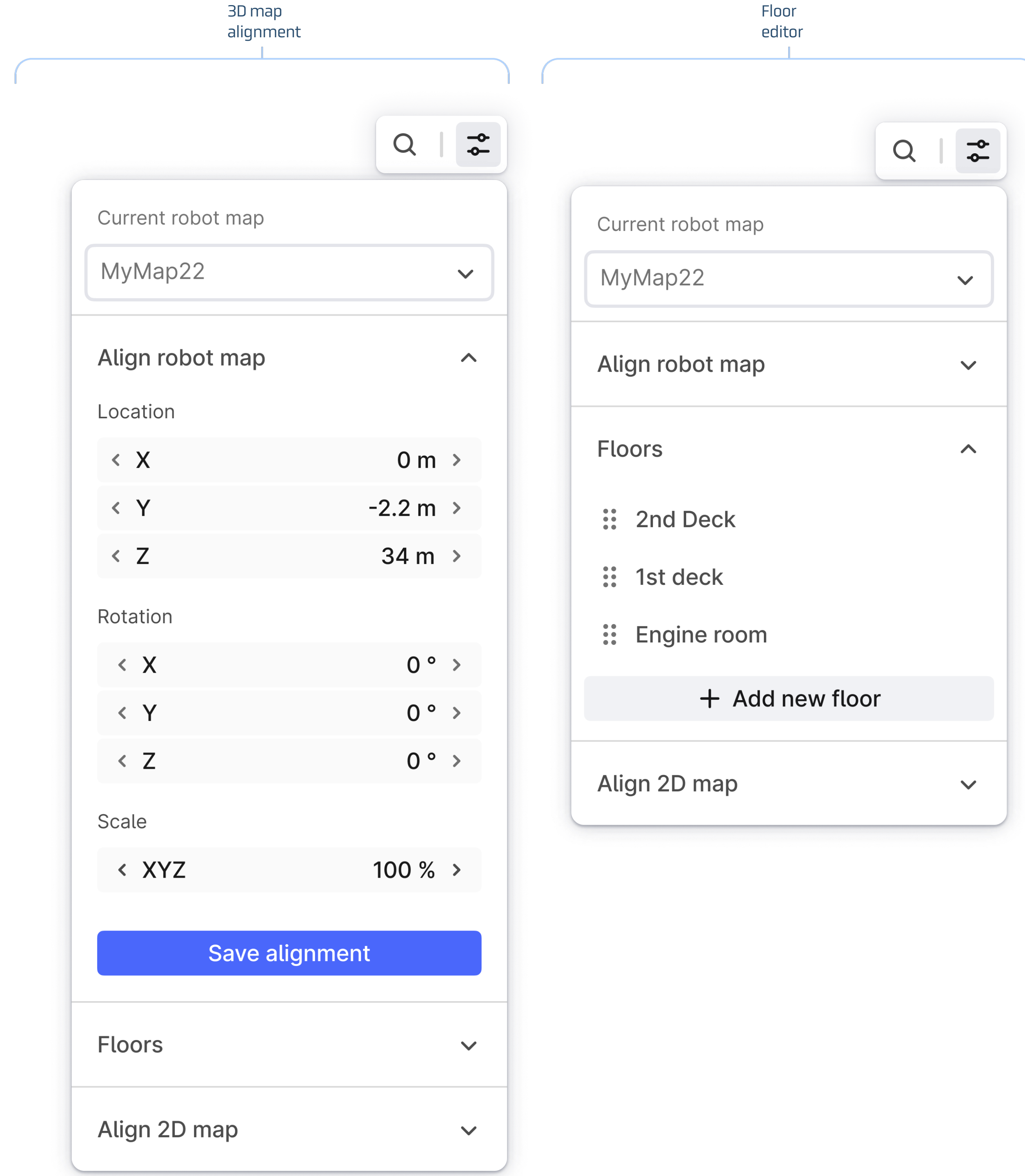
(Improved map controls)

IMPROVED

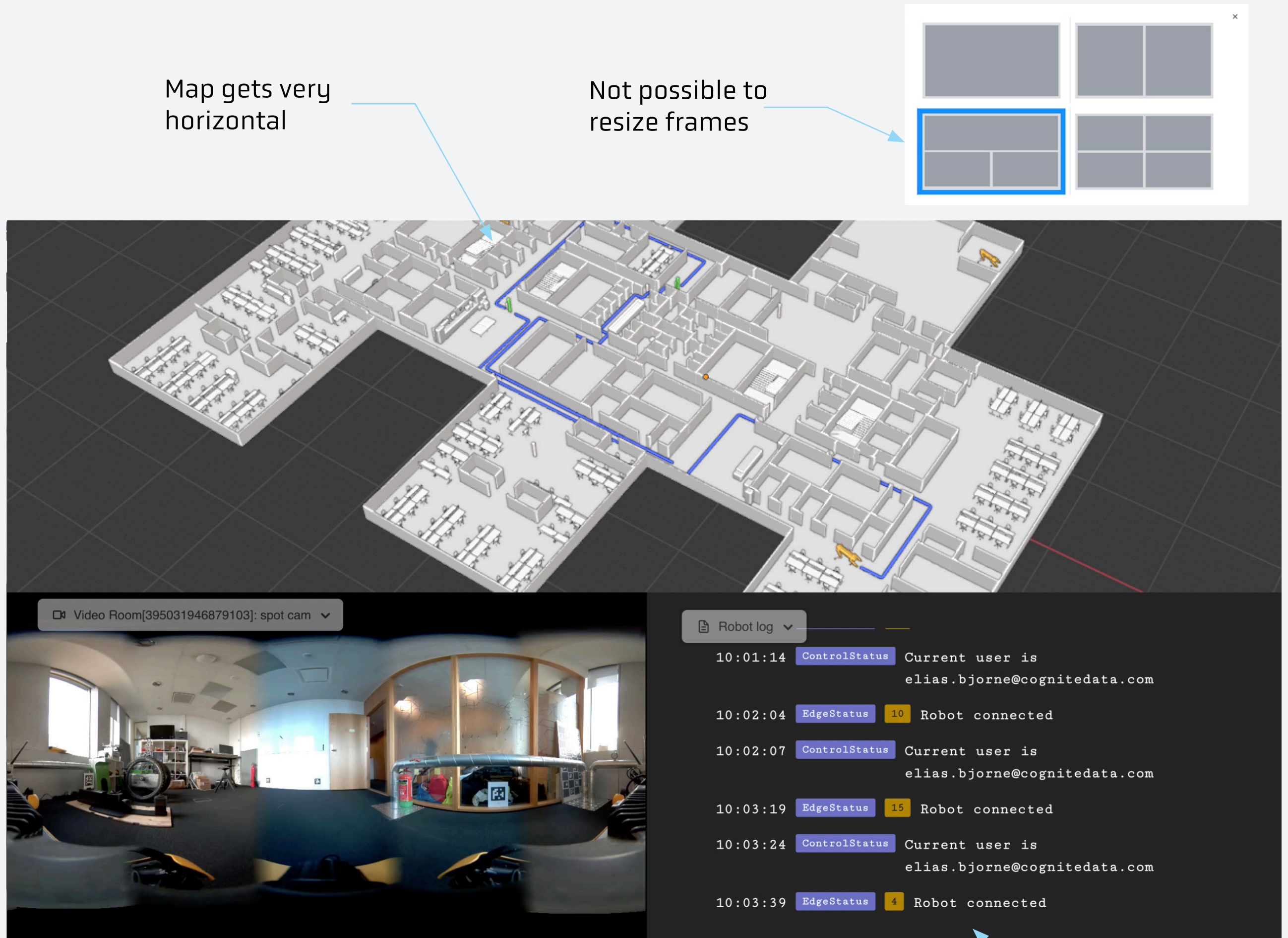
The improved design is updated to the design system and the actions are grouped together and collapsed. One new feature is navigating between floors or levels in a 3D map. The original design had a slice slider where the user could slice through the 3D model, but when regularly navigating between floors this was a tedious tasks. I therefore propose a function enabling users to save pre sets on floors and a up/down button to be able to navigate between floors.







(Map controls component)



(Original layout)

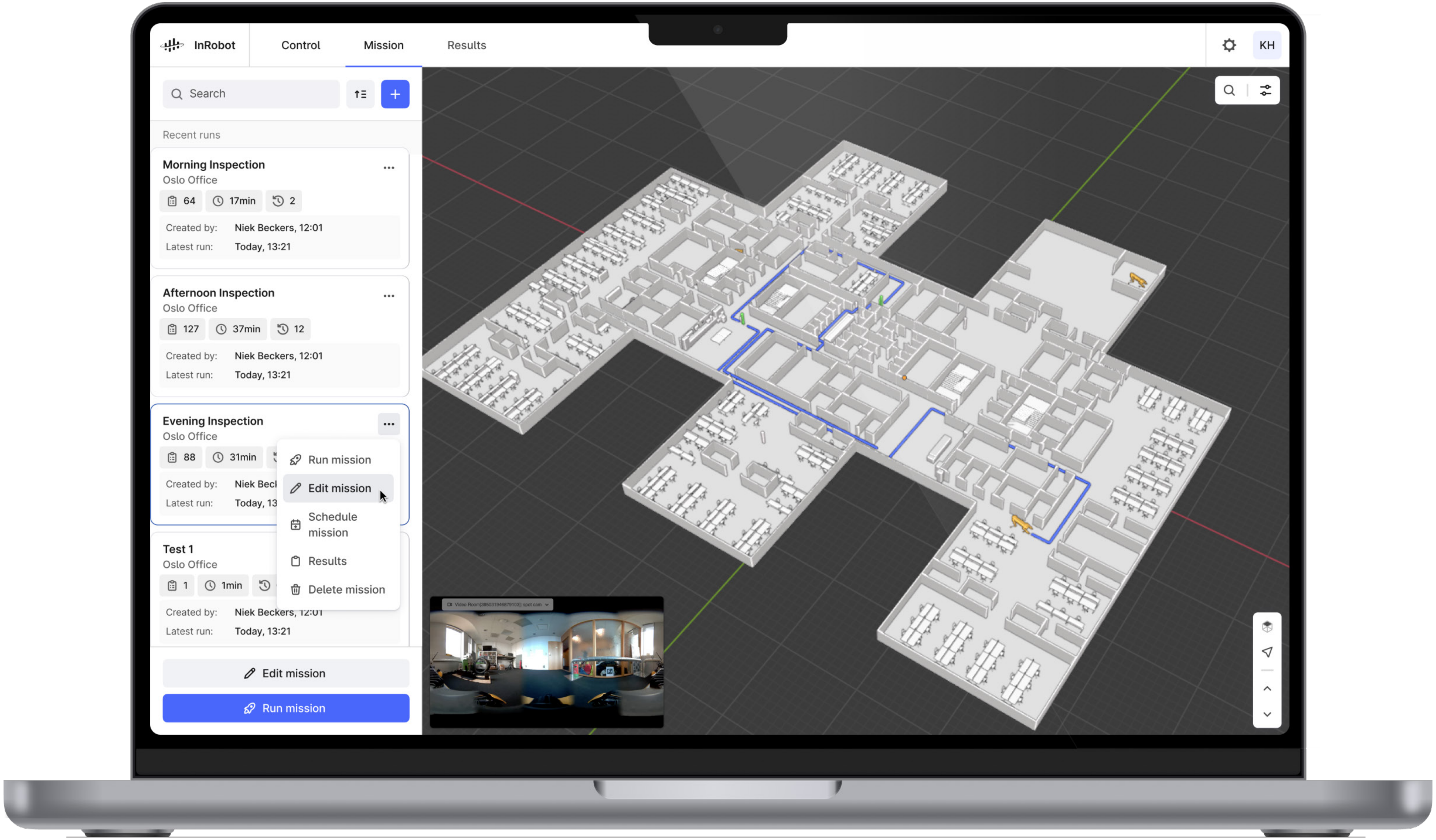
SCREEN LAYOUT
ORIGINAL

The original screen layout of the main work area gave the user the option to have from one up to four different windows open. This could for example be 3D model map, live video feed and a robot log that feeds back information about the robot. But when having more than one workspace, the windows quickly became very small on a regular size lap top screen, leading to a lot of zooming in/out of the 3D model.

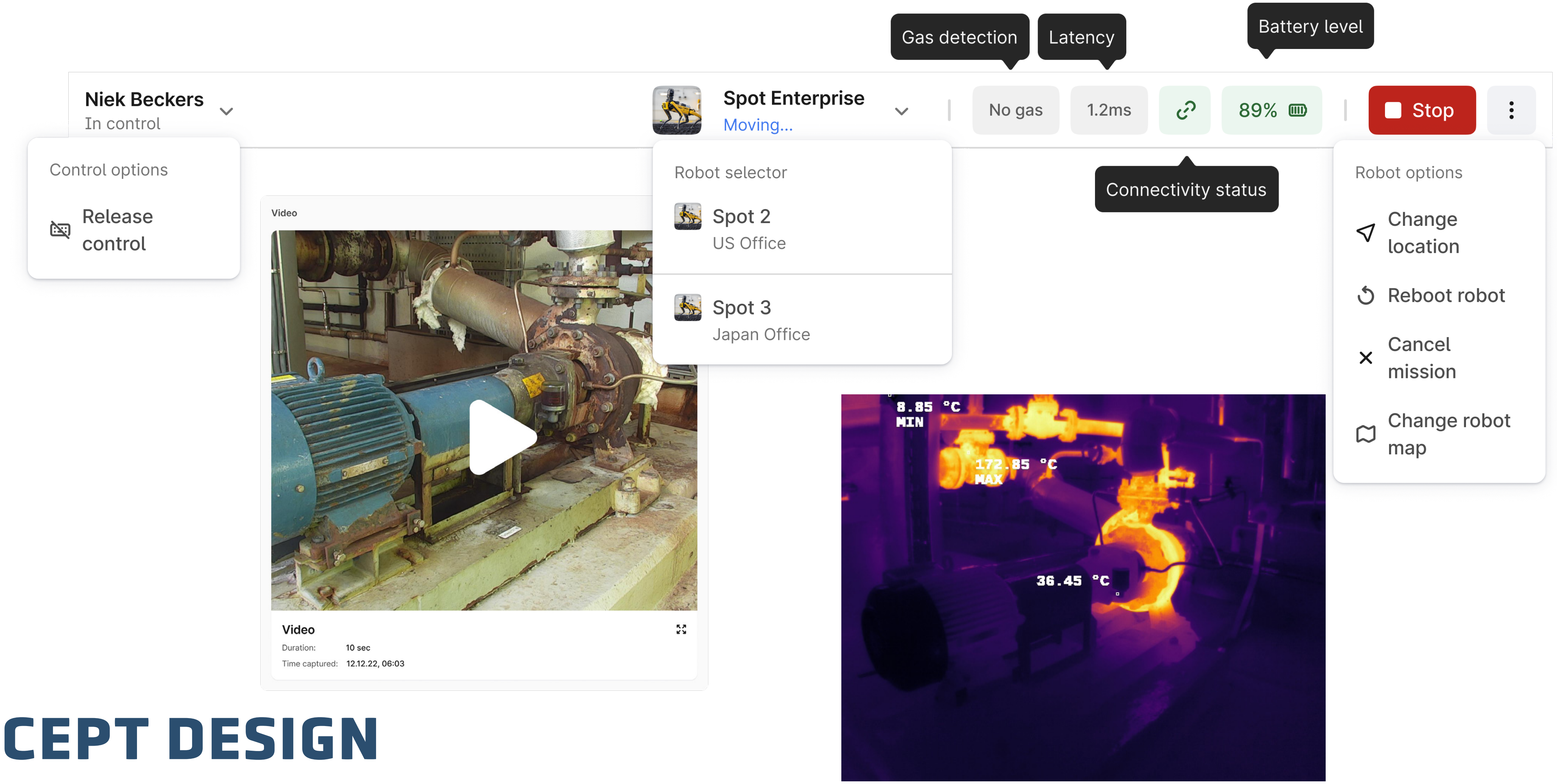
(Improved layout)

IMPROVED

The improved design has taken inspiration from gaming HUDs by having one main view, with a supporting mini map or mini live feed in the bottom left corner. By clicking on the live feed, the main workspace goes from 3D model to live feed, and the mini live feed becomes a mini map of the 3D model. The robot log is still accessible through the menu in the mini map/model.

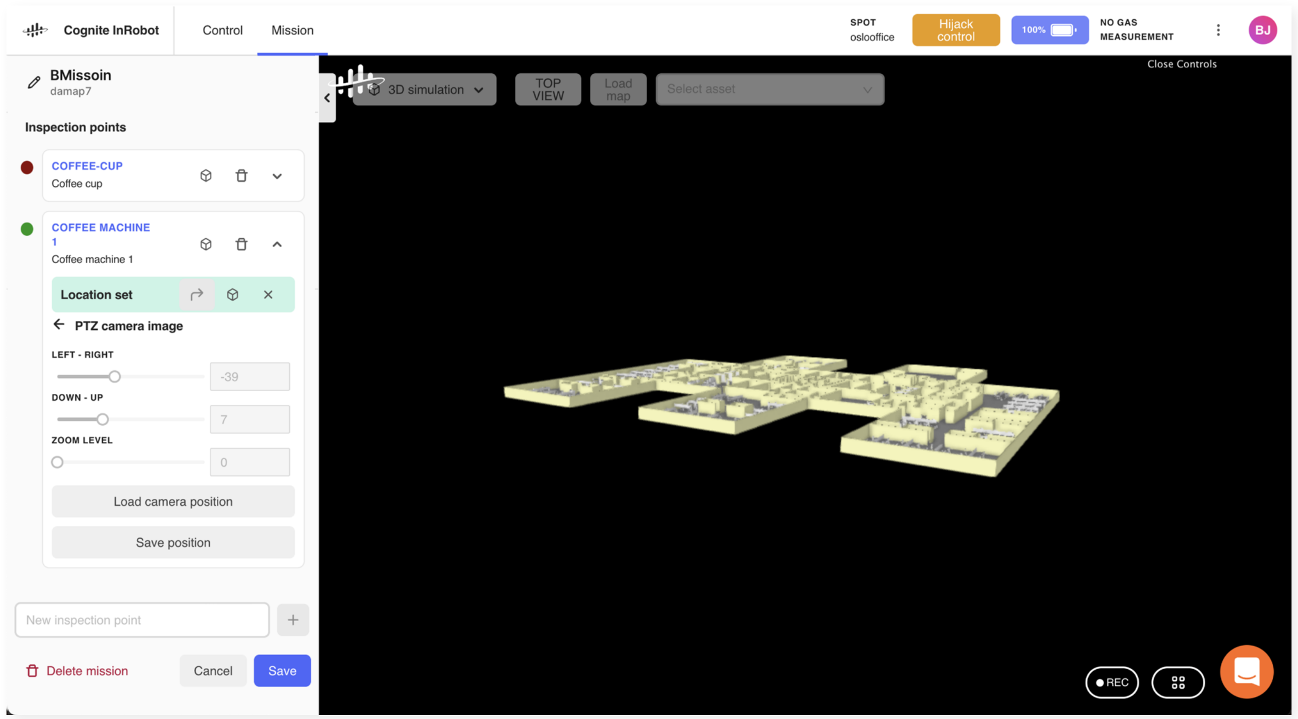


(Improvements in context)



NEW CONCEPT DESIGN

The research and in particularly the field trips revealed needs and missing functionality in InRobot. The new concept design is where I got the opportunity to explore and iterate new concepts answering to those needs. These concepts are not ready for development, but are designed as a foundation for testing and further iteration.

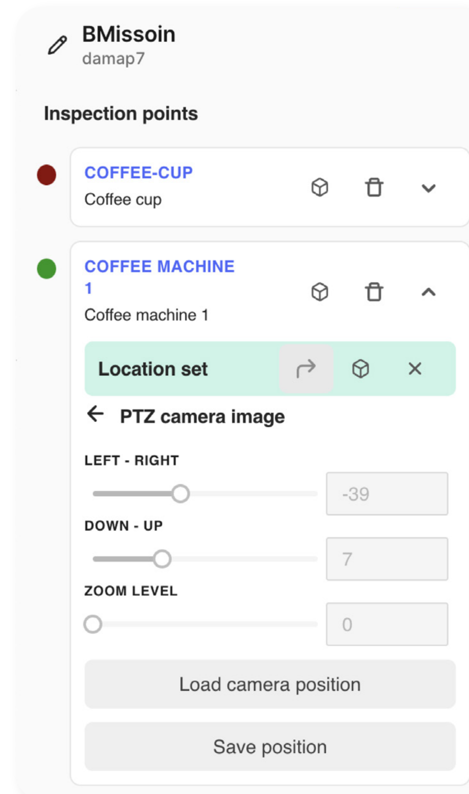


(Existing InRobot mission creation)

ACTION TEMPLATES AND RIGHT SIDE PANEL

NEED

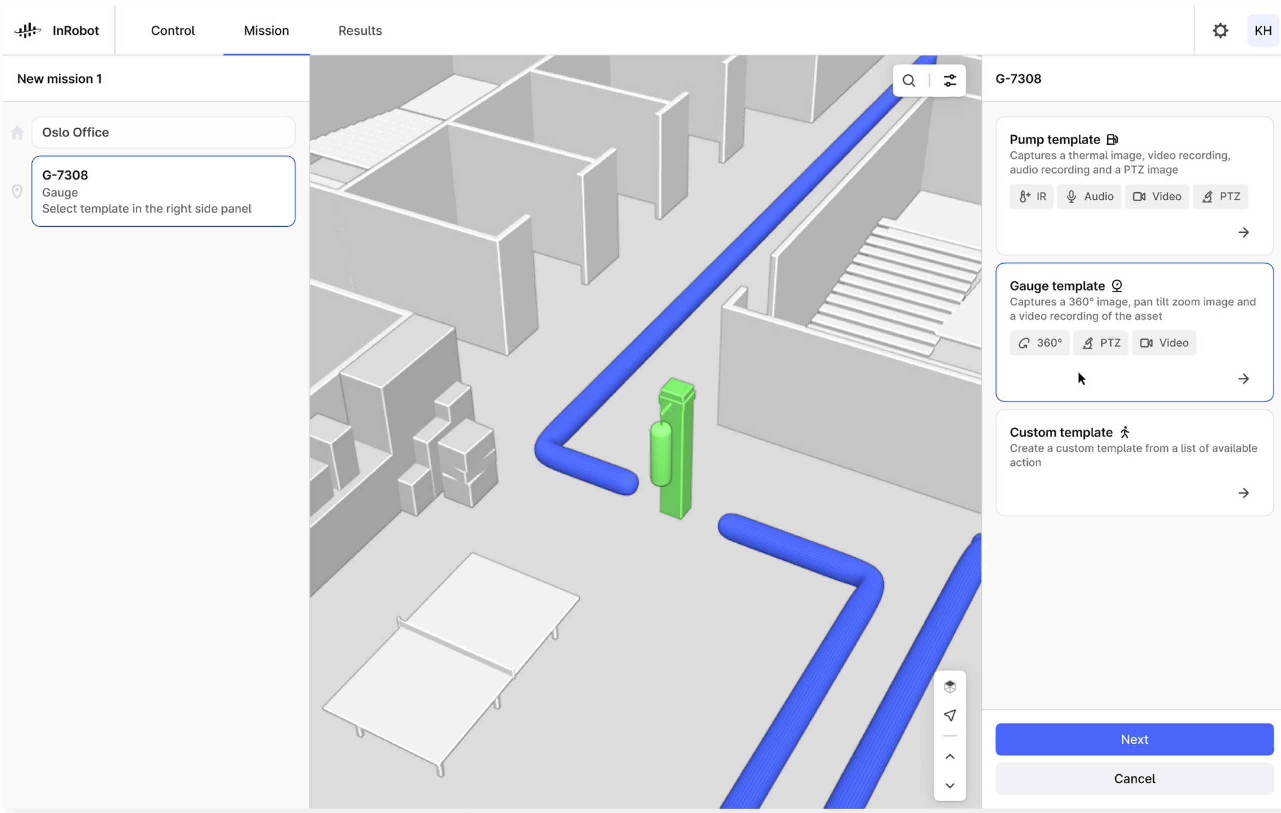
Through the user insights it became clear that the process operators would need more than just one image or a sound recording in order to assess the equipment. They would require a varying group of data depending on the type of equipment they were assessing.



(Existing InRobot mission creation)

EXISTING

In the existing way of setting up an inspection round the users were limited to one action point per inspection point. So if the user wanted to capture a 360° image, sound recording and video of a pump, he/she would have to create three different inspection points. This made the flow tedious and repetitive when creating up to hundred inspections.

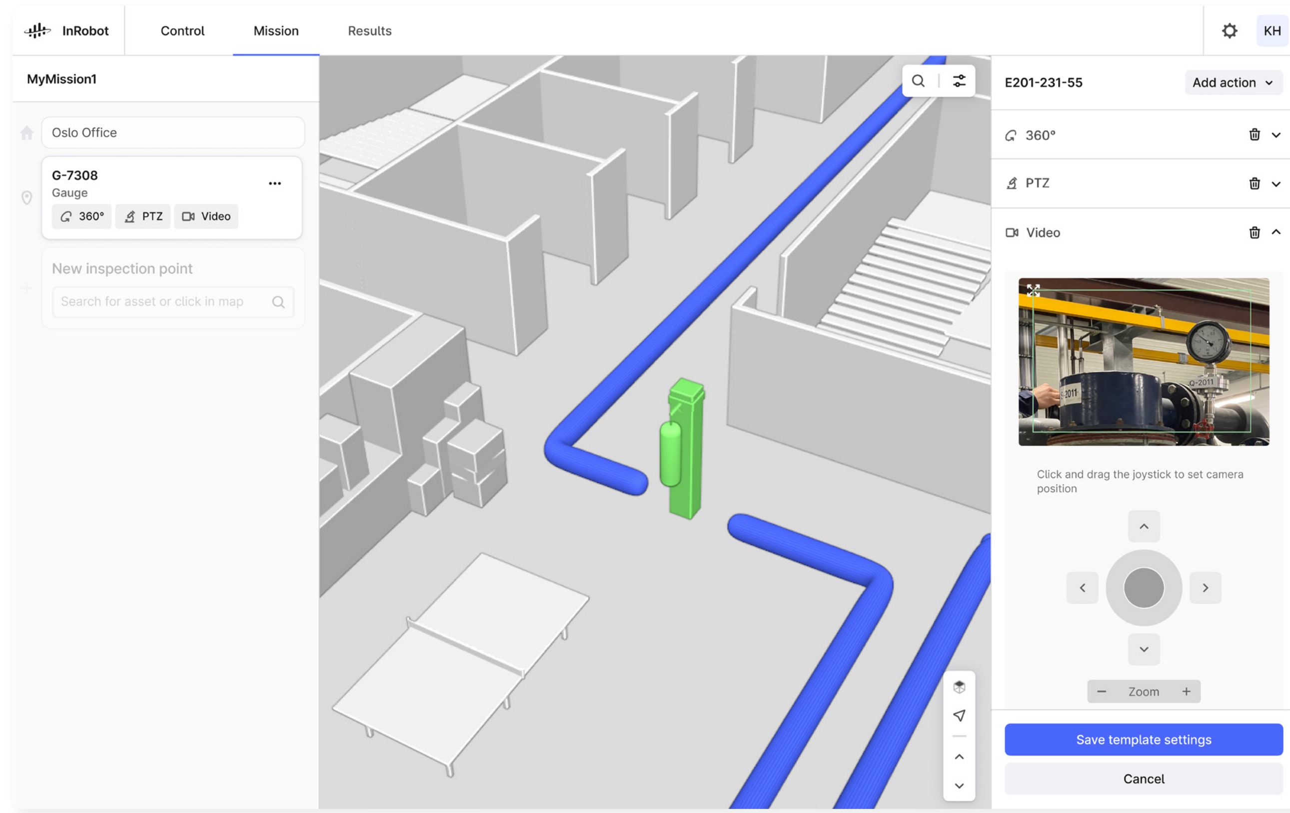


(Right side panel for mission creation)

DESIGN

The new design therefore propose action templates, where the users can select groups of actions for an inspection point, or create their own template. The interaction is inspired by state of the art applications like Figma and introduces the right side panel to InRobot.

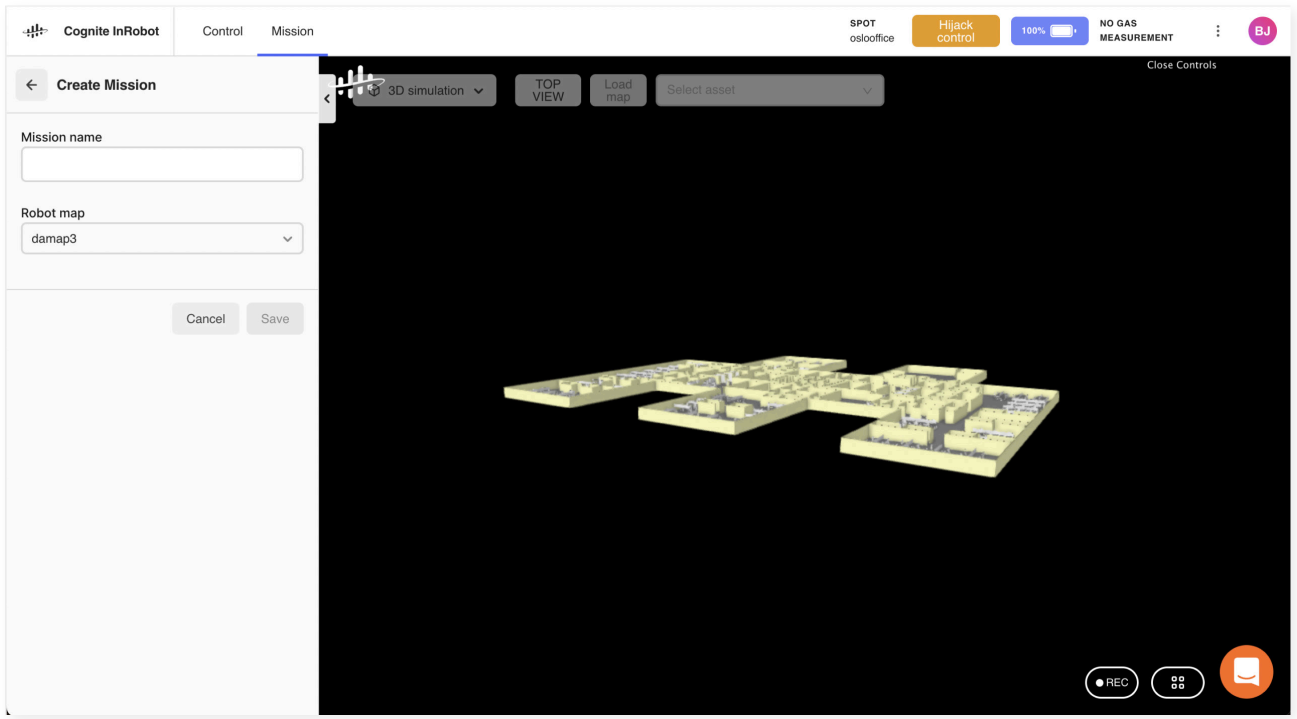
The flow of setting up multiple actions require more space than a singular action, the right side panel is therefore introduced in addition to the left side panel. The two panels work together where the left side gives an overview of inspections, while the right side gives details about the actions related to the selected inspection point.



(Right side panel setting camera position)

The reason for having the two side panels instead of modals or a separate tab is because of the importance of having the map as a reference point, which is common practice in state of the art applications from Google maps to strategy games. In further development it is also suggested that the users can define their own templates, to fully match their needs.

Original top bar

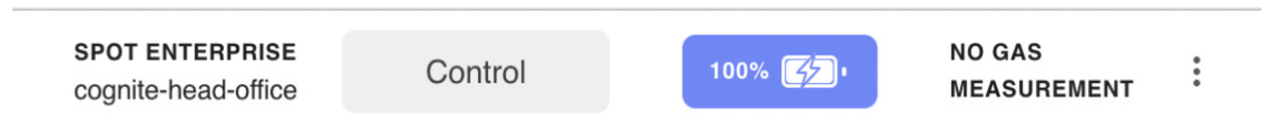


(Existing top bar)

SECONDARY TOPBAR

NEED

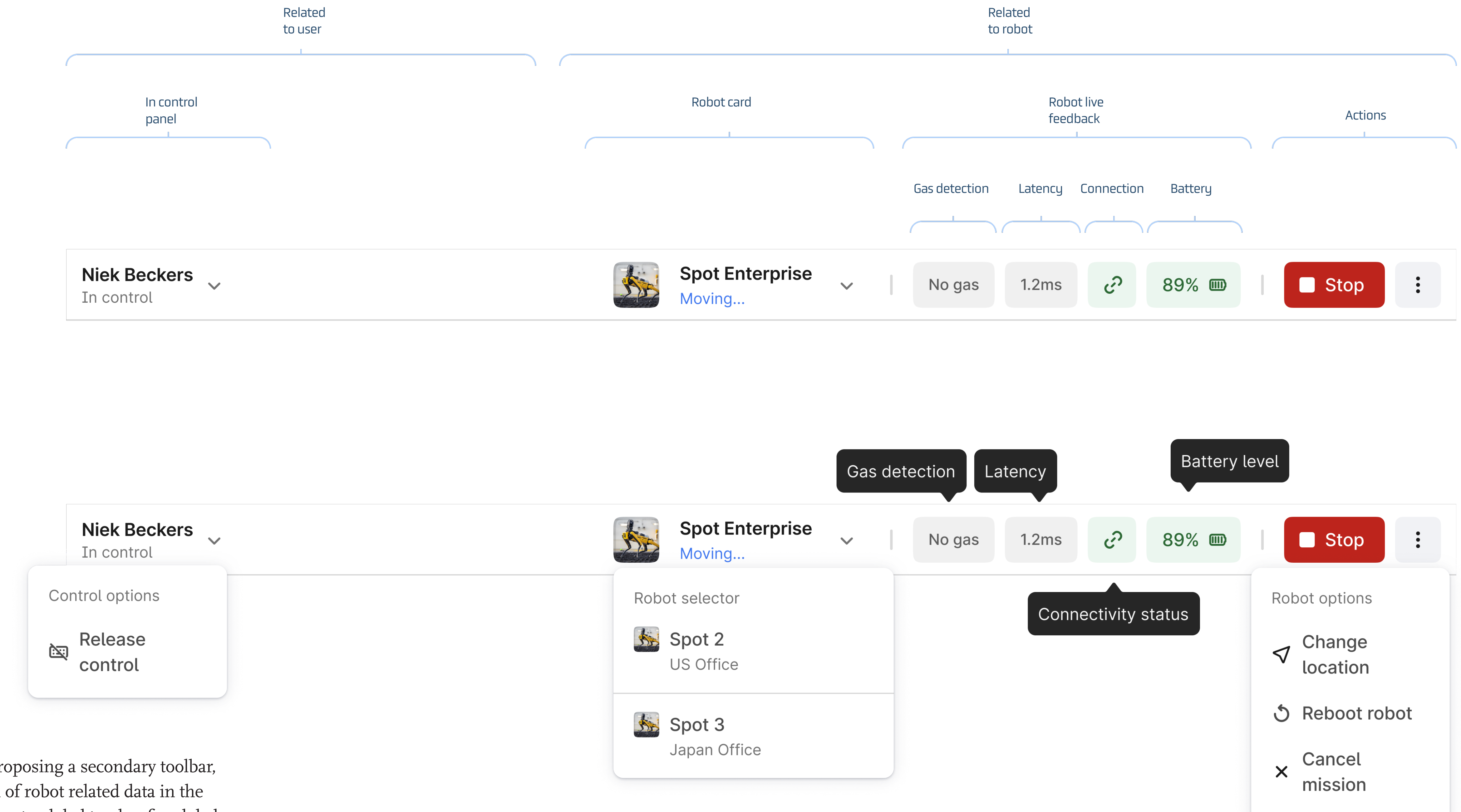
In the research of human-machine teams and state of the art applications, observability was a key factor. Early adopters and the heuristic review also pointed out a need for more feedback, communication and control. The screen shot above is taken from a test in InRobot. What is interesting to note is that it is hard to tell if the robot is currently doing something. In this screen shot the Robot is actually walking around the office. But there is very limited options both in terms of observability - what is the robot doing? And directability how can I control the robot?



(Existing feedback in topbar)

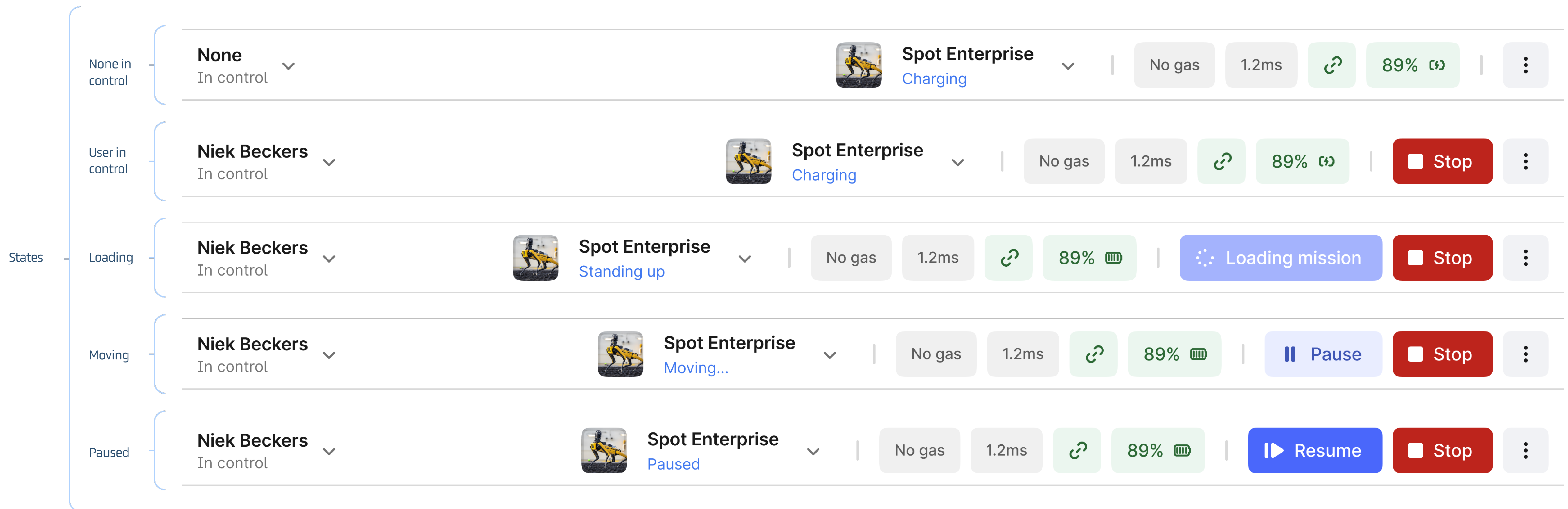
EXISTING

There were some existing feedback parameters in the global top bar of InRobot displaying battery status, gas detection, name and location.

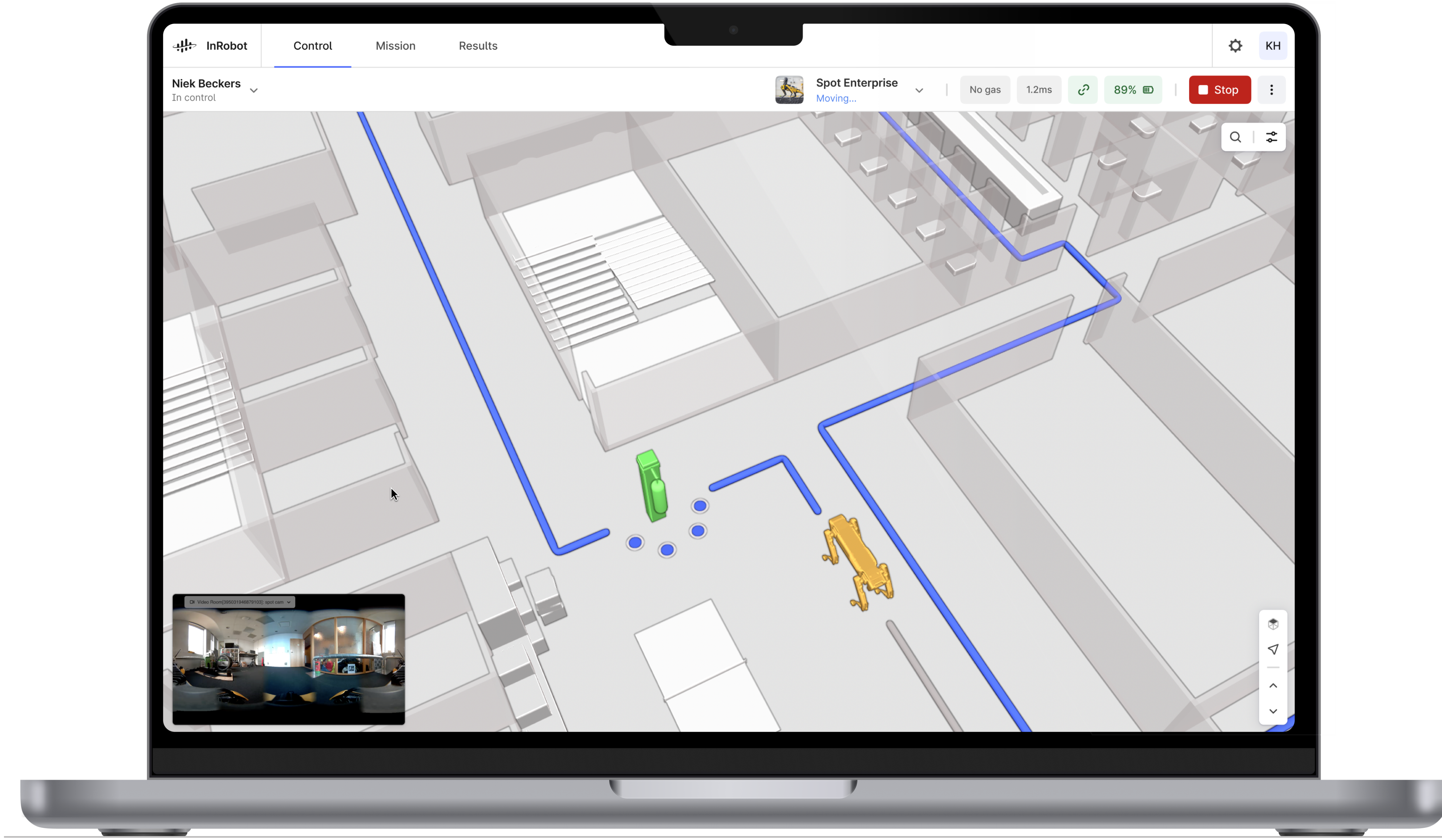


DESIGN

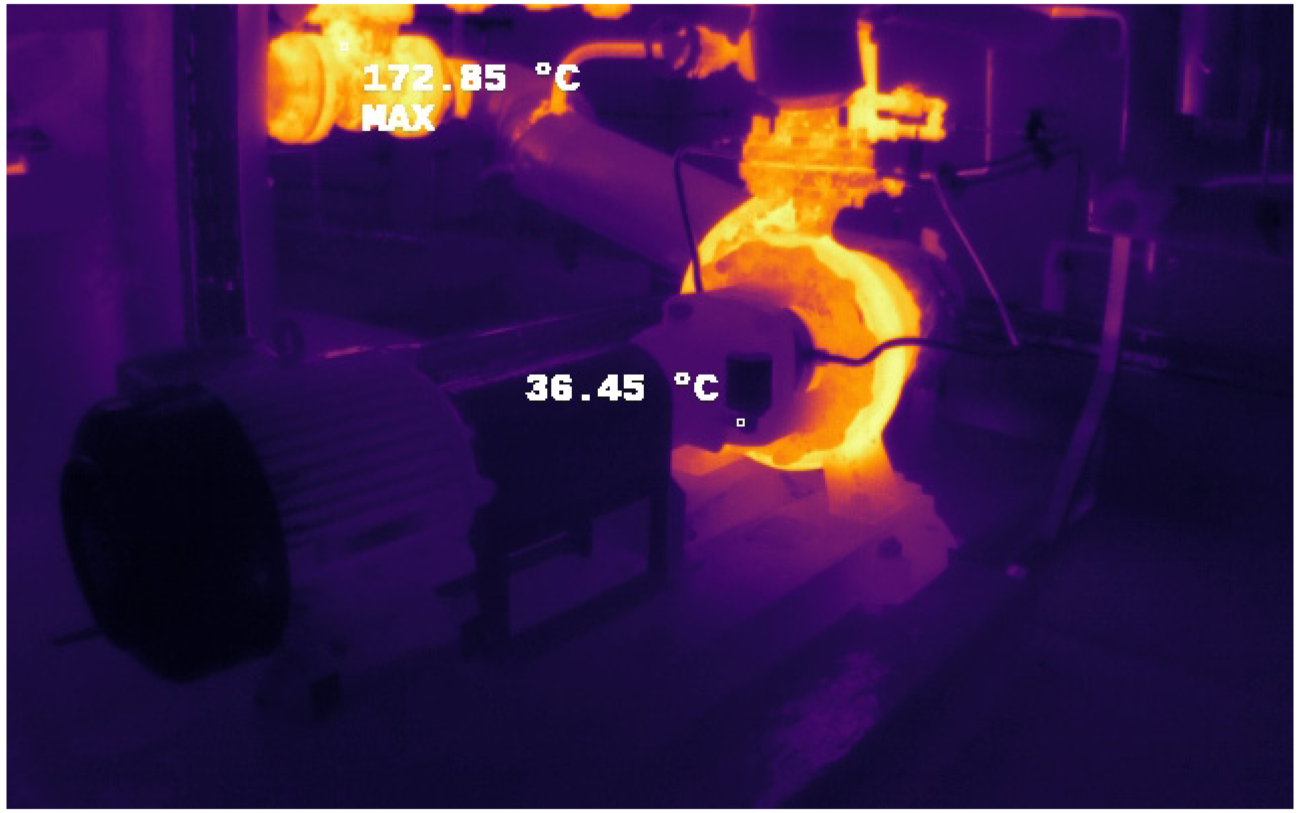
The new concept is proposing a secondary toolbar, replacing the position of robot related data in the global toolbar to reserve to global top bar for global actions. The secondary toolbar provides a home for actions, feedback and meta data related to the selected robot.



(Secondary topbar states)



(Secondary topbar in context)



(IR-image captured by Spot)

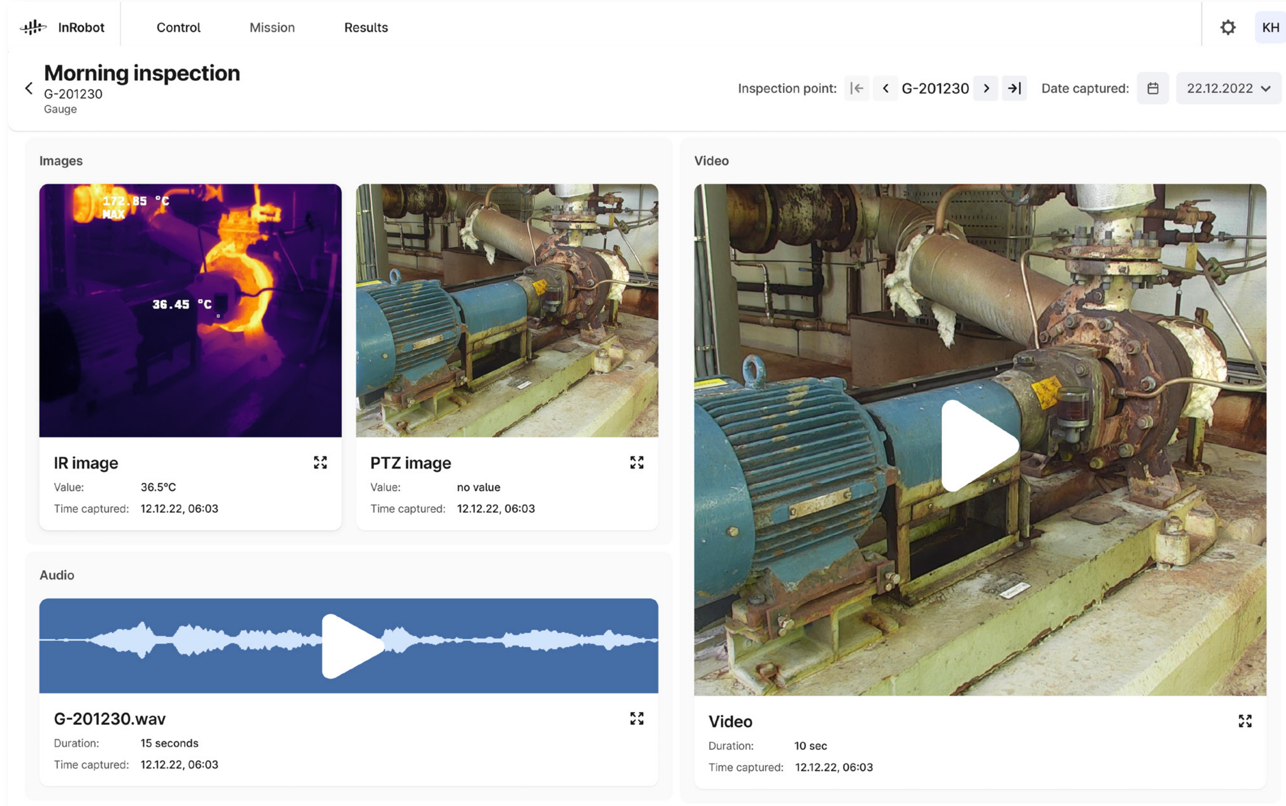
RESULTS

NEED

The most important job for the process operators is having a solid foundation of data to assess equipment. As discovered in the field research, they use all senses to make an assessment, which need to be reflected in the UI of displaying the results.

EXISTING

InRobot did not have a direct access point to the data gathered by the robot. The data was instead sent of to a different database where the user could review the results.

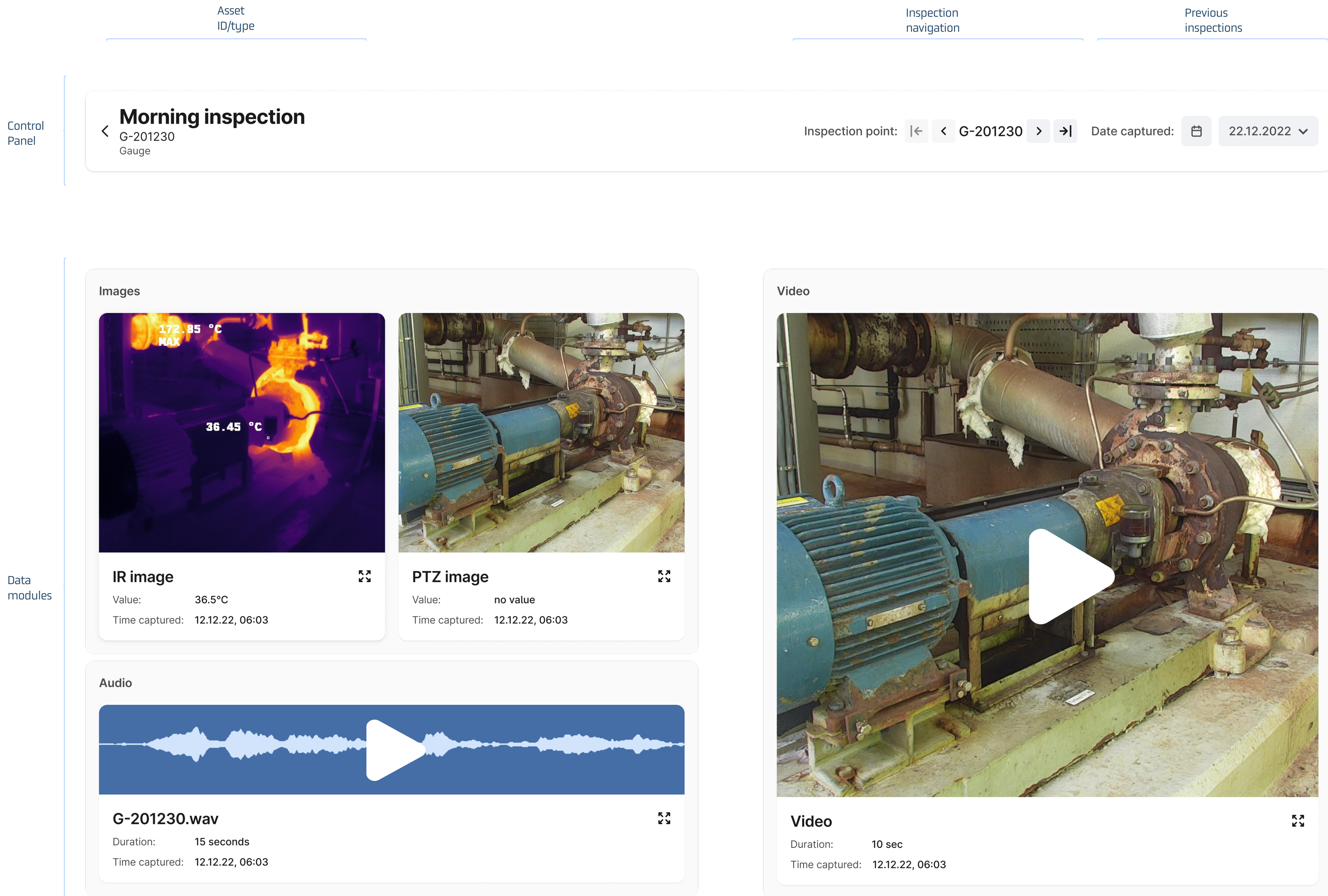


(Results design)

DESIGN

For the design of the results tab I have focused on the main view of an inspection point, and not how to get there by navigating through different inspection rounds.

For the design I wanted to simulate the process operators natural way of using all their senses to assess equipment. I've therefore designed a modular system that can display sound, video and images in one view. I have also added a calender and version option, so the user can compare previous inspections. Simulating they way the process operators go from one inspection point to the next, I have added back/forward buttons to quickly be able to change between inspection points in order.



(Results details)

VALIDATION WITH SUBJECT MATTER EXPERT

After creating click-able prototypes of the improvements and new design concepts, I was able to present them to a subject matter expert with over ten years of experience working in asset performance management. The session lasted for about half an hour and there were three main feedback points.

FLOW AND CONCEPTS

Aleksandra particularly like the results page, as this was part of what she was working with previously. The interaction of navigating between the equipment using back and forth buttons was great, as well as the calender and version options.

She was however interested in the dashboard and overview of multiple inspection rounds and what that would look like. Since I only had basic tables to present she provided very valuable feedback on what is most important to know as a process operators. This is something that will be worked on in the future InRobot in Cognite.

CREATING INSPECTION ROUNDS

Aleksandra liked the way of using the right side panel for creating inspections, and said that this work flow was similar to other programs she used to work in. She did however suggest a concept of being able to import Excel sheets with names and equipment types to generate the framework for an inspection, so the users wouldn't have to fill in hundreds of complicated names. After importing the sheets, the users could then go through the inspection points and add templates. The functionality of importing Excel sheets was already implemented but not in context with inspection templates. This feedback was valuable for the future development of InRobot, and how to create large inspection rounds quickly, which could be a pain for many users.

TERMINOLOGY

Feedback on the terminology kept coming up throughout the session. Missions, actions, runs, inspection and results are all terms that don't necessarily make sense to the users. It gets more complicated because different industries will have different definitions. Adding the "correct" terminology in the designs has therefore been difficult. But the challenge has been raised internally in Cognite, to make sure that InRobot will use terminology in line with other Cognite applications in the future.


BACKGROUND
RESEARCH
DEVELOPMENT
DESIGN
REFLECTION

REFLECTION

WHY ROBOTS?

Robots are impressive and fun things to work with, and as technology develops, robots get smarter, faster, stronger and more reliable. This enables robotics to be used in everything from household tasks to search and rescue. But where can robots prove real value beyond just being cool? And how can we avoid applying technology just for the sake of it? As the saying goes, «technology is the answer, but what was the question?»

Focusing on the asset performance management, sensors and cameras are often used in addition to humans when monitoring equipment. Cameras and sensors can give continuous feedback on the equipment compared to a robot which will only pass by every so often. Depending on the amount of equipment, cameras and sensors can also be less expensive than buying and maintaining a robot. Humans have good manoeuvrability and a complete set of senses. Combined with years of experience this makes us great at inspecting equipment.

Robots on the other hand have the ability to carry cameras and sensors with higher quality than individual sensors, especially taking costs into account. This makes them suitable for recording image, video, sound and gas leaks creating a much more detailed picture of the equipment, compared to individual sensory systems. Robots also don't need to rest compared to people as longs as the batteries are changed. This makes them more reliable in a setting where humans get tired or bored, and better to expose a robot to toxic gasses than a human.

In summary robots are fun and cool to work with, but maybe not the answer to all human problems. Exploring the use of robotics in the way that InRobot is doing, I think is a great way to develop and learn about robotics, and how to apply it in the future, and in some situations robots are beginning to outperform humans, but there is still a long way to go.

(Spot fell over)

(Loading state)

2

SPEED VS. TRUST

One challenge I've met several times when designing interactions for human-robot teams is speed vs. trust. In digital design speed is often the parameter used to measure success. For example in the design of an application for public transport the faster a user can get from not having a bus ticket to having one is one of the main key performance indicators. But when launching expensive robots or drones into potential dangerous areas with people walking around, safety and trust becomes more important than speed.

One example where I met this challenge was in the flow of starting an inspection round. The first time I tested this in the application I pressed the «run mission» button and nothing happened on the screen, but I could hear the robot standing up and walking around the room next door in the office, which was a scary feeling, because I didn't get any feedback on what was going on. Having a one click start is a really fast way of doing it, but it didn't feel safe. When working on the design for the secondary toolbar, I therefore added loading buttons. I also wanted this loading to take at least a couple of seconds, no matter how fast the connection is, giving the user the opportunity to cancel. I also wanted to work on a checklist design that should appear when starting an inspection round, which would slow the process down even further, but this fell outside the time frame.

STEALING JOBS

While on board the offshore vessel one of the crew asked us if the robot could weld. We said no, and then he gave us a big smile and said he was grateful that his job was still safe.

The fear of robots stealing our jobs is real, especially in manufacturing where robots have replaced many human jobs. This diploma project has not gone into depths of the ethic discussion of robots, and will therefore not make clear standpoint for or against. But from what I have learned and seen robots have a big potential for becoming great team players in the future, and not only lifeless machines. But for this to become reality, design and human-robot interaction needs to be a part of the design process from the beginning. Only then will we have robots that enhance and support humans, and vice versa, forming human-robot teams.

(Spot & Me)

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