Mixed reality: the next step in critical emergency calls?

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Preface

While writing this thesis,
I received a great deal of
support, encouragement
and input for which I must
express gratitude and
praise.

First of all, I would like to
thank my supervisory team
for their support. You
have always supported
me during my project and
made sure that there were
still coffee conversations
about the little things that
helped me get to where I
am today.

I would also like to thank my
parents, friends and family
who have supported me
during this remote thesis
project, an experience I will
never forget.

Summary:

Unfortunately, accidents and emergencies happen every day. Today, emergency services only rely on auditory information from the caller; to dispatch the right tools and instruct the caller.

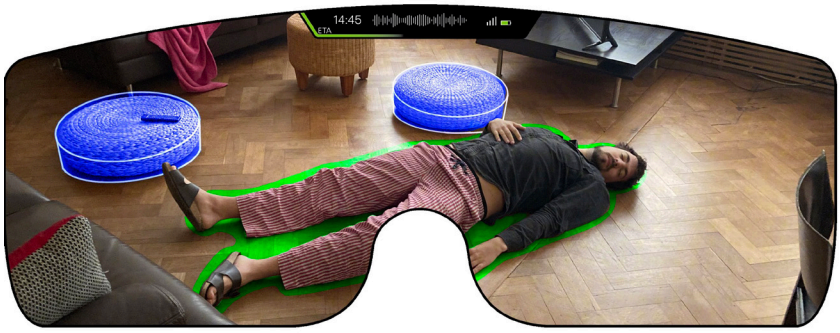
Imagine if the dispatcher gets extra visual information and sensors to their disposal. Or that the caller receives immersive, self-evident instructions right in front of their eyes. So they can provide aid without taking their hands or their attention away from the emergency.

That is all possible with EVU. EVU, Emergency Vision Unit is a mixed reality helmet to professionally deal with critical emergency calls while the first responders are on their way.

EVU provides visualisation of instructions in real-time to the caller during an emergency and gives the dispatcher real-time visual information to assist.

Straightforward three-dimensional instructions in mixed reality so anyone can apply professional first aid without any prior training.

The mixed reality experience highlights all the crucial tools and emergency exits that can help save lives.



Clear communication during the emergency call with a visual feedback layer, so there are no doubts while handling an emergency.

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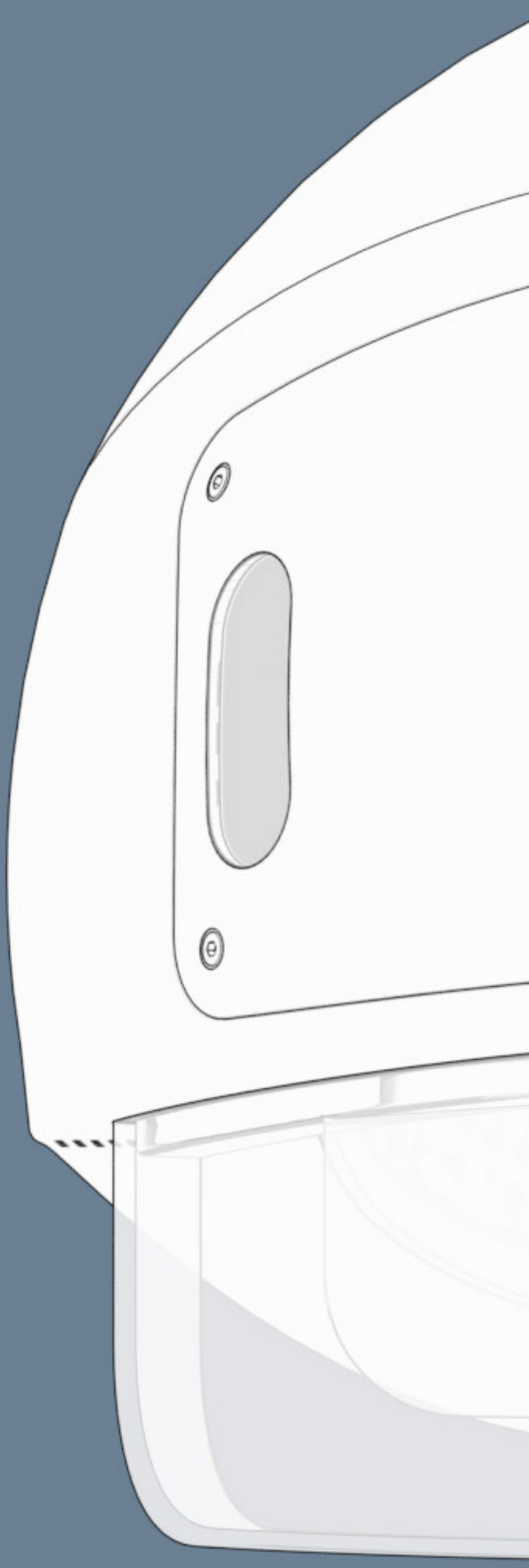

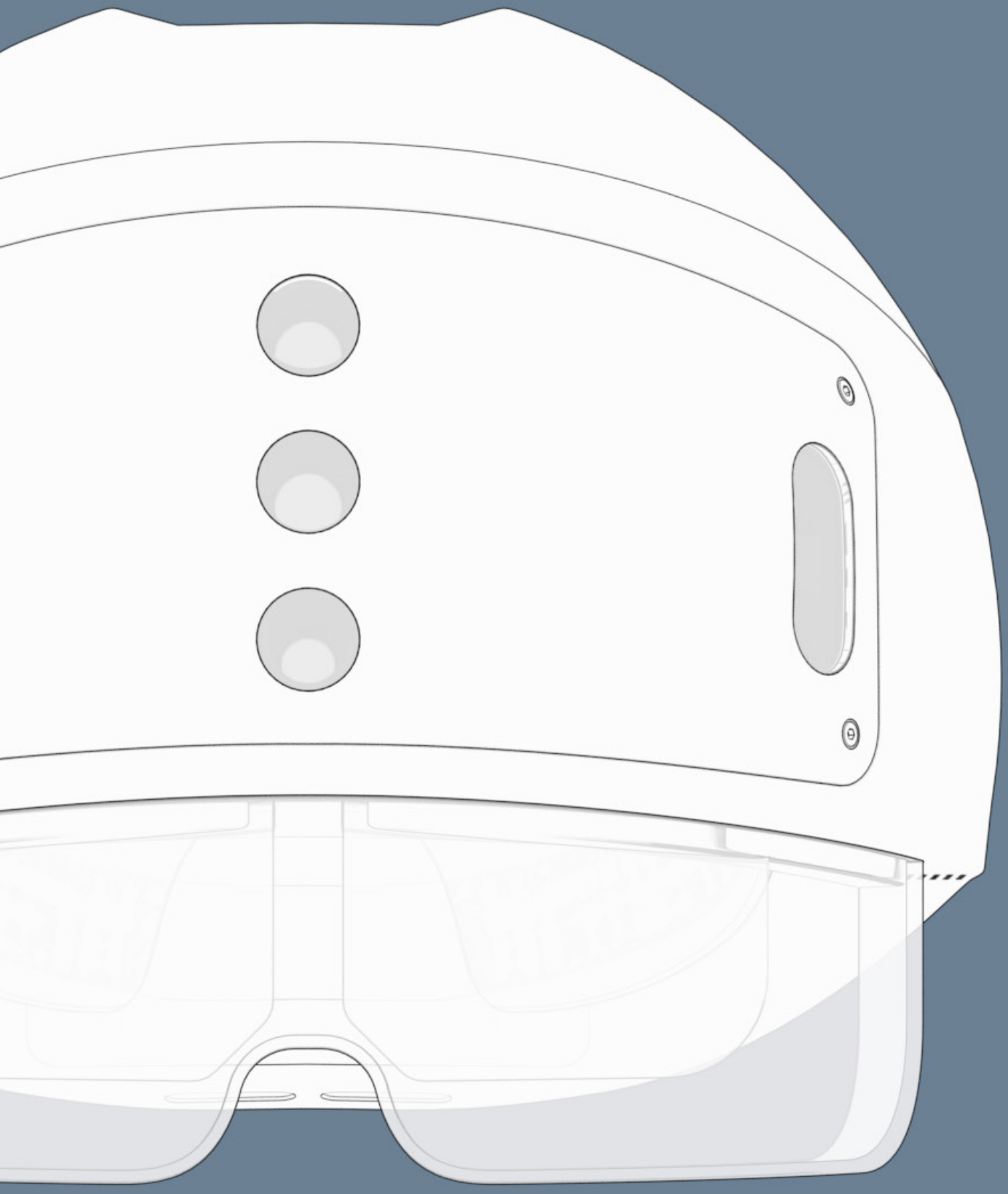

1.1 Starting thought

My graduation idea started from personal experience, before studying design, I studied Nautical science to become a merchant marine officer. During that education, I had a lot of safety courses such as fire fighting, crowd control and medical emergencies.

However, during practice drills, a considerable number of students and professionals failed some simple tasks due to the stressful situation. This reoccurring realisation started my thought process.

If trained people have difficulty to use a fire extinguisher or first aid kit in a stressful situation, how do we expect untrained people to handle right in such an event?

1.2 Assignment

This graduation project focuses on exploring the technological possibilities of upgrading the auditory communication during critical emergency calls with an extra visual layer of information to achieve guided professional support from the start of an emergency (call).

1.3 Approach and methodology

	Month	February			March				April					MAY					June			
	week nr.	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
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	date	8-12	15-19	22-6	1-5	8-12	15-19	22-26	29-2	5-9	12-16	19-23	26-30	3-7	10-14	17-21	24-28	31-4	7-11	14-18	21-25	28-3
Kick-off, midterm, green light graduation		KO							MT									GL				GRA
ACTIVITY	HOURS																					
DISCOVER: insights in the problem		KO																				
RIP the brief																						
Define scope																						
Desk research - context level																						
Desk research -interaction level																						
Prepare interviews																						
Field research Interview stakeholder																						
Desk research technology																						
DEFINE: the area to focus on																						
Combine learning and insights																						
Define opportinities																						
Define design challenges																						
Define List of Requirements																						
Expert interview																						
DEVELOP: potential solutions									MT													
Ideate																						
evaluate ideation phase																						
Define 3 concepts																						
Evaluate value																						
Evaluate usability																						
Evaluate product concept																						
DELIVER: solutions that work																		GL				
Define 1 concept																						
Build, test, iterate (repeating process)																						
Final concept/prototype																						
Verification of final prototype																						
Recommendations																						
FINALIZE:																						GRA
Report																						
Presentation																						

BREAK

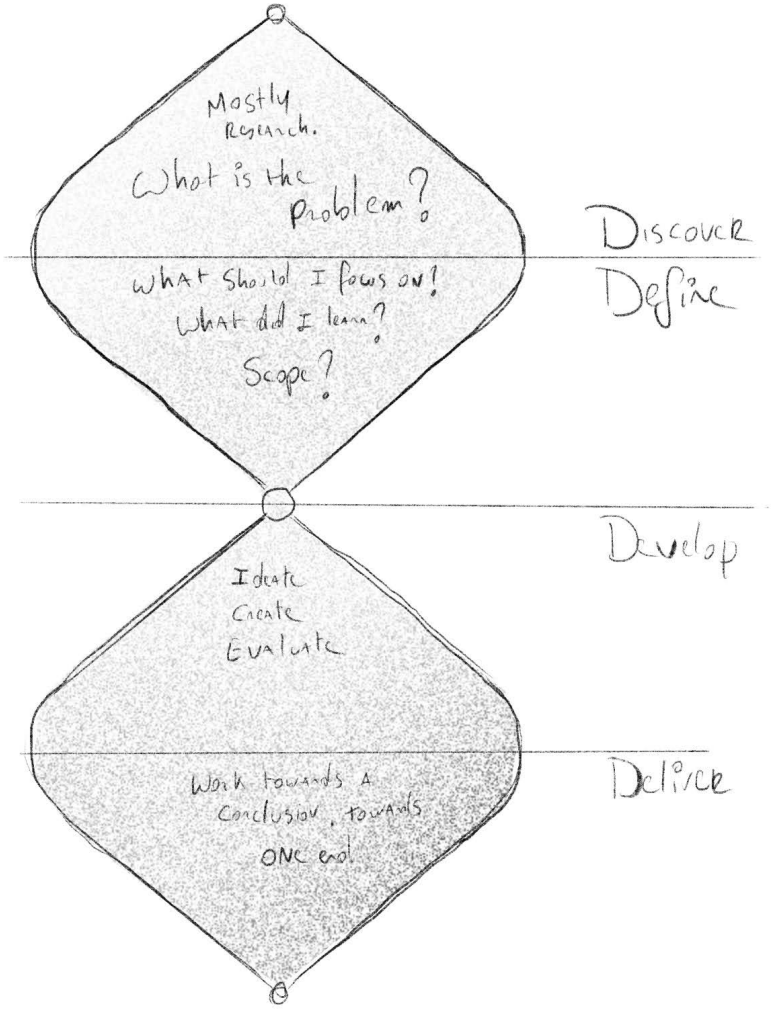
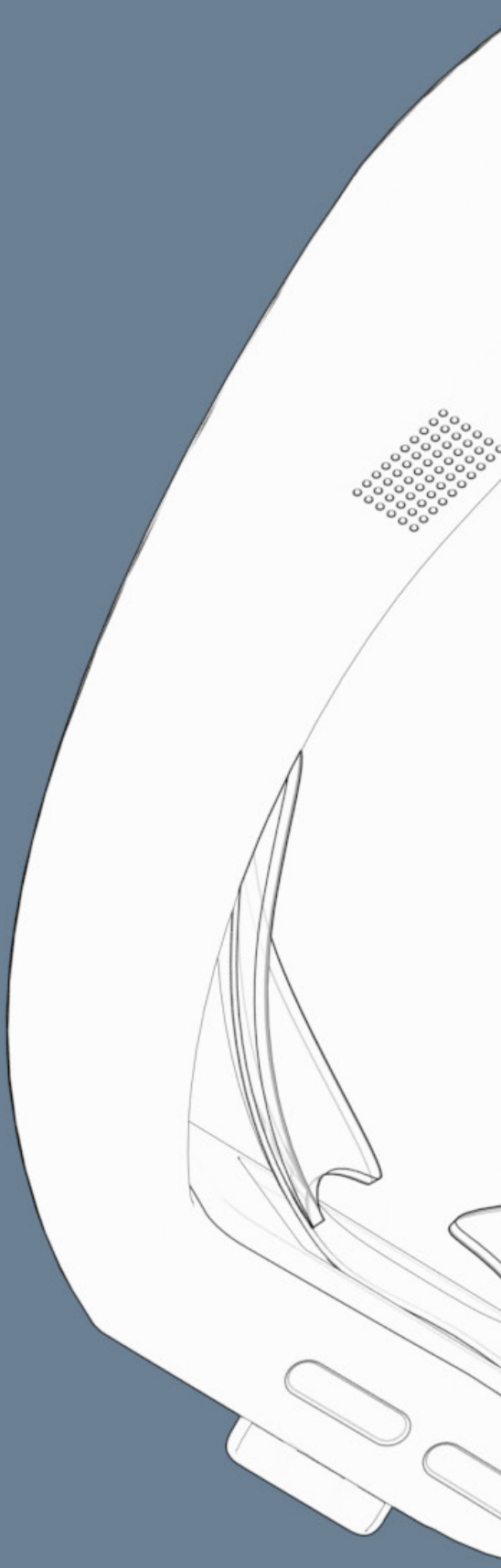


Fig. 01: Double diamond design model

As a design method, the well-known Double Diamond design model was used, consisting of four parts; Discover, Define, Develop and Deliver. It was the basis for planning at the beginning of the project. It was not a linear model, but a direction where going back and forth is allowed.

2 Discover



2.1 Current situation

To discover new opportunities for critical emergency calls, we first must look at today's current situation. How does it work today?

1. The emergency call kicks off with a bystander or a victim, who dials the local emergency number. The caller immediately enters a waiting list at the emergency call centre. As soon as possible, the call gets transferred to an available dispatcher.

2. Instantly the dispatcher will interview the caller to collect relevant information with as few questions as possible. The minimum information required to send help is the location and the sort of emergency.

Simultaneously with the interview, the dispatcher will fill the gained knowledge in an emergency form. This form will be the minimum intel provided to the dispatched emergency services.

3. Before sending out help, the dispatcher will double-check the location of the caller if possible. Unfortunately, automatic location sharing is not always reliable yet.

4. Instantly after receiving the form, the emergency services will drive out to the location of the emergency. Meanwhile, the dispatcher will instruct the caller, how to help until the emergency services arrive on the scene. Only if the caller wants to provide help, the caller cannot be obligated to help.

5. During the drive to the emergency scene, the call-taker will contact the dispatched services to update them more in detail before arriving.

6. The dispatched services are followed up by the call centre until they are back available for duty. On arrival, the emergency services will take over the scene and handle it from there.

Fig. 02: Storyboard – current situation

2.2 Emergency situation

What is an emergency?

According to the current legislation an emergency situation is:

- an event or situation which threatens serious damage to human welfare.
- an event or situation which threatens serious damage to the environment; or
- war, or terrorism, which threatens serious damage to security.

(Secretariat Civil Contingencies, 2004)

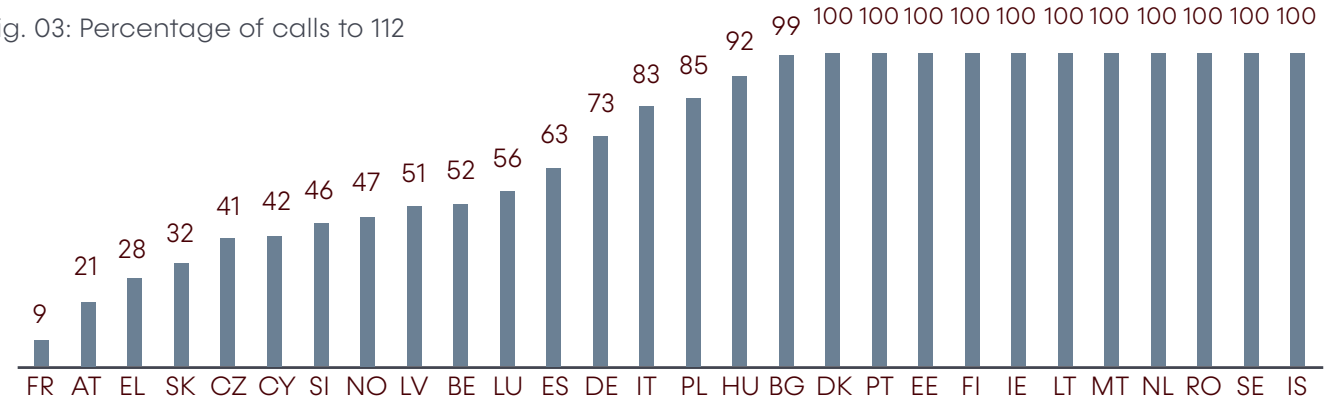
Who to call?

In case of an emergency, 112 is the number to call. It is the European emergency number in all EU member states and other European countries. It is free of charge and available 24/7. ((EENA asbl Director of Publication: Dr Demetrios Pyrros, 2020)

With the emergency number, you can reach the fire brigade, an ambulance, or the police. For other not urgent emergencies, specific numbers exist, such as the suicide line or Child Focus. (112 SOS, 2020)
The dispatchers will speak to you in the language of the country in which you call. Assistance in English is also possible when you do not speak the local language. When calling the emergency number, a physical dispatcher on the other side of the line will answer your call.

In other words, if a person calls 112 without a valid reason, the dispatcher will not be able to take the calls from people who are really in danger.
112 is the official European emergency number since 1991. It is free and accessible by mobile as well as landlines. Close to 150 million 112 calls a year are made. However, the 112 calls only represent 56% of all emergency calls made in Europe every year. Of all emergency calls last year, seventy-three per cent are mobile phone users.

Fig. 03: Percentage of calls to 112



Roaming end-users, or people calling with a foreign phone number, account for 2.3 million emergency calls within Europe each year.

However, the use of 112 heavily depends on the awareness of the number and the co-existence of national legacy numbers.

Since 31 of Match 2018, new cars are obliged to have an E-call connection as standard in case of an accident on the road. Even today, reaching out

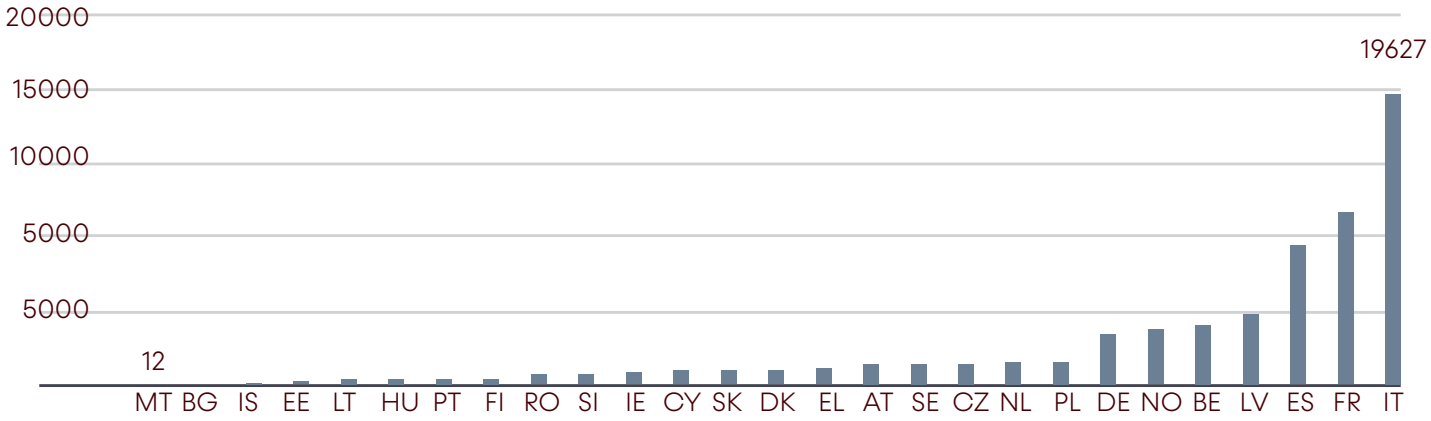


Fig. 04: Number of eCalls placed in the EU

to the emergency services for callers with disabilities is still a hassle. SMS is the most used solution. However, this does not work in every country. Some countries only offer text conversations through their local emergency app.

With today's technology, location-sharing is still the main problem. 60 to 70% of the calls do not share their accurate position with the dispatcher, although there is a system to do it in place, AML. According to the European Commission, emergency

communication could become more efficient using: Automatic location sharing, text, and video for users with disabilities, vertical location (z-axis) and other contextual data. (European Commission, 2020)

To call or not to call?

To call:

- In case of a building, forest, or car fire
- When there is smoke coming out of a building
- When people are stuck or trapped during an evacuation
- When people are stuck or trapped in a car and in need of evacuation
- When someone tries to steal a car
- If you are the victim or the witness of a fight or aggression
- If you witness a suicide attempt
- When someone is unconscious
- When someone does not stop bleeding
- When someone is suffocating

Not to call:

- To test if the emergency numbers work
- To make a joke
- For general information such as someone's address
- If you locked yourself out of the house

(112 SOS, 2020) (Politie.be, 2021)

Why do people call?

19% of all emergency calls fall under the category "unclear problem", which is the most frequent category. If we look at the most common know reasons why people call for a medical emergency, then we find:

- Wounds, fractures, minor injuries 13%
- Chest pain, heart disease 11%
- Accidents 9%
- Intoxication, poisoning, overdose 8%
- Breathing difficulties 7%

(Møller, et al., 2015)

Response time:

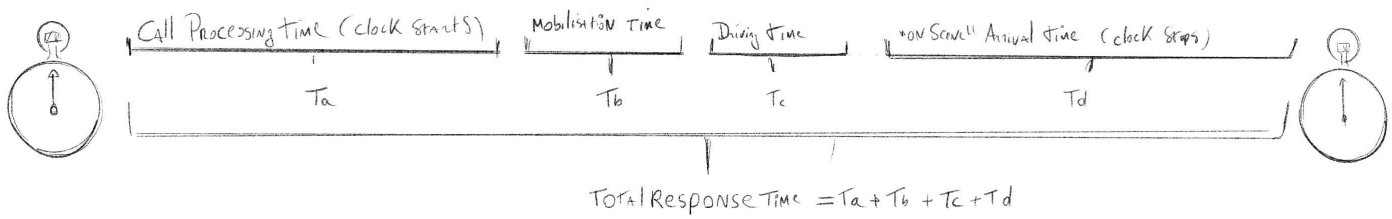


Fig. 05: Response time

The total response time for an emergency depends on several inputs, as seen in the picture. However, the response time is measured from the perspective of the caller. From the moment she or he makes the call to the time the emergency service arrives on the scene. The emergency services are required by law to record these time slots for every intervention or call. (EENA asbi, 2014)

Call processing time:
The processing time starts from the moment the call reaches the emergency centre. In other words, from the moment the caller hears a ringing tone.

This way, they can also take the waiting or queuing time into account. According to the operational standards, the dispatcher will determine the caller's location, the nature of the emergency and the required actions to undertake.

Mobilisation time:
This timeslot is the time taken for the allocated units to prepare and depart towards the emergency scene. The clock in this timeslot starts running from when the dispatcher sends the notification to mobilise until the allocated emergency response unit left the base.

Driving time:
From the moment the units leave the base until they send the message " Arrived on the scene".

Emergency Intervention:
Time of the intervention at the scene.

Some numbers:
- 95% of all incoming calls is answered within 5 seconds. (IBZ 2016, 2016)
- Firefighters in Flanders take an average of 10 minutes 23 seconds to arrive on the scene. (Rommers, 2016)
- 85.6% of the time police response arrives on the scene within 15 minutes. (Politie NL, 2021)

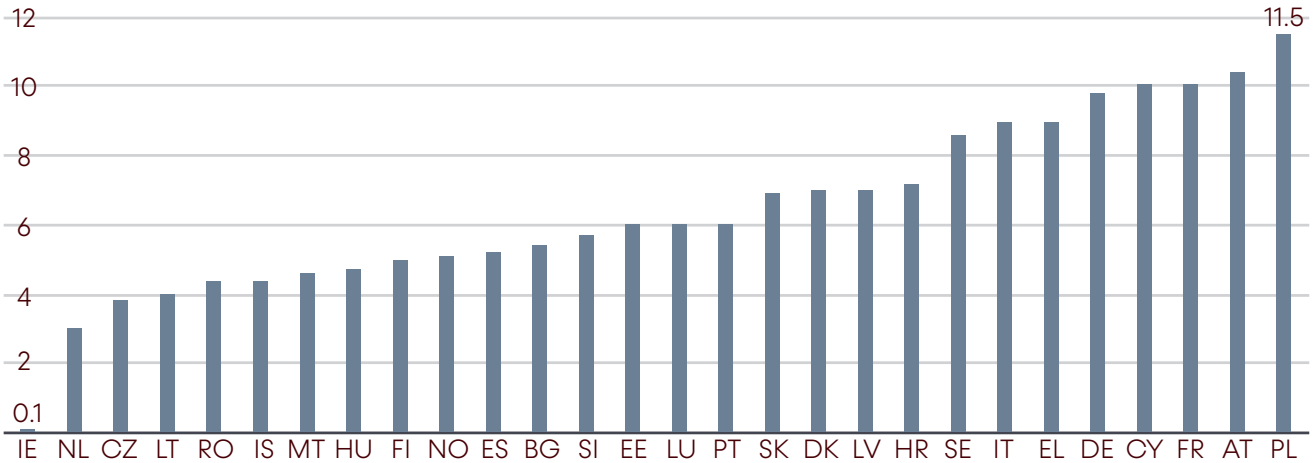


Fig. 06: Average answering time

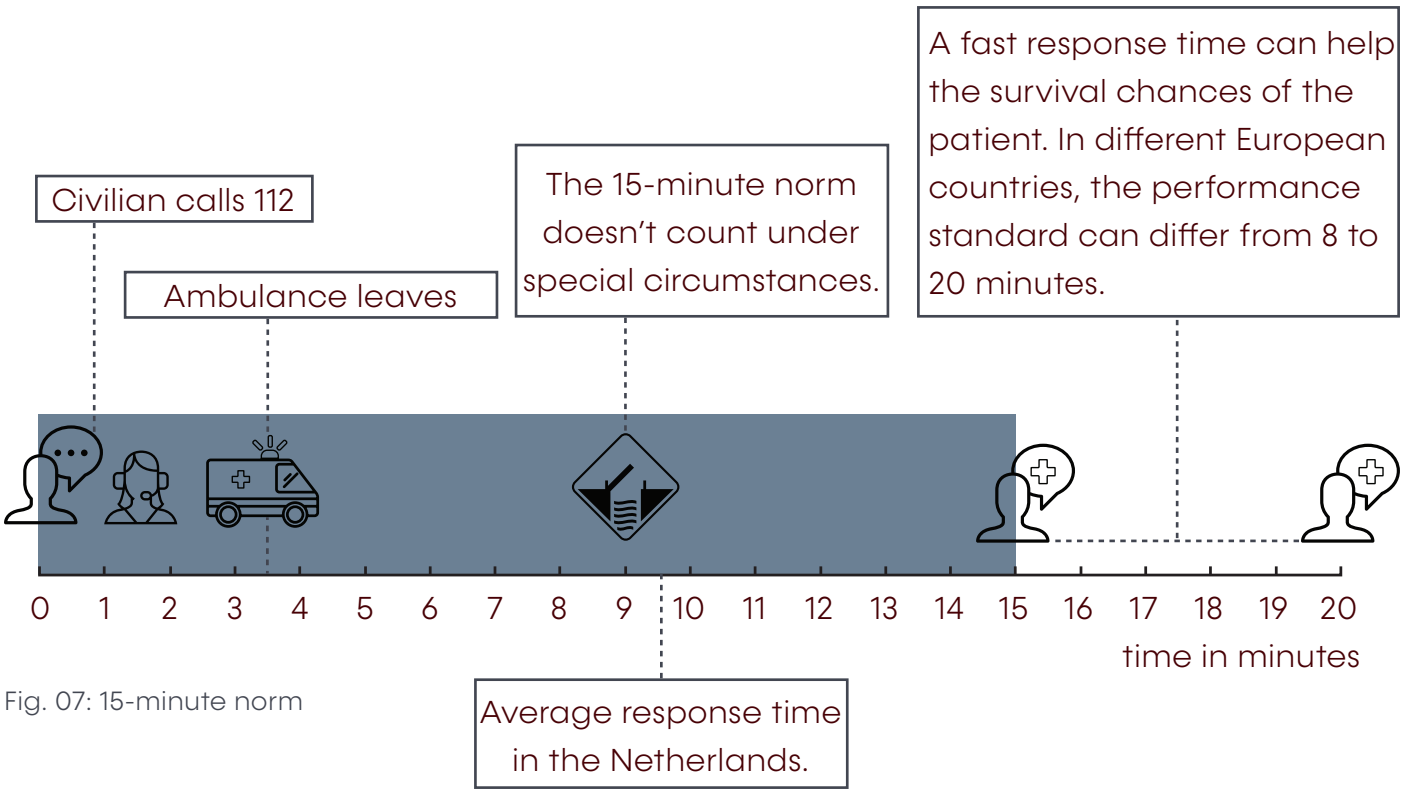


Fig. 07: 15-minute norm

Since 1996 a quality law is in place to ensure an ambulance on the scene within 15 minutes. (Nivel, 2015) This law made it possible that in Europe, 95% of the high priority emergencies, an ambulance arrives within 15 minutes. (AZN, 2019) The average response time an ambulance took in 2017 in the Netherlands was 9 minutes 41. (AZN, 2018)

Not only, the arrival time has a fixed goal, but there is also a norm-time for bringing the patient into the hospital. Within 45 minutes after the dispatcher receives the call, the patient should arrive in the hospital. The 45 minutes rule is a destructive norm. After that time gap, the survival chances drop rapidly, and the changes of permanent health damage increase. But it also impacts the entire intensive care. (AZN, 2019)

2.3 Prehospital care

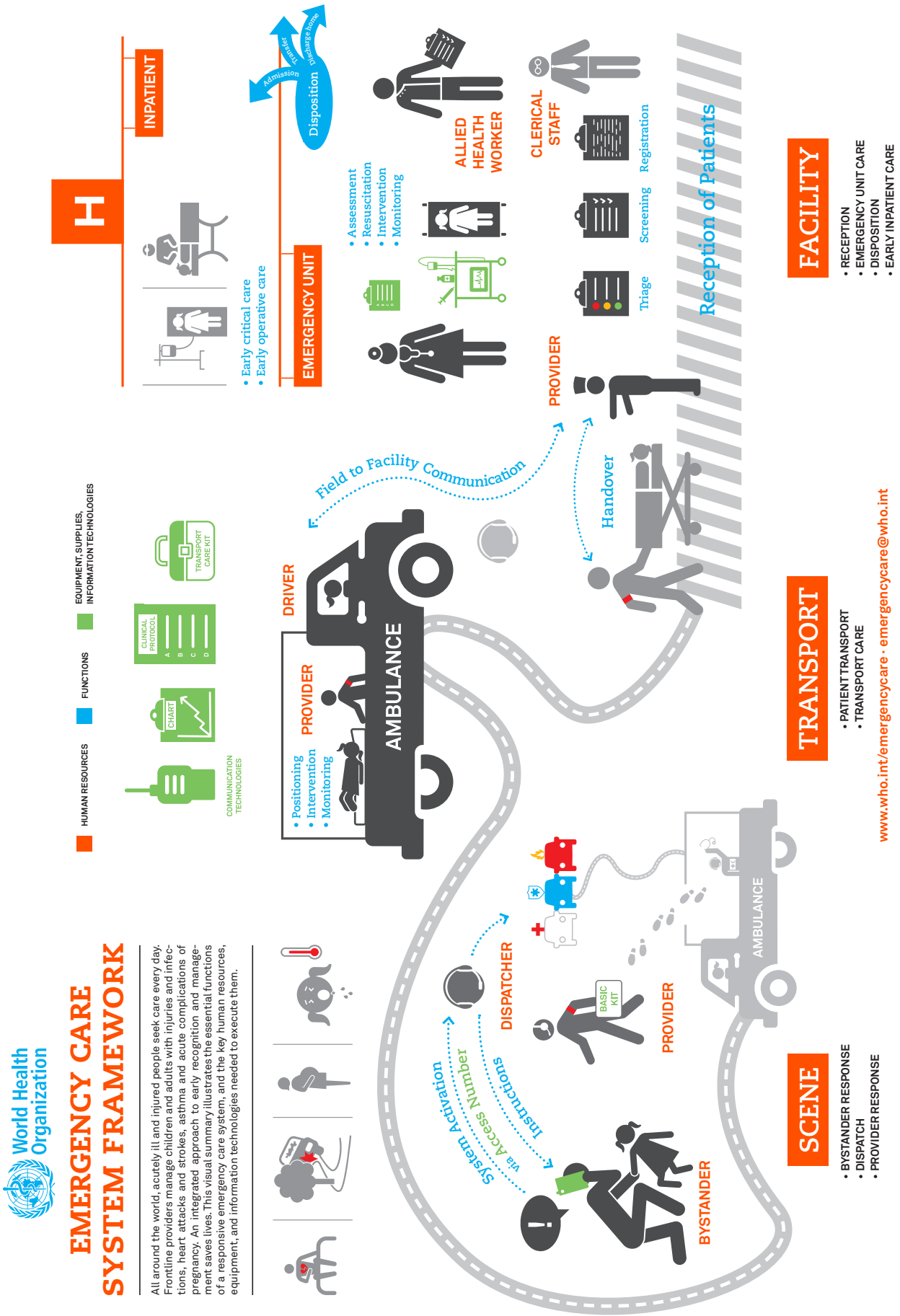


Fig. 08: WHO Emergency Care Framework

World Health Organisation:

Emergency services are civilians' access to prehospital care. Bystanders help to save lives by activating the emergency response system and performing first aid until professionals arrive. (WHO, 2018)

In the infographic above, the WHO illustrated the framework of emergency care. This graduation project will focus on what happens on the scene: the bystander response, the dispatch, and the provider response.

Bystanders of an emergency; call for help and are forwarded to a physical dispatcher. The dispatcher will initiate the emergency care and will instruct the bystander until a professional support provider arrives at the scene.

The bystander (or caller) is the stakeholder that initiates the whole process. He/she is the eyes, ears, and hands of the emergency service until professional support arrives at the scene.

On top of providing the correct information, they will have to perform first aid or support the victim. The dispatcher receives the call and handles it according to predefined protocols. They filter and transfer the correct information to the professional support agencies while instructing the (stressed) caller.

The professional support providers prepare themselves according to the received information and take over the care when arriving on the scene.

Why focusing on emergency response?

- Fast recognition and treatment significantly reduce mortality from sepsis and pneumonia. (Gaieski, 2010) (Hortmann, 2014) (Rivers, 2001)
- A functional-organised trauma system has proven to half preventable deaths among severely injured. It also improves the functional outcome of survivors. (Siman-Tov, 2013) (Tallon, 2012)
- Timely emergency care saves lives and reduces disability, but there is a global disparity in access to emergency care. Implementation of emergency care can save up to 500 000 road traffic fatalities every year. (Geneva: World Health Organization;, 2017)
- Early recognition plus emergency care within 60 minutes decreases the mortality rate for myocardial infarction. (Terkelsen, 2012)
- 25% decreased risk of dying from trauma in areas where prehospital care is in place. (Henry & Reingold, 2012)
- Only 55% of countries have prehospital providers, Despite the enormous potential impact of prehospital on reducing mortality. (Geneva: World Health Organization, 2018)
- The probability of death increased approximately 1% for each 3 minutes before laparotomy from trauma. (Clarke, Trooskin, Doshi, Greenwald, & Mode, 2002)

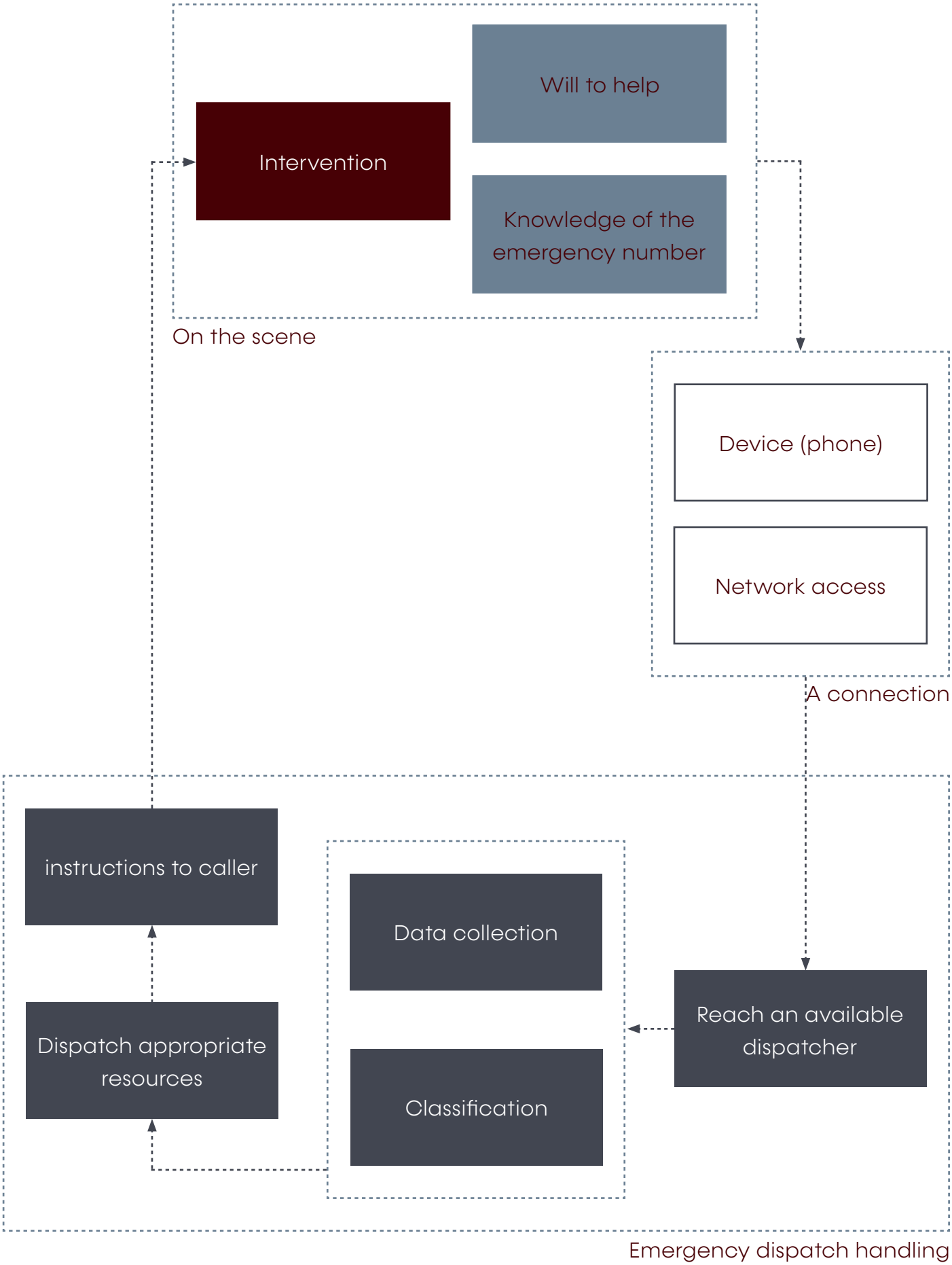
Sustainable Development Goals:

An overview of the sustainable emergency goals that are focused on emergency care and response:

- 3.1: By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births. (United Nations, 2021)
- 3.2: By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births (United Nations, 2021)
- 3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases, and other communicable disease. (United Nations, 2021)
- 3.4: By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being (United Nations, 2021)
- 3.5: Strengthen the prevention and treatment of substance abuse
- 3.6: By 2020, halve the number of global deaths and injuries from road traffic accidents (United Nations, 2021)
- 3.7: By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes (United Nations, 2021)
- 3.8: Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality, and affordable essential medicines and vaccines for all. (United Nations, 2021)
- 3.9: By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination. (United Nations, 2021)
- 3.d: Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks (United Nations, 2021)
- 11.5: By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations (United Nations, 2021)
- 16.1: Significantly reduce all forms of violence and related death rates everywhere (United Nations, 2021)

2.4 The emergency call:

Service chain:



When a civilian calls the emergency services, it initiates a sequence of tasks. This chain of events exists of different steps performed by several stakeholders. As seen in the picture, the chain starts with the willingness to call and knowing the (local) emergency number.

It sounds strange that the willingness to help is a crucial step in the emergency care chain. However, according to the Antwerp Emergency centre, people nowadays are less eager to help strangers in need. The current Covid crisis increased the barrier to help, according to their recent experience.

During an emergency, the civilian may be under stress and does not have time to search for the correct contact information. That is why Europe has strived for one European emergency number to call in distress "112".

The next step in the chain is a functioning device that can establish a connection with the emergency centre. After dialling 112 the civilian is quickly connected with an available call-taker.

After establishing a secure connection, the call-taker will gather as much information as possible and classify the emergency. The dispatcher will dismiss the appropriate resources and services and assist the caller with instructions over the phone.

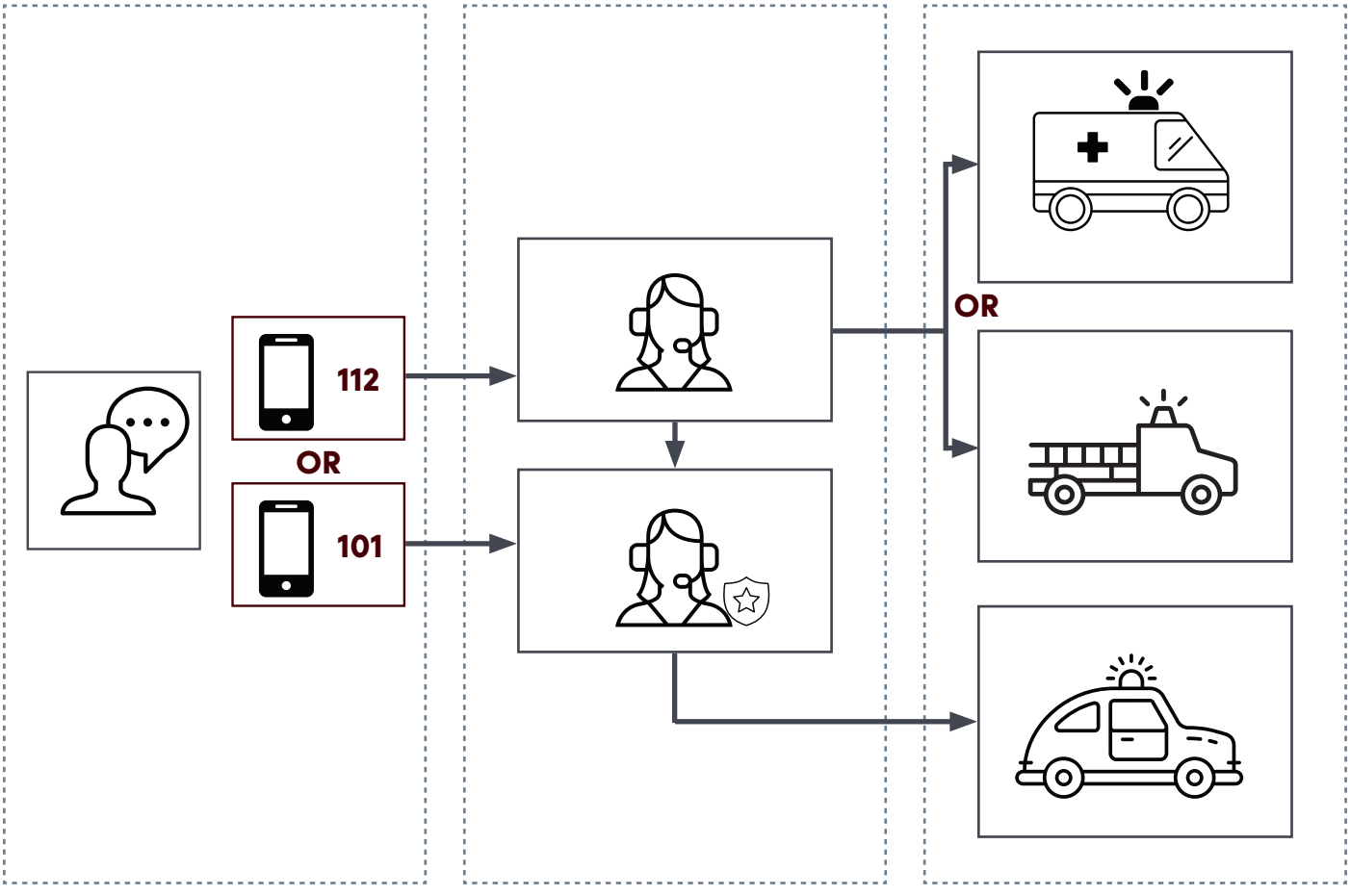
Care call model:

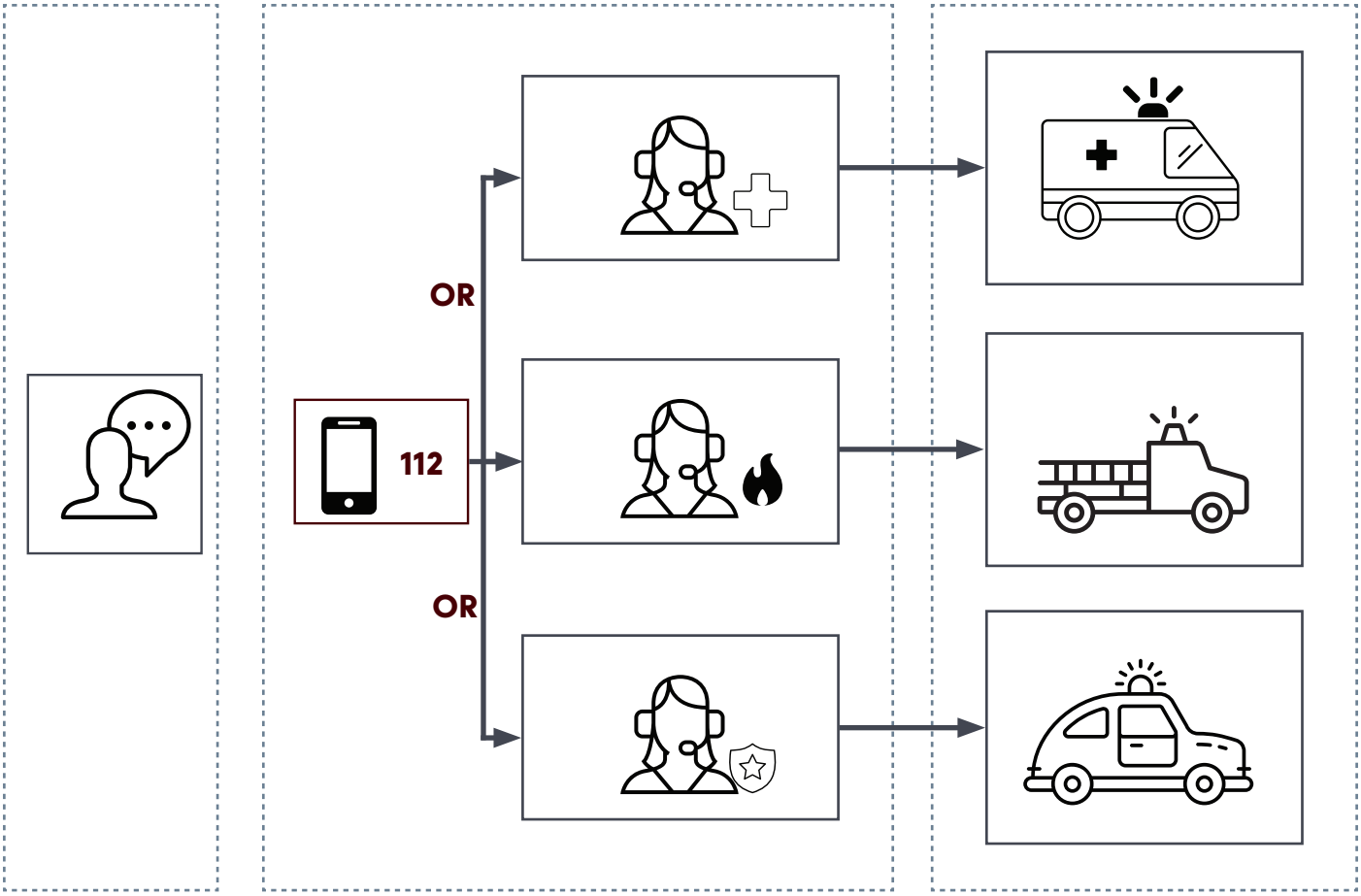
Not every country handles the emergency call handling chain the same. Some models will be used to provide a general overview and highlight the differences. In the Netherlands, there is only one general emergency number in use. At the start of the call, you choose the department. And you are automatically forwarded to the specific department's dispatcher.

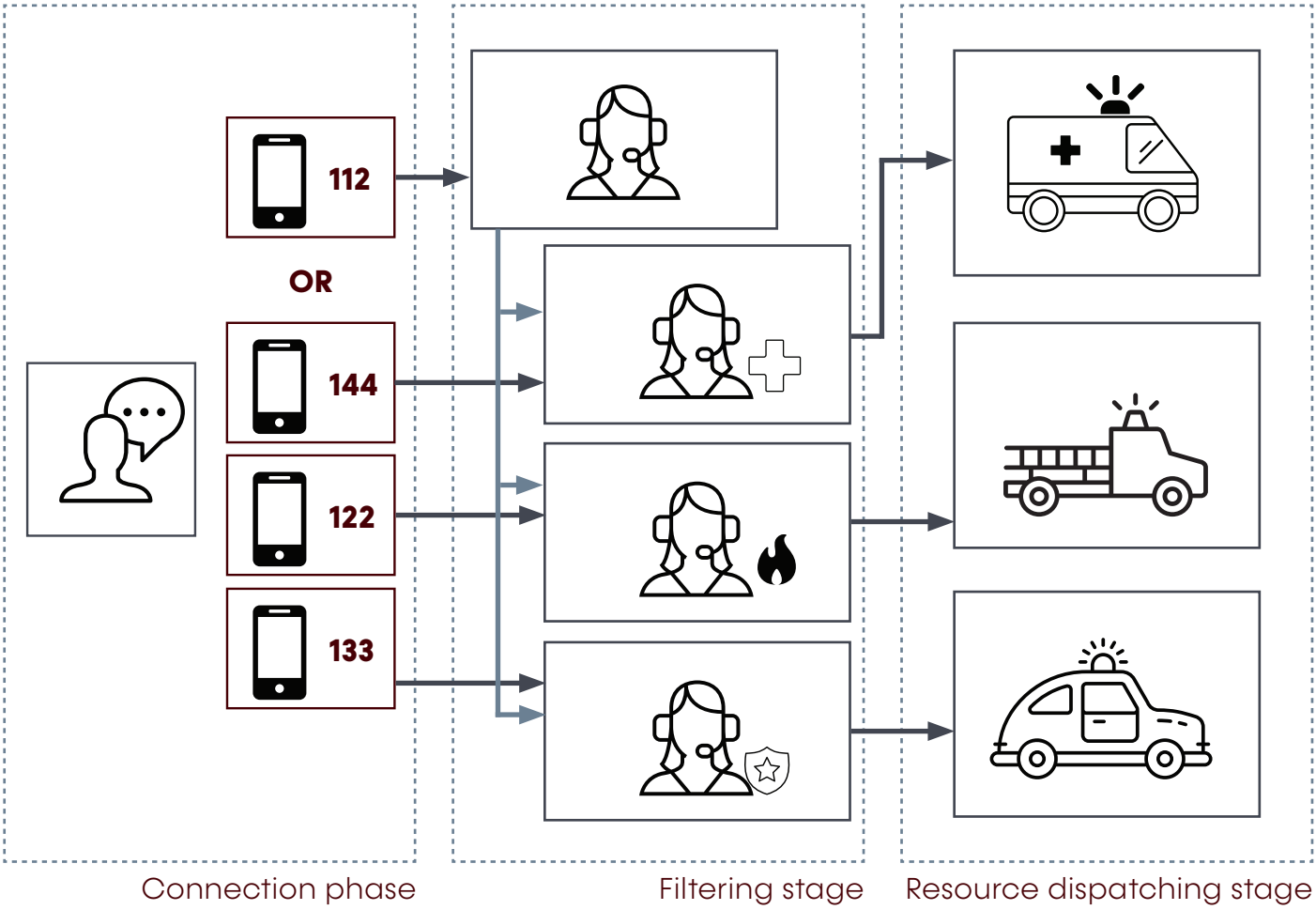
The dispatcher can automatically forward you to a different department if needed. In this model, more than one emergency response can be in the same physical place to improve mutual coordination.

In Belgium, they use a complimentary number to reach the police department (101). If you dial 112, a neutral organisation will take your call. They will handle fire and medical emergencies and manage them accordingly. But, if you call 112 for the police, they will forward your call to the police departments operator.

Some countries, like Austria, still use a different number for each department. You can call each department directly or you call 112 and be forwarded according to the nature of our emergency.
(Lumbreras, 2020)




OR
112
OR
Connection phase
Filtering stage
Resource dispatching stage


112
OR
144
122
133
Connection phase
Filtering stage
Resource dispatching stage

Different models and numbers are used all over the world but 112 will help you almost everywhere in Europe and more: Belgium, Bulgaria, Croatia, Cyprus, Denmark, Germany, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, the Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Spain, the Czech Republic and Sweden and some other countries outside the EU - such as Switzerland and South Africa (112 SOS, 2020)

Basic interview procedure:

1. Where? Localisation
    - City / postcode
    - Street / number / floor / name tag on bell
    - Landmark
    - Coordinates
    - public place or private place
    - Rendez-vous point
    - . . .
2. What? Situation / risks
3. Casualties / wounded people / people in danger?
4. Phone for contact

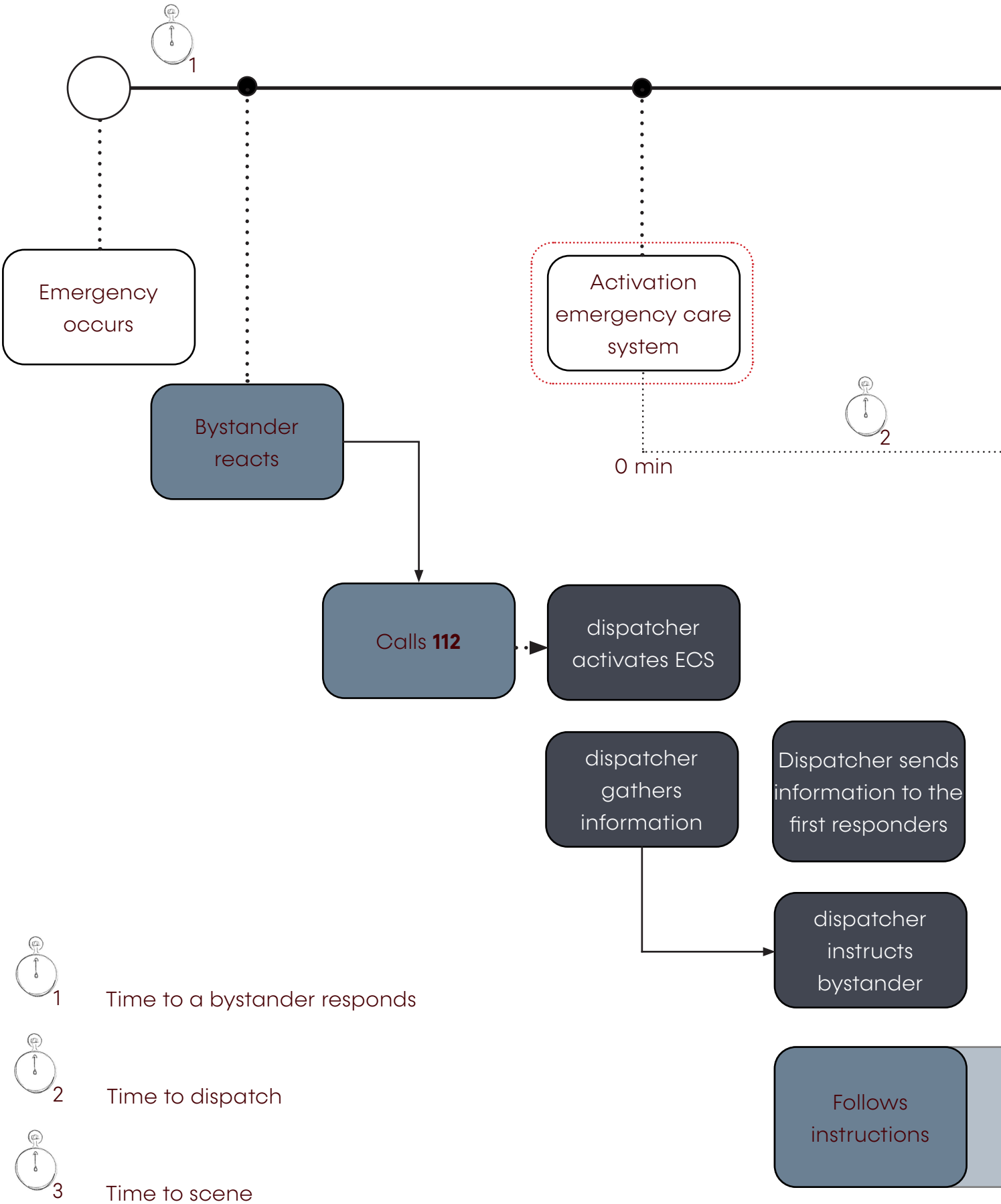
Overview emergencies

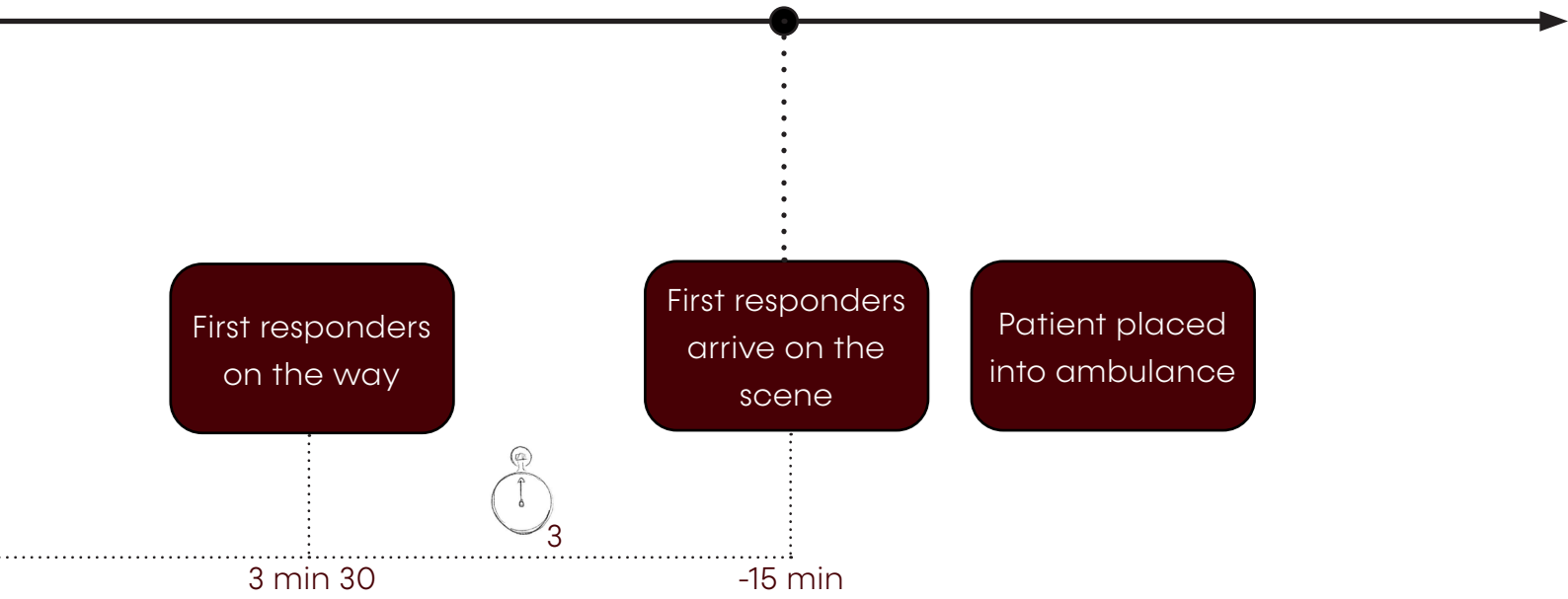
To identify the condition of a victim during a medical emergency. The dispatcher uses a bilan. A bilan is a template to classify the situation according to three main topics: consciousness, respiration, and circulation.

According to the observations written in the bilan and the information the dispatcher receives from the call-taker. It will tell how critical the victim's condition is and what steps to undertake next.

Next to a vital sign bilan, the dispatcher has a scroll book to help him recognise the type of injury. The scroll book (or script) also helps him guide the call-taker during the conversation and which instructions to give.

Medical emergency





First responders take over the emergency care on the scene

Dispatcher decides which resources are needed

First responders interview bystander

Informs first responders

1. Bewustzijn

Het doel is het bepalen van de bewustzijnsgraad.

OBSERVATIES	TYPE	ACTIES
• Houdt de ogen gesloten en • Spreekt niet en • Reageert niet op stimulaties (Glasgow < 8)	Bewusteloos slachtoffer	• Stuur Ambulance & MUG • Bilan van de vitale functies vervolgen
• Opent de ogen enkel op vraag of na stimulatie en • Spreekt bijna onverstaanbaar of onverstaanbaar en • De waakzaamheid is gedaald, dreigt in te slapen (8 < Glasgow < 12)	Semi-bewust slachtoffer	• PIT zenden • Eventueel uitsturen van MUG in functie van de rest van het bilan
Opent spontaan de ogen en spreekt op min of meer verstaanbare wijze en gehoorzaamt simpele bevelen en reageert op stimulatie* (Glasgow >12)	Bewust slachtoffer	Bilan van de vitale functies vervolgen
Geen (de oproeper bevindt zich niet bij slachtoffer)		

* Het aanmoedigen van de oproeper om een simpele prikkel uit te voeren (lichtjes schudden aan de schouders van het slachtoffer, uitvoeren van een lichte pijnprikkel (nijpen) enz.).

2. Ademhaling

Het doel is het bepalen van de ernst van de ademhalingsstoornis.

OBSERVATIES	TYPE	ACTIES
• Ademt niet meer • Of Afwezigheid van thorax bewegingen • Of Gasping • Of Ademhalingspauzes	Ademhalings-stilstand	• Zenden van een Ambulance en een MUG
• Kan onmogelijk spreken of slechts enkele woorden • Veralgemeende cyanose • Piepende ademhaling • < 14 jaar • Gebruik hulpademhalingsspieren	Ernstige adem-halingsstoornis	• Zenden van een Ambulance en een MUG
• Moet zinnen onderbreken om terug op adem te komen • Is erg kortademing • Cyanose rond de mond • Ademt luidruchtig	Matige adem-halingsstoornis	• PIT zenden • Bilan van vitale functies vervolgen
• Spreekt • Heeft een gezonde kleur • Geen waarneembaar geluid bij ademhalen	Normale adem-haling of licht gestoord	• Bilan van de vitale functies vervolgen

3. Circulatie

Het doel is het bepalen van de ernst van de circulatiestoornis.

OBSERVATIES	TYPE	ACTIES
• Geen tekens van leven (bewusteloos en ademhalingsstilstand)	Hartstilstand	• Zend Ambulance & MUG • Phone CPR en/of AED*
• Bleekheid van de huid • Zwakke, oppervlakkige pols • Hartslag > 120/min of < 45/min • Kind: > 140/min of < 60/min • Zweten • Groot bloedverlies • Verwardheid • Duizeligheid bij rechtstaan of halfzittende houding	In shock of mogelijkheid tot shock	• PIT zenden • Overweeg een MUG • Bilan van de vitale functies vervolgen
• Heeft normale huidskleur • Hartslag tussen 60 en 100/min • Heeft geen of beperkt bloedverlies	Circulatie is normaal of licht gestoord	• Specifieke fiche vervolgen

* Cfr A.L.E.R.T.-protocol (Algorithme Liégeois d'Encadrement à la Réanimation par Téléphone)

Fig. 09: Triage BILAN

During a critical emergency call, the dispatcher will use a form (= bilan) to evaluate the victim's condition. The dispatcher will go through this form based on the auditory information obtained from the caller's interview.

The bilan contains three main parts:

- Consciousness:
  The goal is to determine the victim's degree of consciousness.
- Respiration:
  In the second part, the goal is to determine the severity of the breathing disorder.
- Blood circulation:
  In the last part, the goal is to determine the severity of the circulatory disorder.

The form not only identifies the victim's condition but also how critical the victim's condition is. It also states what the following actions are to save the victim.

What is most striking about the form is that all observations are based almost exclusively on visual features, despite the communication over the phone.

After evaluating the victim's (critical) condition, the dispatcher will determine the medical emergency as specific as possible. Herefore, the dispatcher will use a script book.

The script book exists out of a collection of different medical protocols. It will guide the dispatcher to eliminate the uncertainties of the victim's condition.

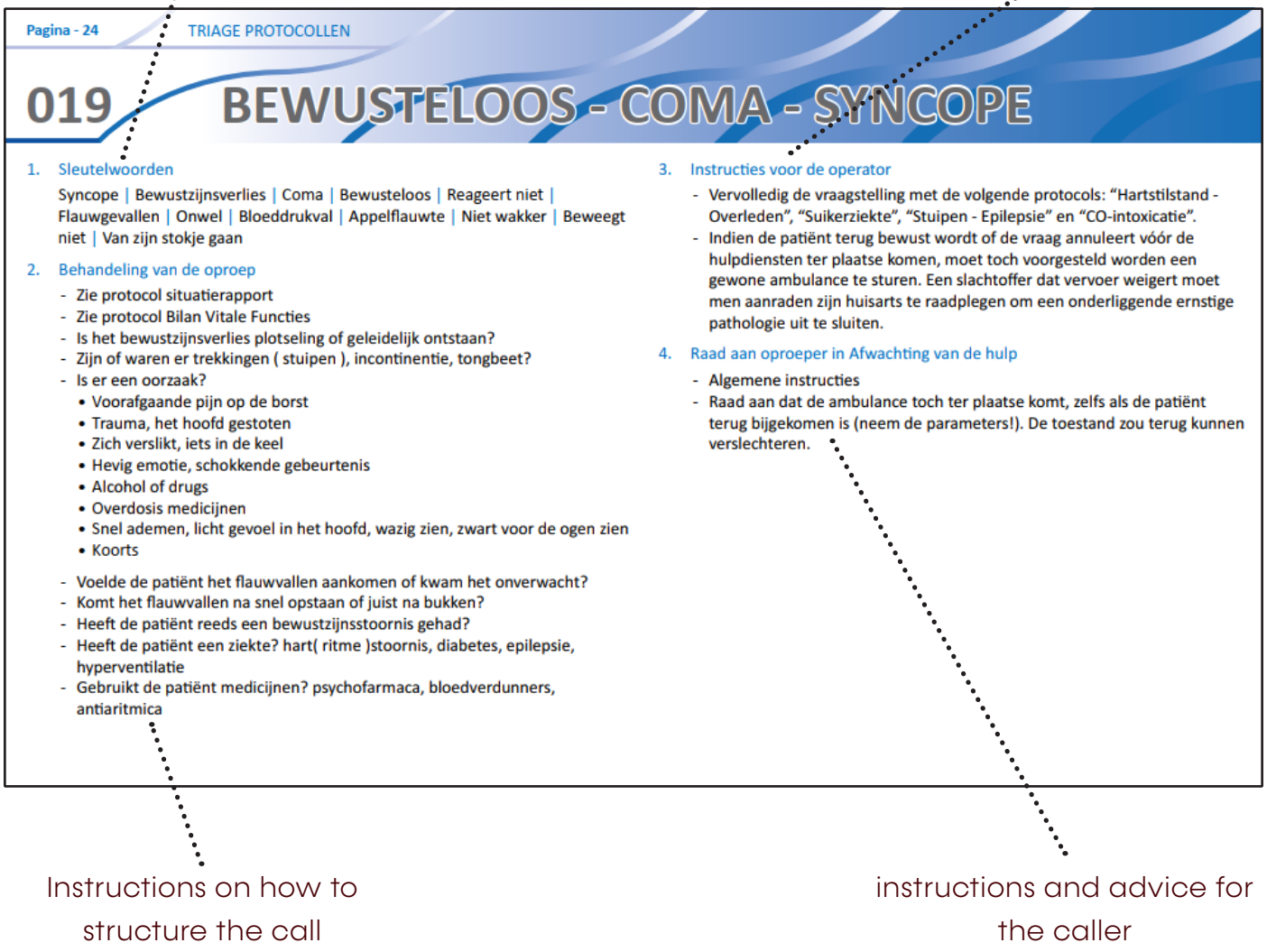
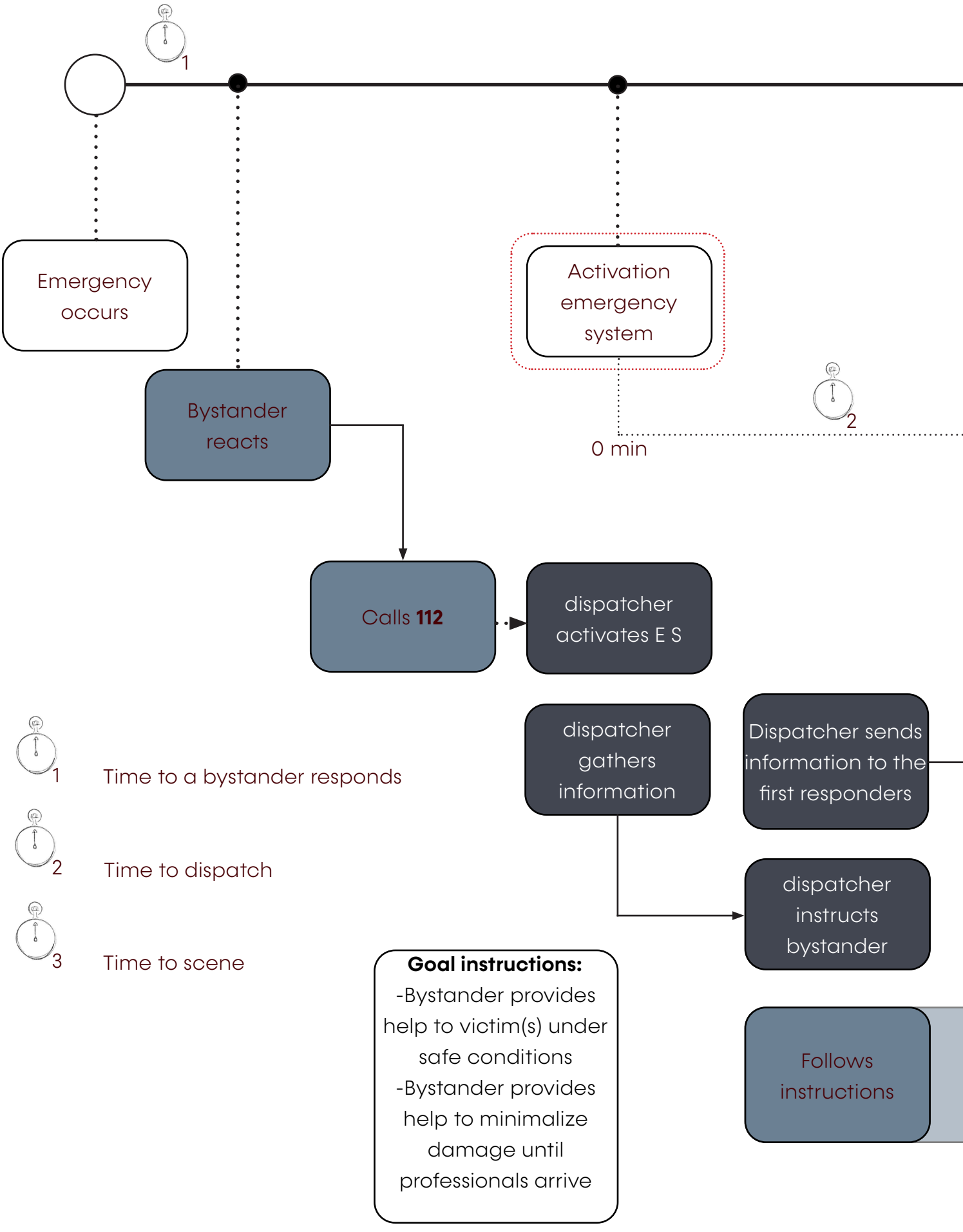
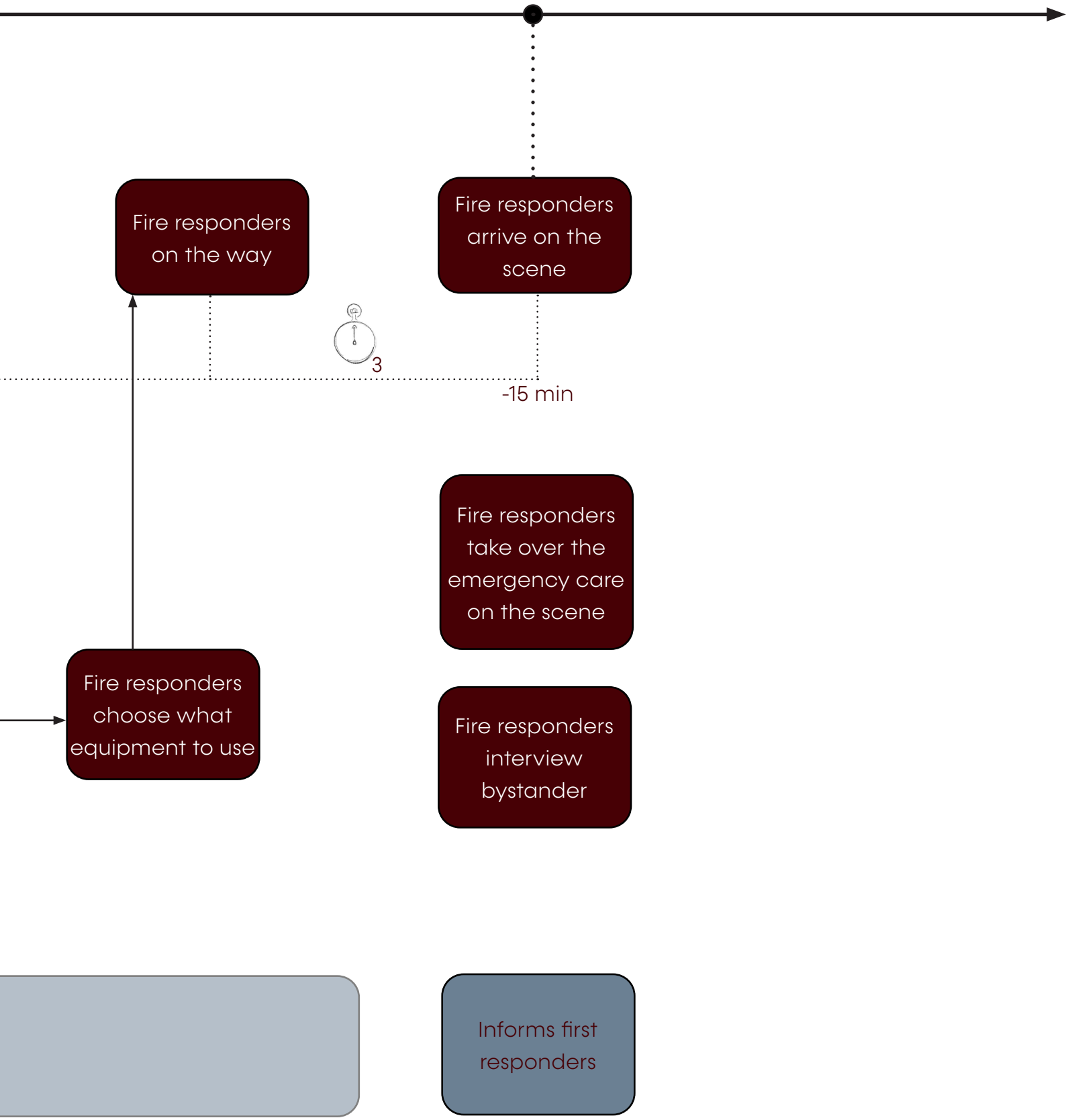


Fig. 10: Script example – medical emergency

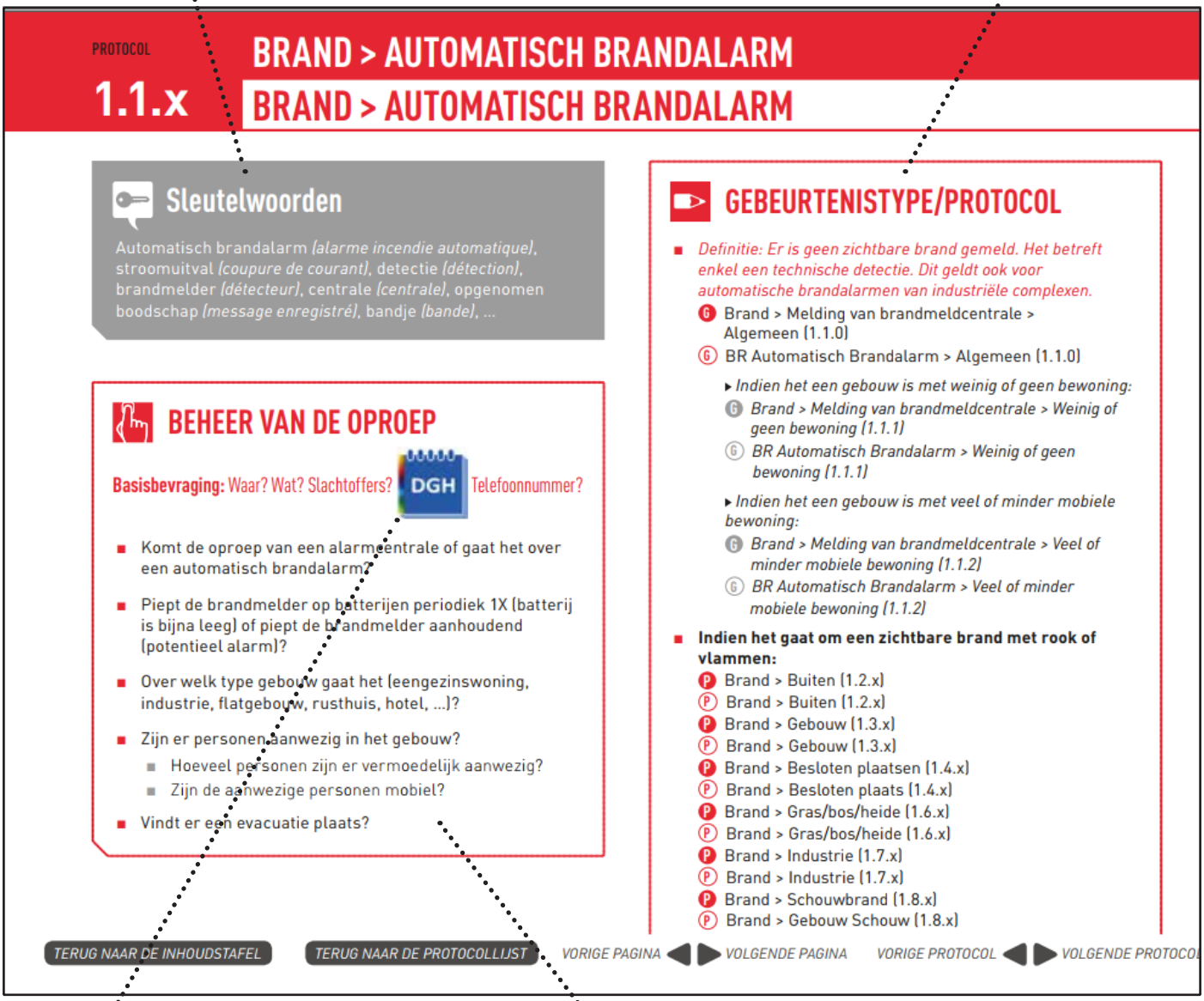
Fire emergency




Fire responders on the way
Fire responders arrive on the scene
3
-15 min
Fire responders take over the emergency care on the scene
Fire responders choose what equipment to use
Fire responders interview bystander
Informs first responders

Flowchart checklist to determine the situation as specific as possible

Keywords



Basic interview instructions

Instructions on how to structure the call

Fig. 11: Script example – Fire emergency

The script is meant as a teaching aid for the new dispatchers but also to support the daily work of the operators.

It clarifies their role and gives them the necessary support to handle a fire call. The operator's task is to select the event type corresponding to the situation on the ground and, if possible, to identify and advise the caller remotely while waiting for the arrival of the emergency services on the scene.

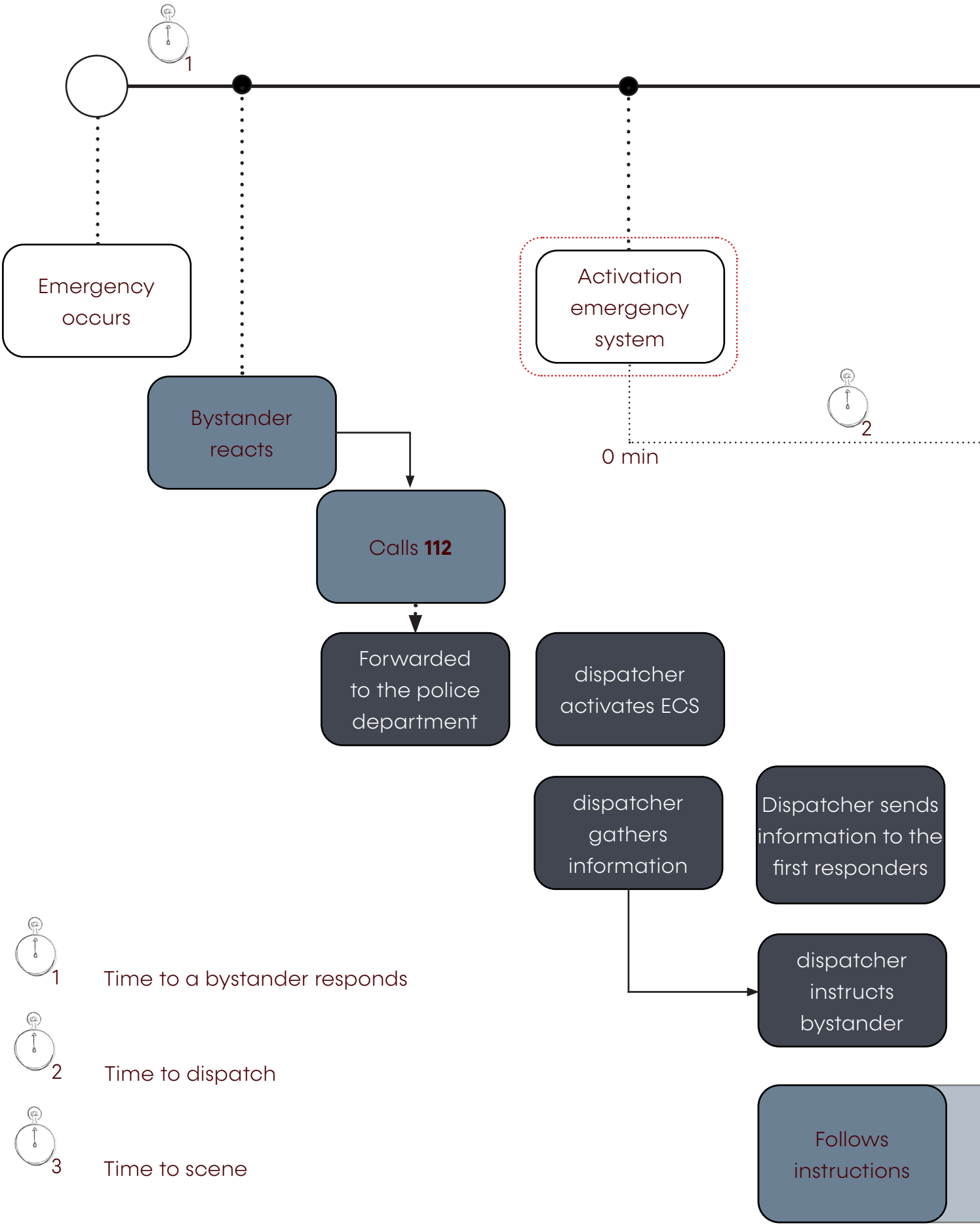
This manual will never replace the expertise and common sense but guides the managing of fire department calls.

The operator chooses the event type that most closely matches the information he/she obtained through the query and adds any relevant information for the fire department as comments. Then the operator alerts the fire department according to the applicable alerting modalities.

The operator is only responsible for alerting the fire department. The dispatch of the fire fighting equipment is the responsibility of the fire department itself.

The operator must advise the caller as best he/she can so that he/she can safely provide assistance to the victims or limit the damage associated with the incident while waiting for the arrival of the emergency services.

Police emergency



Police on the way

Police arrive on the scene

3

-15 min

Reasons to call the cops?

-Witness burglary or theft

-you or someone is being threatened

-you witness a fight

-Traffic accident

-Robbery or stabbing

Police responders take over the emergency care on the scene

Police responders interview bystander

Informs first responders

Emergency application:

Fig. 12: Emergency mobile app 112

Instead of text communication through SMS, some countries only provide it through a mobile application. Here, a closer look at the Belgian emergency app "112 BE". One app to contact them all!

With this app, you can reach out to the fire brigade, medical, or police department. Instead of calling 112, you can select inside the app which department you need, which will automatically forward you to the right dispatcher.

The main difference with a normal emergency call is that the application sends your location every 30 seconds to the dispatcher during your call. It also allows the dispatchers to activate a sound alarm on your phone to help locate you when the emergency units cannot find you on the scene.

The app is the only way to communicate with the emergency services for the deaf and the hearing impaired.

Inside the app, there is a chat function available, however, this function is only available if you write down in the app that you have communication problems.

As mentioned above, the application allows you to write down your medical conditions. So that in case of an emergency they can be automatically shared with the dispatcher.
(112 SOS, 2021)

AML:

AML is short for Advanced Mobile Location, is a free of charge protocol that transports the location data from the smartphone to the emergency call centre. In order to do so, it makes use of SMS and/or HTTPS.

It works on all Android and iOS devices, however, because of recent security updates, not every smartphone user has it enabled. If enabled on all smartphones in Europe it could save up to 7500 in 10 years. (EENA, 2020)

TETRA:

"TETRA, or "TErrestrial Trunked RAdio", is a standard for digital voice and data communications that was developed in Europe and designed to meet the needs of a range of professionals, in particular those working in the emergency and security services".

(ASTRID Communication for

security , 2021)
Main reasons why emergency services (such as the Belgian) use TETRA:

- It allows the emergency services to establish a connection within 500 milliseconds.
- User-friendly group calls.
- It is possible to prioritise calls.
- It can authenticate users and encrypt data and voice communications.
- It is an open standard so multiple manufacturers provide TETRA approved devices.

2.5 Organisations

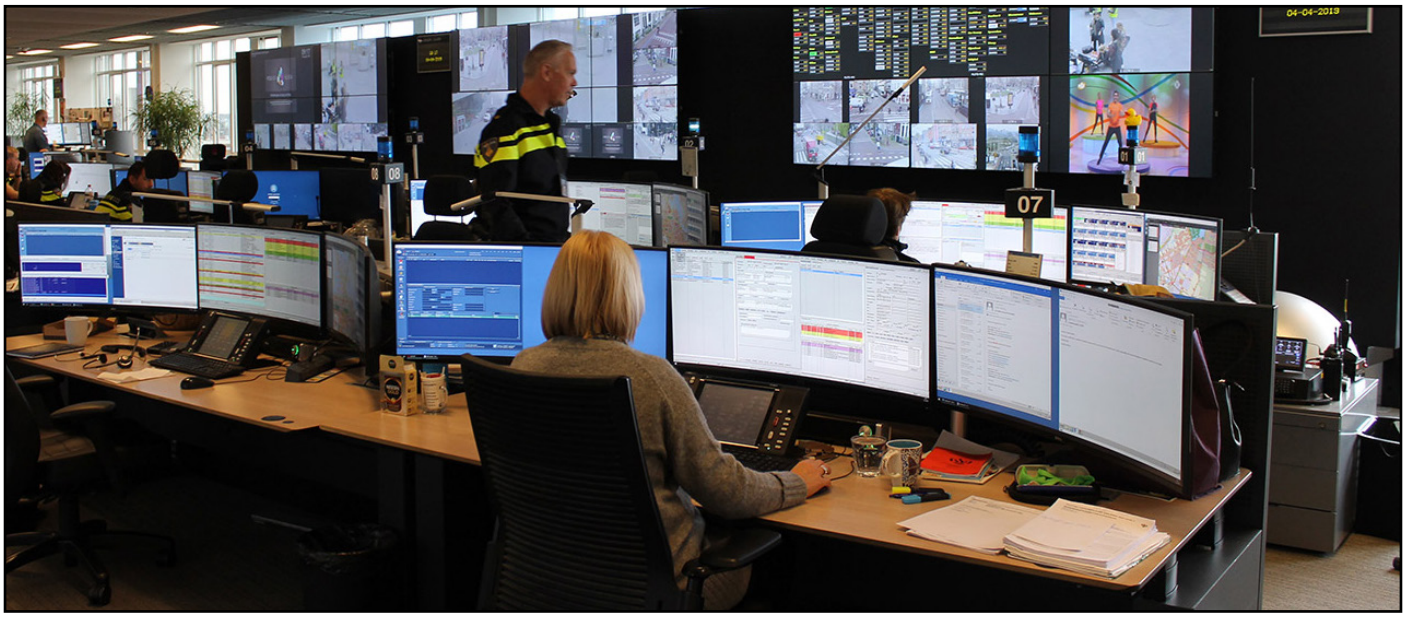


Fig. 13: Office view emergency call centre

EENA:

EENA, short for the European Emergency Number Association, is a non-governmental organisation devoting its mission to boosting the safety and security of people. (Paris, 2021)
EENA focuses on bringing stakeholders together and technological modernisations.

The main topics EENA currently works on are (EENA, 2021):

- Advanced Mobile location
- Next generation 112
- Public Warning
- Emergency apps
- Drones
- Tech and public safety programme
- Artificial intelligence
- Transnational database
- Cybersecurity
- Waze partnership
- Social media use in crises

Let's analyse deeper into some of EENA's focus points. Can emergency services benefit from artificial intelligence? During video and voice recognition, AI can process large amounts of data, find patterns and new insights. In the future, it can even take over some procedural tasks currently done by humans. (Paris, Artificial intelligence , 2021)
However, the emergency services themselves have some scepticism and resistance against the implementation of AI or ML. The resistance can probably be linked to not knowing and understanding the responsibility and how it works. (Atos, 2019)
In Sweden, on the other hand, they started implementing AI to help make paramedics life-saving decisions. (Corti, 2021)

The program is called Corti. To date, Corti already supported 12,123,198 medical consultations (Corti, 2021) and is improving with each one.

LMS:

Each country is responsible for its emergency services following the rules of the European Union. In some countries such as Belgium, the dispatching of emergency calls is directed from within the government. In others, like the Netherlands, they are managed by an independent organisation. In the Netherlands, the network of emergency calls is organized by the Landelijke Meldkamer Samenwerking (LMS). Paramedics, firefighters, Royal military police, and the police have one local network of 10 control rooms.

They can assist or take over each other tasks and are available 24/7. The LMS also covers the technical side, while in Belgium, Astrid arranges the technical side and the government the management and dispatchers.
(LMS, 2021)

ASTRID:

Astrid is a specialised telecom operator for safety and emergency services in Belgium. One operator to communicate within and between all the emergency services to guarantee the civilian's security.

Astrid's focus areas are:

- radiocommunication
- paging-solutions
- dispatching-solutions

It operates 100% digital based on the European TETRA-norm.
(Astrid, 2013)

In Belgium, twenty-one emergency call centres are spread over the country. They handle more than six million calls a year, around 2000 a day in each call centre. Thousand two hundred dispatchers are currently in service, striving to answer your call within 10 minutes. (Civiele Veiligheid Be, 2021)

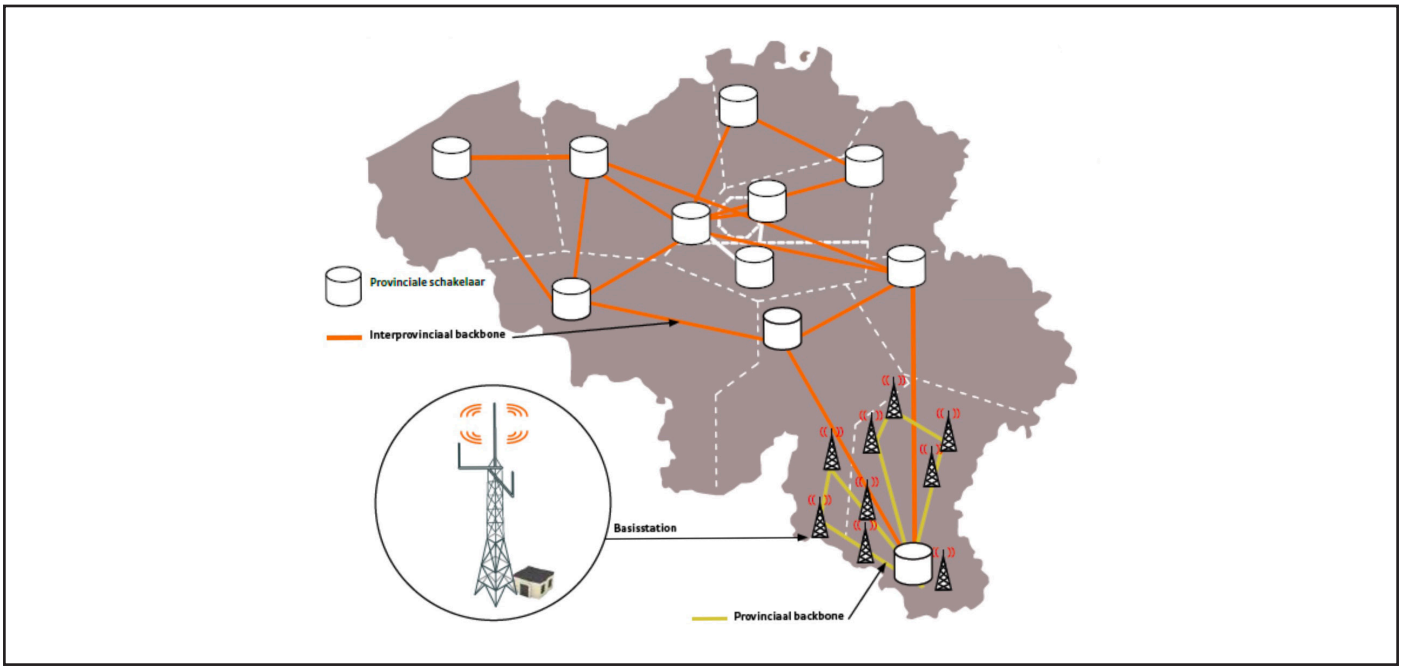


Fig. 14: Overview distribution ASTRID

2.6 Call centre, field research

To become familiar with critical emergency calls, I visited the emergency response centre in Antwerp, Belgium. Due to the ongoing Covid restrictions, it was in a more controlled setting. However, this opportunity opened a deeper understanding of the local emergency response.

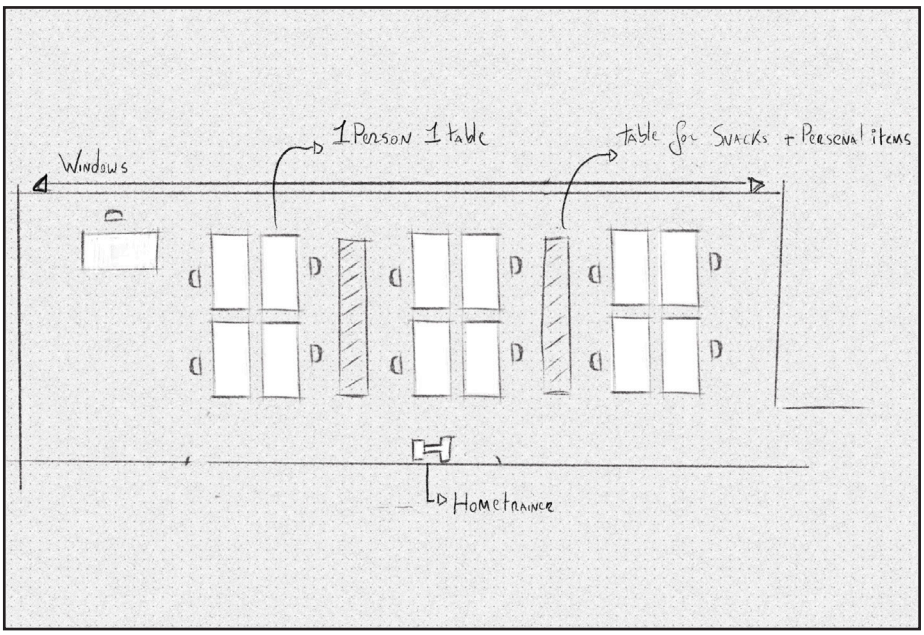


Fig. 15: Office layout call centre Antwerp

Observations:

Approach:

The observation aimed to understand and interpret the behaviour of the emergency response dispatch team. Next to focusing on the dispatchers, the equipment and work setup was my second focus.

Due to privacy reasons, some simple fieldnotes and sketches are used for documenting the observations. Entering the field without predetermined notions allowed for being open to every kind of behaviour, which suited this study as it had an exploratory nature.

The results:

The first element that surprised me was how calm it was in the dispatch room. Everyone looked relaxed. There was a pleasant, friendly aura in the room. Nonetheless, the room was small enough to overhear every ongoing conversation and calls. (See small overview sketch).

Despite current technologies and hardware, the dispatcher's desk setup existed out of multiple devices, which immediately filled up all the available desk area. (sketch X).

There was an inferior row of tables between the dispatchers to accommodate drinks, food and personal belongings.

The obtained results were captured in three different models: A sketch of the current desk setup, a storyboard of the emergency response and a wireframe of the dispatchers' monitors during the call.

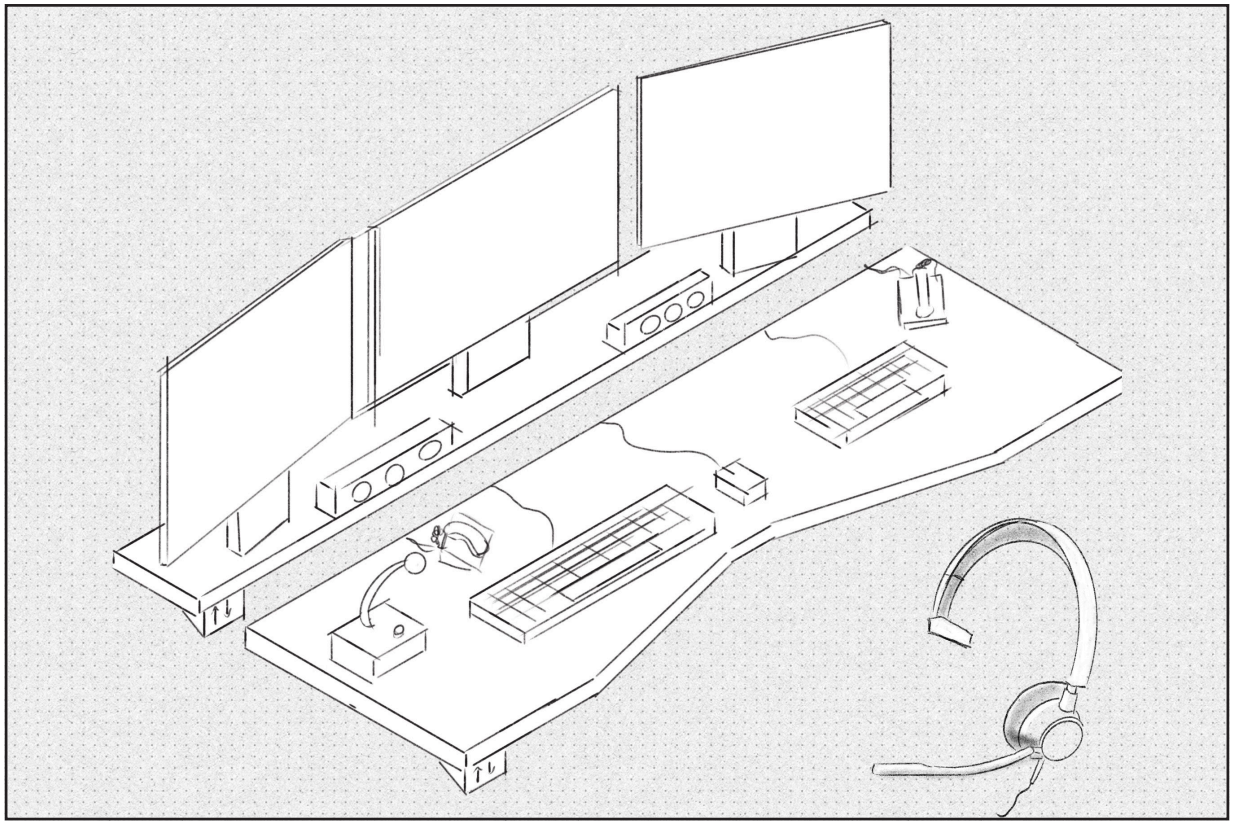


Fig. 16: Desk setup dispatcher

Desk setup:

Nowadays, the dispatcher has a desk set up with multiple screens. The screen on the left (1) shows new, incoming calls. Together, with an overview of the call-ups currently handled by the call centre and by which dispatcher. The available units and the real-time position of the ambulances are also visible on the left screen.

The main screen in the middle (2) runs the emergency form. This form contains all the information about the current emergency call. After fulfilment by the dispatcher, he, or she forwards the form to the paramedics or firefighters.

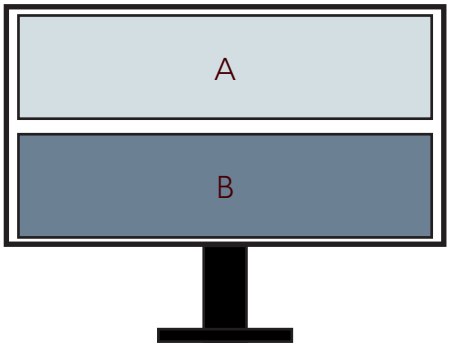
Moving towards the right, we find the final screen (3). This display is mainly to run Google. However, new dispatchers use this screen also to display the emergency scripts and manuals.

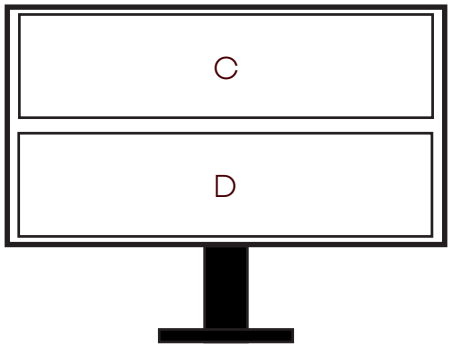
Between the screens, two horizontal lying speakers (5) are mounted. They are used as output for the radio (4). In order to communicate and locate the ambulances, they use radio as a direct connection.
The team of dispatchers also handles non-critical emergencies. To do so, they have a separate phone (6) on their main desk.

As a backup, when the building would lose power or fire, they have a backup phone (7). On this phone, they handle all critical and regular calls coming in.
In contradiction to the radio communication, the emergency calls are answered by a headset with an integrated microphone.

Wireframe:

Before call:

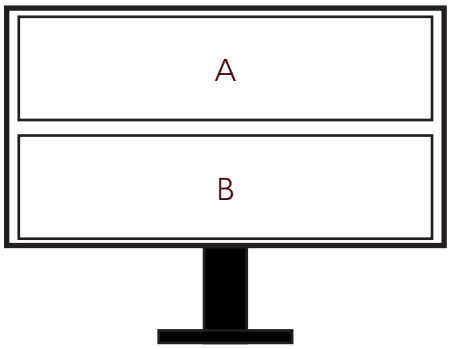


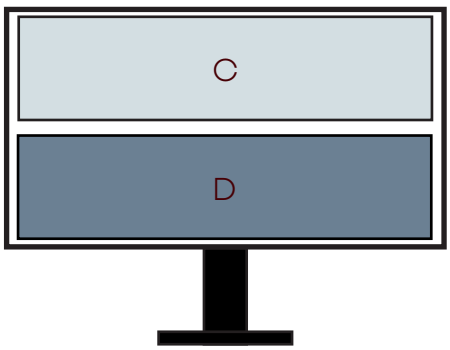


A: A: This window is always open, with all call ordered by time. Here you can see all calls on the waiting list, the ones currently handled, and the older ones. The dispatchers engage with one of the calls on wait to start the emergency response.

B: A live map with all emergency units in the area in combination with a list of the ones on duty. Fast connections to the units possible.

During call:

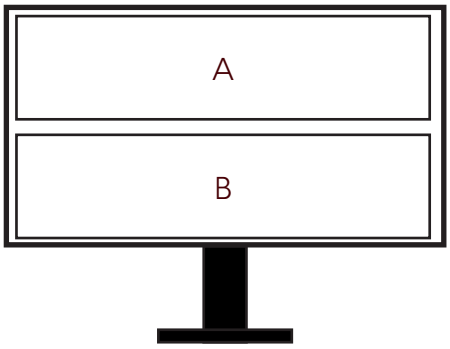


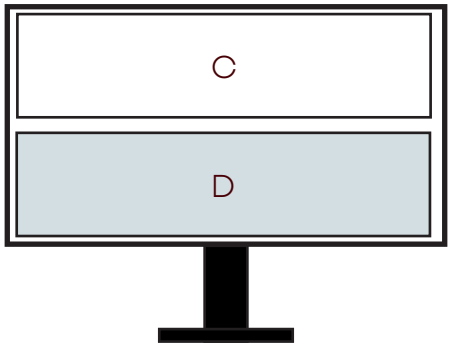


C: When answering a call, an emergency form pops open on the middle screen. Here, the dispatcher will fill in all information from the interview. After fulfilment, this form is forwarded to the emergency units; on their way to the victim.

D: Underneath the form, a map shows up with the caller's phone location or his/her billing address. This map is updated according to new information if the location is wrong.

After call:





D: In case of a medical emergency, the dispatcher will follow up the ambulances until they are back available for a new ride.

Google:
Not every caller doesn't know his/her exact location, if they tell visual clues of their whereabouts, Google is used as a tool. For example Parking lot next to the McDonalds on the highway.

However, this screen is also allocated to show the script for every emergency or the instructions for phone-CPR.

Fig. 17: Storyboard – current situation

Storyboard:

This storyboard is created and updated after observing a real-live critical emergency call during my visit. For a more detailed description go back to page 17.

Interview:

A second step of the field research was doing interviews in order to get a deeper understanding of the dispatcher experience and handling of critical emergency calls.

The main research questions were:

- How do dispatchers experience answering a critical emergency call?
- How do dispatchers judge the situation on the other side of the line?
- Which pain points are encountered (daily) during an emergency call?

Approach:

Selecting the appropriate people to participate is critical to the success of the project since the design process can be significantly affected by the insights of people in the field. A face-to-face interview was performed with the Antwerp 112 emergency system expert with more than 20 years of experience in the field.

Due to the sensitive information around emergency response, only field notes were made during the conversation. (No audio recording was made).

Results:

The emergency number is for people in urgent need of help. However, in reality, a majority of calls is for non-critical information. The top five phone calls received in Antwerp consist of police assistance, non-critical information, home-garden-kitchen-accidents, fall accidents and fire brigade assistance. The fire brigade assistance mainly exists out of fire intervention, road accidents and storm/water damage.

Next to physical phone calls, the rise of E-calls is also noticeable in Belgium. They are becoming a greater part every day. However, the dispatchers are not happy with this technical automatization. Most of the E-calls received are false alarms like cosmetical parking accidents caused by the over-sensitive sensors.

According to the expert, the E-calls work with a subscription. When people stop those subscriptions, the triggered E-calls will automatically go to the emergency centre without any prior filtering. Every incoming non-critical emergency call can potentially keep a critical one on hold.

Up to 80 per cent of the total amount of incoming calls are a medical emergency. For a medical emergency, the dispatcher will always instruct the call-taker. What actions the call-taker can undertake until the paramedics arrive on the scene. But only if the call-taker wants to help, he/she cannot be forced to do so.

Unfortunately, the will to help is decreasing compared to some years ago. Before dispatching the fire brigade or paramedics to the scene, the dispatchers need to know what the nature of the emergency is and how critical it is.

The classification of an emergency happens by visual indicators, but the communication is auditory-only. In other words, the caller is the eyes (and hands) of the dispatcher. There is blind trust in the judgement of the caller and what the caller is saying. However, instructing people needs to be crystal clear, with no room for interpretation. The dispatcher does not know the skill or ability the caller possesses to help.

And sometimes these instructions go wrong. A real example: Someone called for an electric blanket that caught fire in the bedroom. By following the instructions, the caller successfully extinguished the fire.

Afterwards, the caller asks if it is okay to open the windows to let the smoke escape. As long as the caller killed all fire sources, it was okay to open the windows in the room.

However, unfortunately, the house still burned down. The caller did not mention or notice that the mattress was smouldering. The increased oxygen fuelled the fire and caused an increase in the spread of the fire over the whole building.

As described above, blind trust does not always end well. That is why in Antwerp, they send out an ambulance in 90 per cent of the cases. However, this availability of paramedics to dispatch is a luxury that is not possible for most other cities or countries.

In order to dispatch help, the location of the caller needs to be known. Even with current technologies, this is still the biggest pain point for emergency services. Around 60-70% is able to share its location. Once the location is double-checked, help can be sent away.

However, confirming the location is not an automatic process. Most phones can do it automatically if the user allowed it in its settings. If this is not allowed, they can check the billing address of the caller as a backup.

But nowadays, especially with the work from home situation, the billing address is often the employer's office. Which makes this a rather unreliable backup.

Is the dispatcher ready for receiving pictures or live feed during a call? Yes and no. Video CPR is being tested, however, the results are not what they hoped for. The video feed did not add any value because if people perform CPR, they need both hands. So, the phone will be on the speaker next to them, which gives the dispatcher the view of the sky or ground.

Nevertheless, they still believe a visual feed can be useful if they can oversee the situations and handlings. Although they are concerned that when a video feed is shared the caller will not tell what the problem is anymore but will just show it for them to see. Video also brings an extra danger with it. It can cause an overload of footage or stressful footage for the dispatcher. Ten to 15 per cent of the dispatchers already experiences PTSD, with unfiltered footage these numbers could rise.

Outside interviewing the call-taker, the dispatcher also decides the tools and the amounts of ambulances needed for an emergency. From the moment the dispatcher knows the exact location and sort of emergency he/she will contact the paramedics or fire brigade.

While continuing to interview the caller, the dispatcher will fill in a digital report with all the details for the first responders on their way. The dispatcher will also follow up on the medical emergencies until the ambulance is free to go again.

Some facts and loose information shared during the conversation:

- The average call time is one minute twenty.
- Depending on who you call, police or paramedics you will get different questions and priorities.
- The dispatcher, call centre and caller always anonymous.
- An emergency app exists, however in case of an emergency the phone of a victim is never used.
- The app allows people with hearing/speaking disabilities to chat with emergency services.
- A shift is 12 hours.
- 2000 calls a day is the average number they receive in Antwerp.

Fig. 18: Look in the past, old dispatcher communication device

Experiences from callers:

In order to understand what the caller experiences during a critical emergency call, a shoutout was done to people who had been in the situation of calling 112.

During one of the windy storm nights during the previous year, a tree came down on the callers building. He called the emergency services to ask for the fire departments assistance. They responded that assistance will be sent on his way.

However, no ETA of extra information was shared. This left the caller in a full state of stress plus extra annoyance. The caller had to wait and undergo the situation and extra damage until after some hours, help arrived.

The next experience shared is of a bystander, who found a person on the streets in need of medical assistance. The bystander saw someone on the street bleeding and approached the person to help.

Some passing pedestrians instructed her to call an ambulance, however, they just walked by without assisting or calling themselves.

As recommended, she called 112, she described the call as: to the point, short questions, location, situation, triage by description followed with some minor instructions. The call took around one minute.

When an ambulance arrived, a paramedic asked her for a more detailed explanation, but the paramedic already knew the red line of the story.

The last experience that was shared for this research was a burglary. The person arrived home and saw that her place was turned up completely. She called the police department, she got answered in the local dialect by the dispatcher.

It was a calm, casual conversation but nothing was done to calm her down. Even after the call, she was still in shock for some time.

The dispatcher had sent some officers on the way; however, it took some hours before they arrived. Because no ETA was shared this only made the wait for help more emotional and stressful.

To conclude these experiences, high emotions involved but not knowing when help arrives is the biggest pain point from a caller's perspective.

Current interactions:

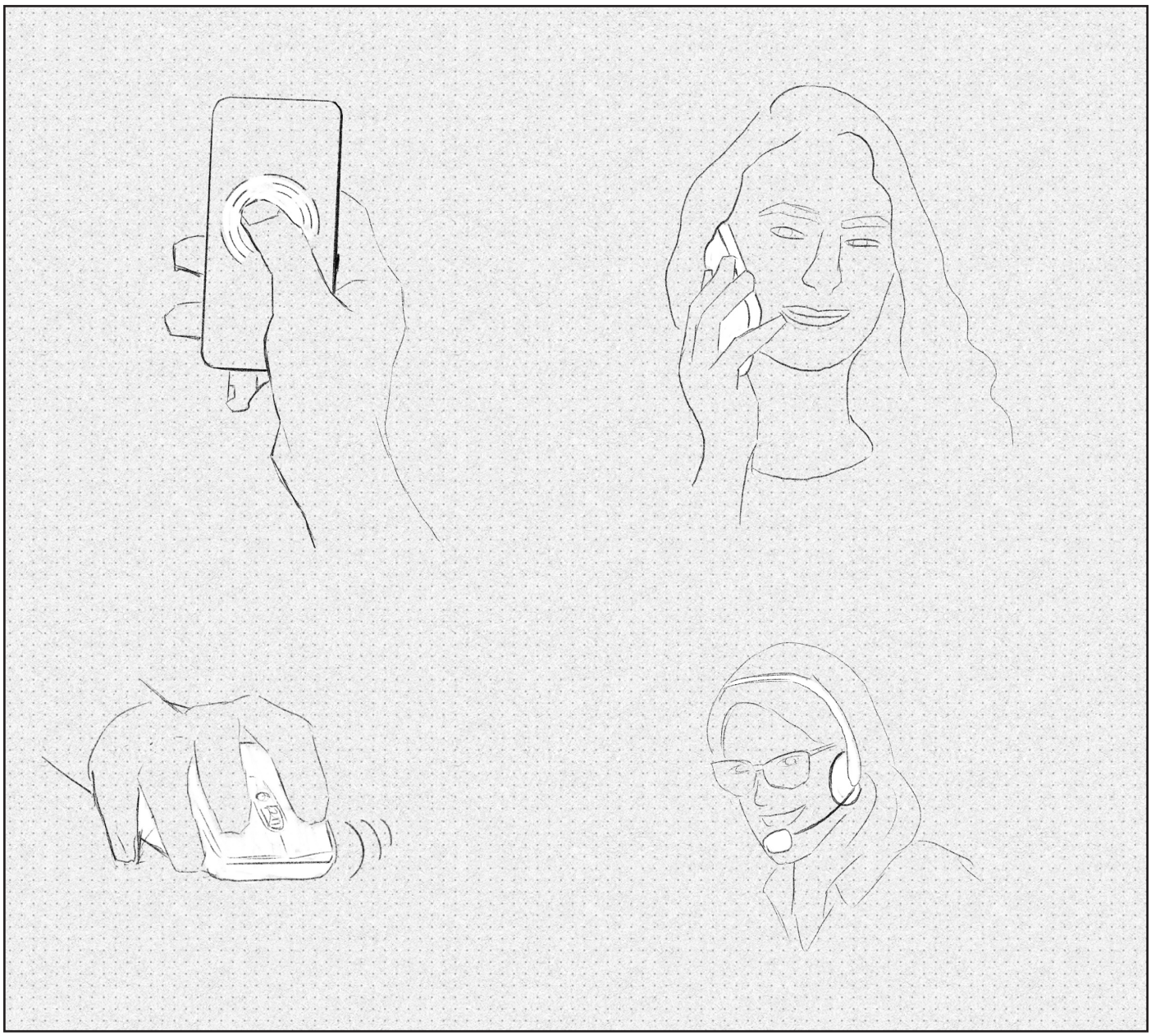


Fig. 19: Current interactions 1

What interactions occur during a present-day emergency call? We can divide it into three main parts: Human-device interaction, human-human interaction, and device-environment interaction.

Human-Device:

- Dial 112 on the phone.
- Hold the phone to ear to talk.
- Mouse-click to answer the phone.
- Answer the phone through the headset.
- Type in the form on the keyboard.
- Track ambulance on a digital map.
- The map shows the caller's location.
- Send digital form.
- A radio call to providers (ambulance).
- Read digital form.
- The devices interacted with during the call are a phone, monitor, headset, mouse, keyboard, and radio (mic + speakers).

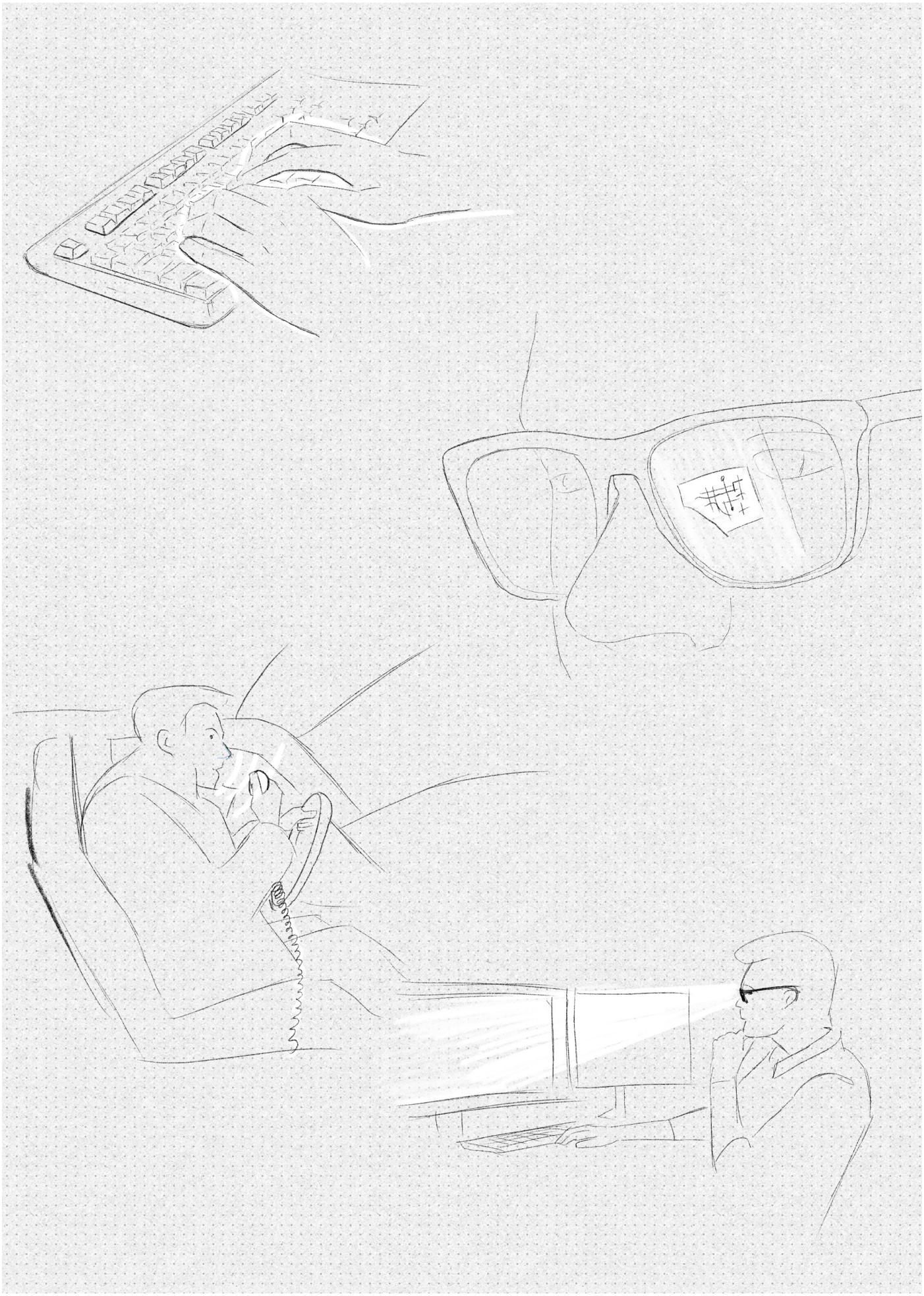


Fig. 20: Current interactions 2

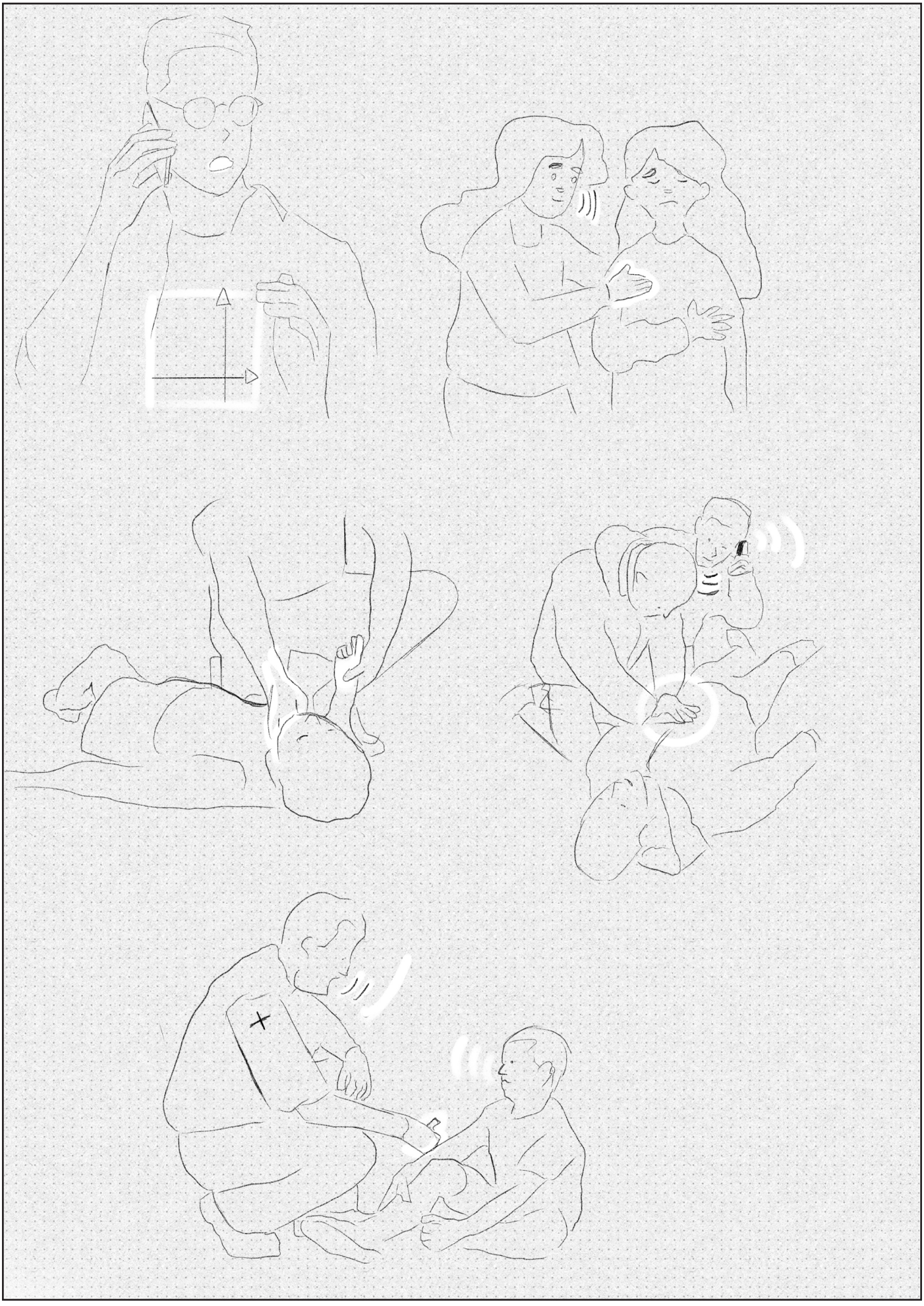


Fig. 21: Current interactions 3

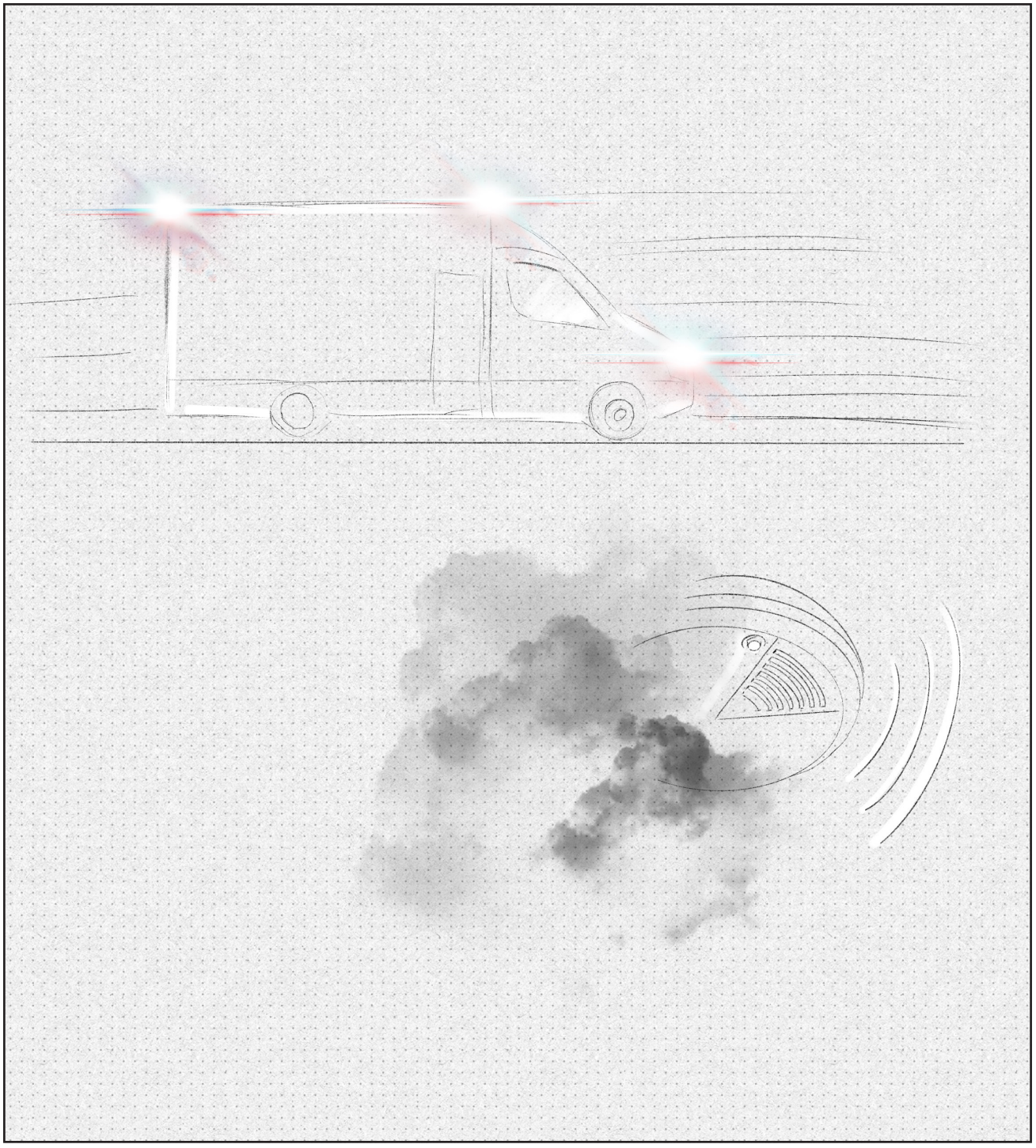


Fig. 22: Current interactions 4

Human-Human:

- Talking to explain and describe.
- Talking to comfort
- Talking to instruct
- Physical interactions between the caller and the victim according to the situation. For example, CPR.
- Professionals on the scene

Device-environment:

- The flashing lights of the emergency vehicle warning the environment they are close by.
- (Smoke alarm)

Customer journey:

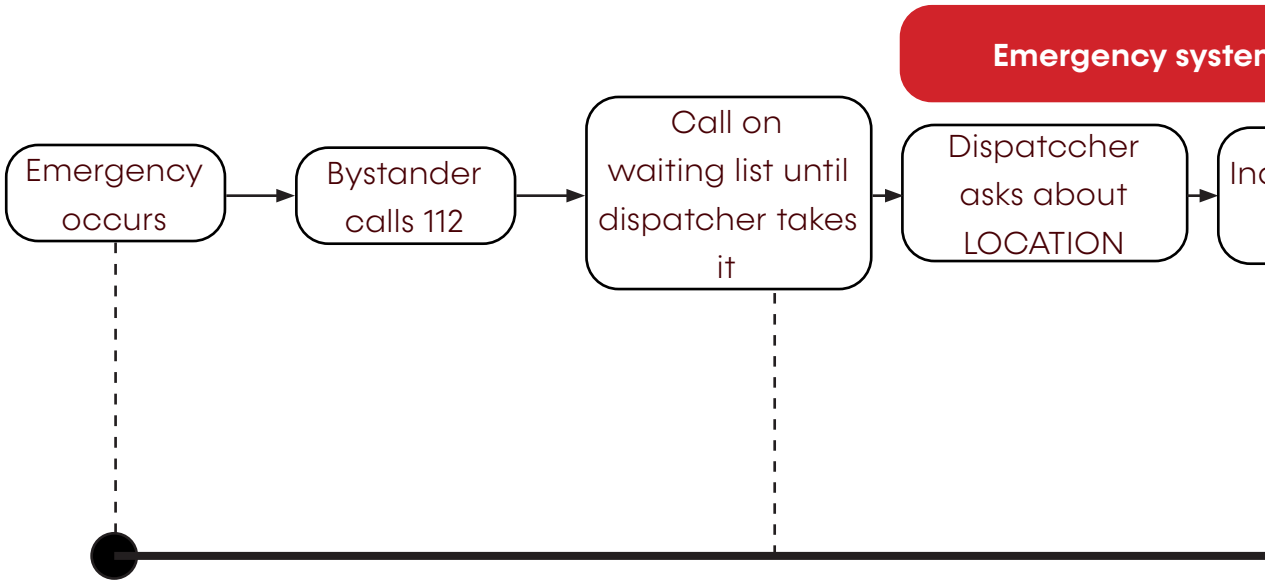
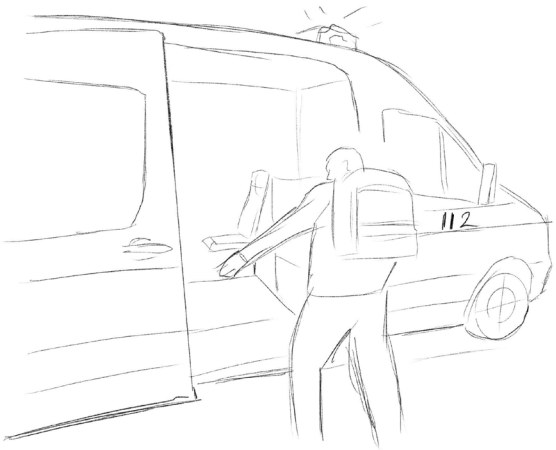
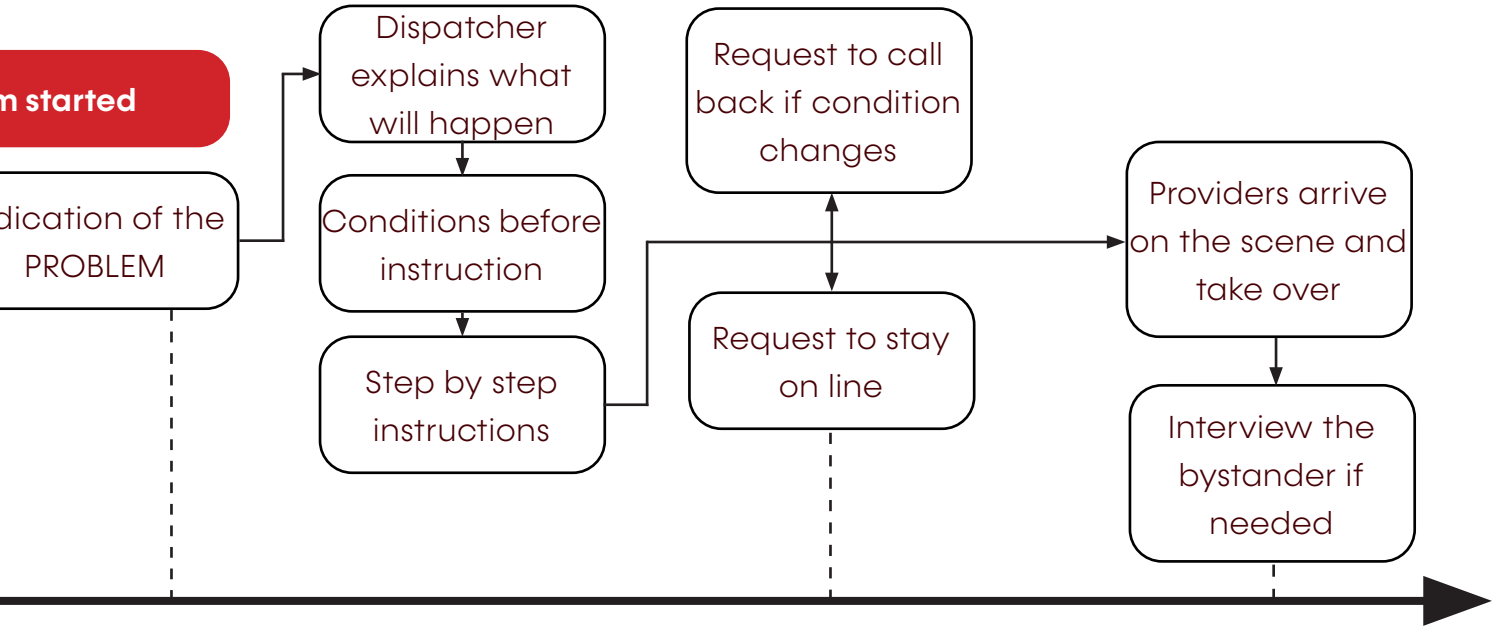
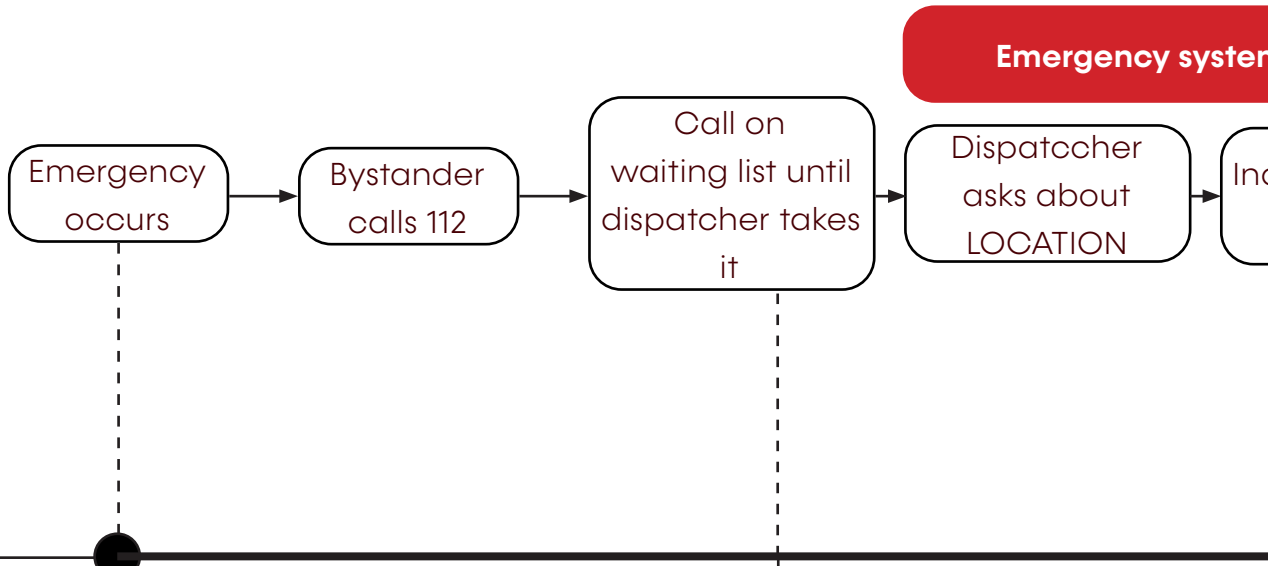


Fig. 23: Costumer Journey

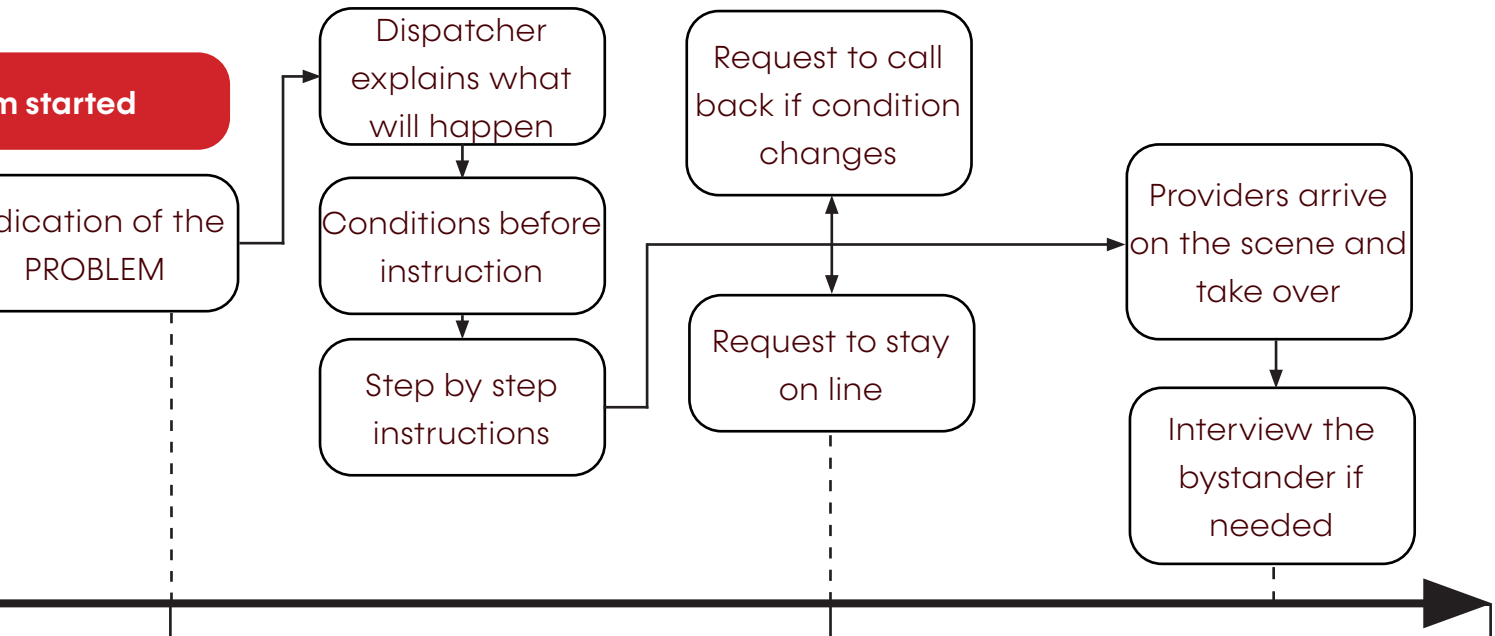

What Happened?
Location?
Condition Patient?
Danger?


112


m started
dication of the PROBLEM
Dispatcher explains what will happen
Conditions before instruction
Step by step instructions
Request to call back if condition changes
Request to stay on line
Providers arrive on the scene and take over
Interview the bystander if needed



STAGE	ACCIDENT/BEFORE THE CALL	CALL - INFORMATION
ACTIONS	• React on the accident • Call the emergency number	• Interview the caller • Answer the questions, exp situation
GOAL	• Call for help	• Call for help • Get the necessary informa react on the emergency
EMOTIONS	• Shocked • Stressed • Fear	• Shocked / Stressed / Fear • Calm / Curious / Skeptica
PROBLEMS	• Not everyone wants to help • Time saves lives	• mostly visual indication of problem but auditory communication only • blind trust in caller • stressed caller • no clue of abilities of calle • location tracking
OPPORTUNITIES	• Encouraging to help others	• visual communication • simple in use to save time • own location tracker

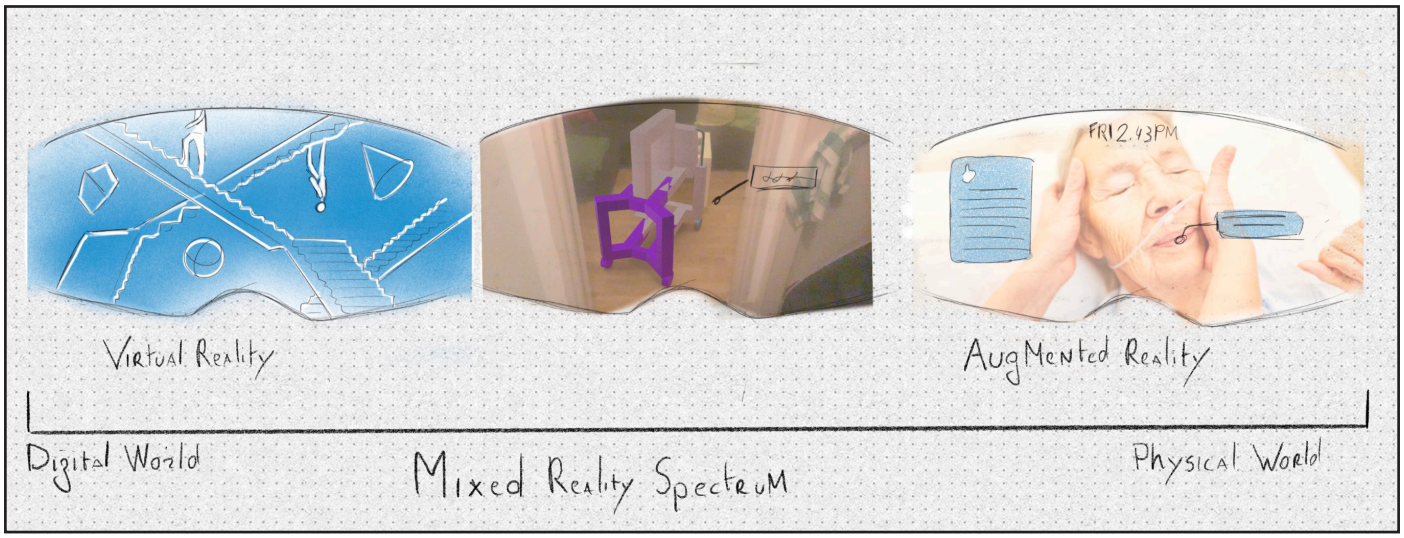


	CALL - ACTION	AFTER THE CALL
plain the	• Instruct the caller • Activate the emergency respons system • Follow the instructions	• answer questions of the providers • take over the emergency response
ation to	• Help / Follow instructions • instruct caller • Pass all the useful information to the providers	• Handle the emergency
r l	• Shocked Stressed Fear • Calm • encouraging	• hopeful • stressed
er	• blind trust in caller • stressed caller • no clue of abilities of caller • auditory constructions	• preparation providers based on intel dispatcher • Exact location caller
s	• share clear instructions • inclusive design - used by everyone	• Exact location sharing

2.7 Mixed reality

What is it?

Fig. 24: Mixed reality spectrum



Virtual reality, augmented reality, and mixed reality; three different terms but often brought up together. All three together is referred to as the term extended reality.

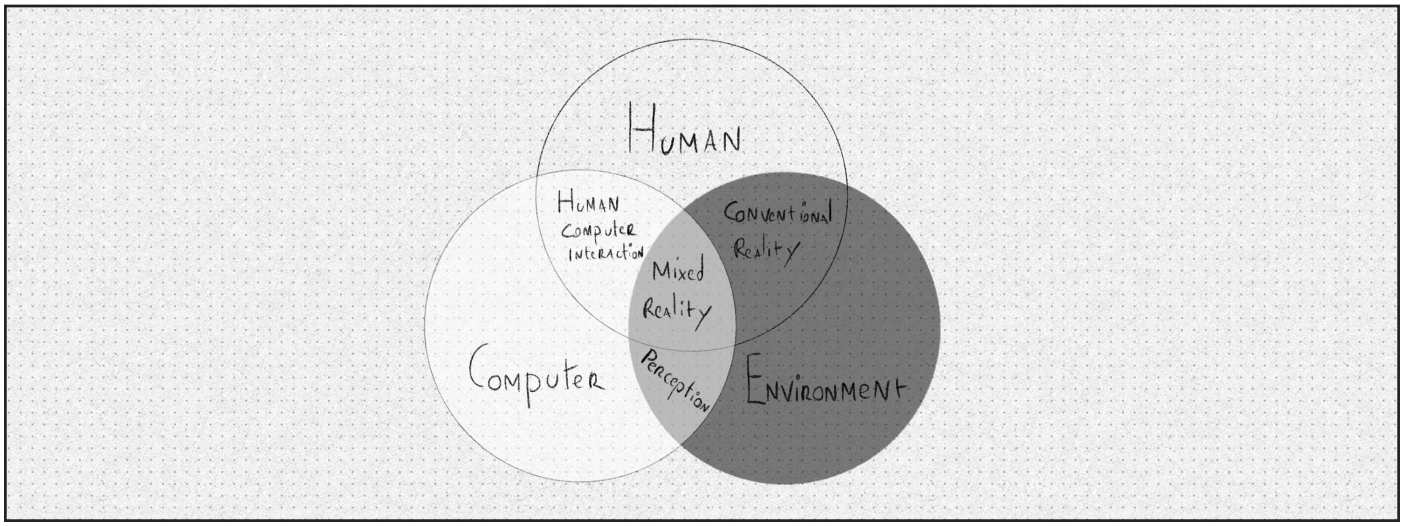
Virtual reality, the best know term, fully immerses you into a virtual/digital environment. It completely shuts you of the real world.

The other two enhance your real-world view by blending digital elements into your field of view. Augmented reality overlays digital content in your real-time view. Such as an extra layer in Photoshop over what you see.

While mixed reality project three-dimension objects into your view.

The core difference with AR is that MR enables both virtual and physical reality to interact with each other. It blends the physical and digital world and makes use of human, computer, and environment interaction.

Fig. 25: Human-Computer-Environment interaction



History

1968

Sword of Damocles
First head-mounted display by Ivan Sutherland
-> to show users wireframe drawings

Videoplace
Artificial Reality laboratory by Myron Krueger
-> Interactive experience with projection and camera technology

1974

1990

Augmented Reality
First official use of the term AR. By a Boeing researcher called Tom Caudell

Virtual fixtures
First fully functional AR system by Louis Rosenburg. It was built for the Air Force

1992

1994

Dancing in Cyberspace
First use of AR in the entertainment business. The show featured dancers alongside virtual objects on the physical stage

NFL Yellow line
First broadcasting of the virtual yellow first down marker during a live NFL game

1998

1999

NASA X 38 spacecraft
First time AR is used for navigation to overlay map data.

2000

AR Quake
First AR game + Head-mounted display

2005

AR tennis
AR games are being developed for smartphones.

AR enabled magazine
Readers of Esquire could scan the cover to make it come to life on the page

2009

MARTA
Volkswagen introduces the MARTA app (mobile Augmented Reality Technical Assistance. Step by step instructions to align and streamline the process.

2013

Google glass
First wearable AR device

2014

2015

Snapchat Selfie lenses
Snapchat introduces AR selfie lenses to the public.

HoloLens
Microsoft ships its first generation of wearable AR technology

Pokémon Go
Introduces the masses to the emerging technology.

2016

2017

IKEA Place
The app allows users to virtually preview furniture in their own home before actually buying it.

Web AR
Google adds AR as a new feature to its browser search results

2019

Volkswagen ID.3
The complete windscreen is used as a head-up display in combination with AR.

2020

Army AR Headset
The US Army closed a deal of $22 billion for army AR headsets

2021

What's out there?

Microsoft's Hololens is the most advanced mixed reality device in use today. For now, it is not yet available for sale to the general public. However, enterprises and businesses start to experiment with it. For example, Mr.Watts, a company that offers mixed reality solutions to companies with the Hololens as the main device: (MR.watts, 2021)

Fig. 26: Microsoft's Hololens

Fig. 27: Hololens in use by Deme

Deme, a Belgian dredging company uses the Hololens to remotely control a crane on one of their unmanned ships. It offers the same POV as a crane with a cabin, plus extra information, and warnings overlay on the camera feed. (Microsoftbelux, 2021)

Mr.Watts also deploys the Holosens on construction sites or to help to pick orders in large warehouses. It's an interesting glimpse we see here of the near future. (MR.Watts, 2021)

Fig. 28: Hololens in use in a distribution centre

In the medical world, the Hololens is being used as a surgical assistant by several companies. They see the future in mixed reality for surgical guidance and planning as well as training procedures. (Imec, 2021)

Fig. 29: Magic leap Surgery showcase

Fig. 30: Magic Leap

Fig. 31: Magic leap for medical training

The mixed reality devices for enterprises is not a monopoly for Microsoft with the Hololens. Magic leap is offering goggles too. They are a smaller company but sell cheaper devices, which helps them gaining traction with companies with smaller budgets.

Interactions in MR:

Despite some products out there already embrace mixed reality. There are not yet guidelines or a lot of examples available of how it can or should be.

In order to understand the current world of mixed reality, an overview is made of the current elements and interactions used in today's applications.

Elements to create a user experience for mixed reality:

The physical space:

- The ambient environment: The physical space around you, where the mixed reality elements can react with. (Approximately the 5m radius around you.)
- The wall.
- The floor.
- Objects in the room/space.
- Hands of the user

The user's input:

- Gaze tracking
- Eye-tracking
- Hand gestures: Point, tap, tap and hold, pinch hold, pinch and drag.
- Keyboard
- Voice commands

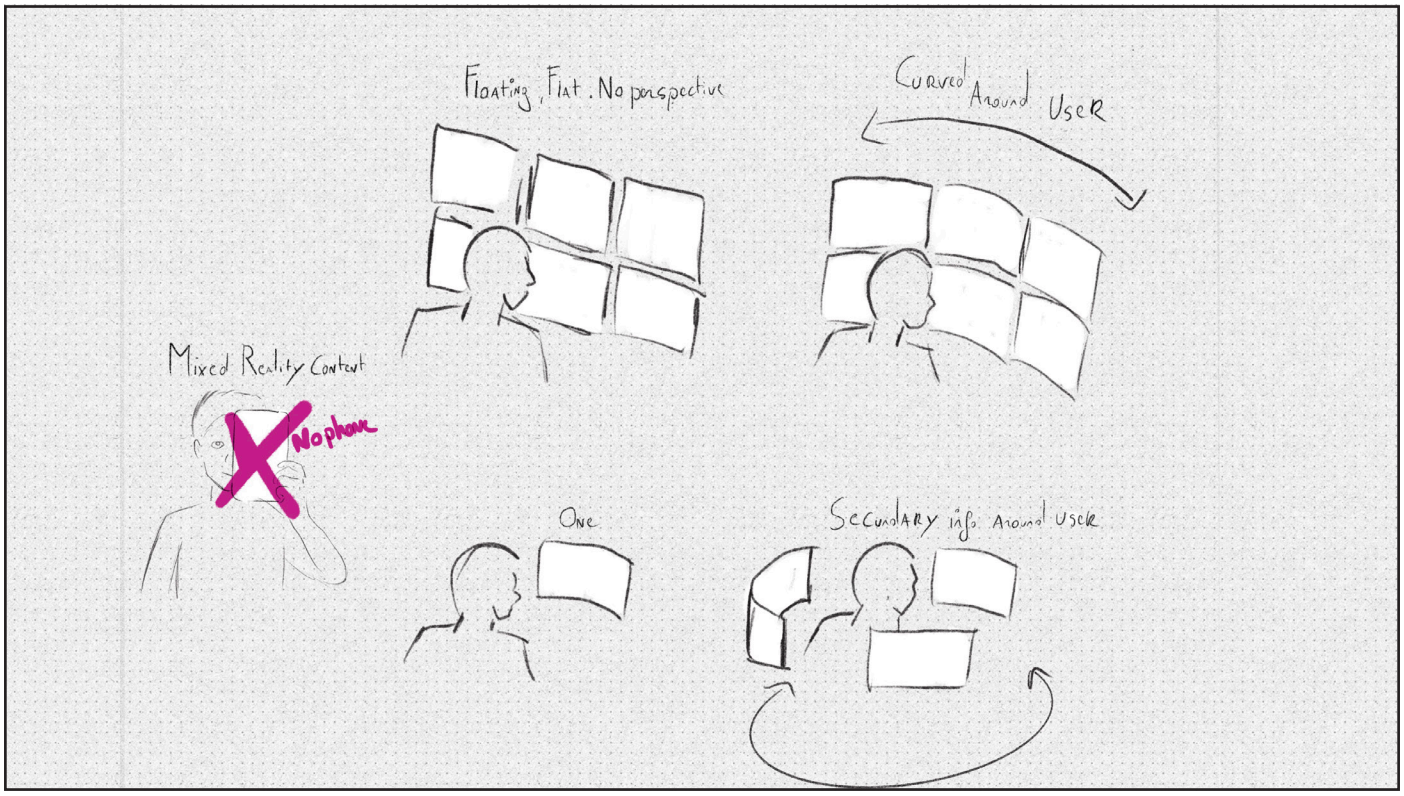


Fig. 32: MR interactions 1

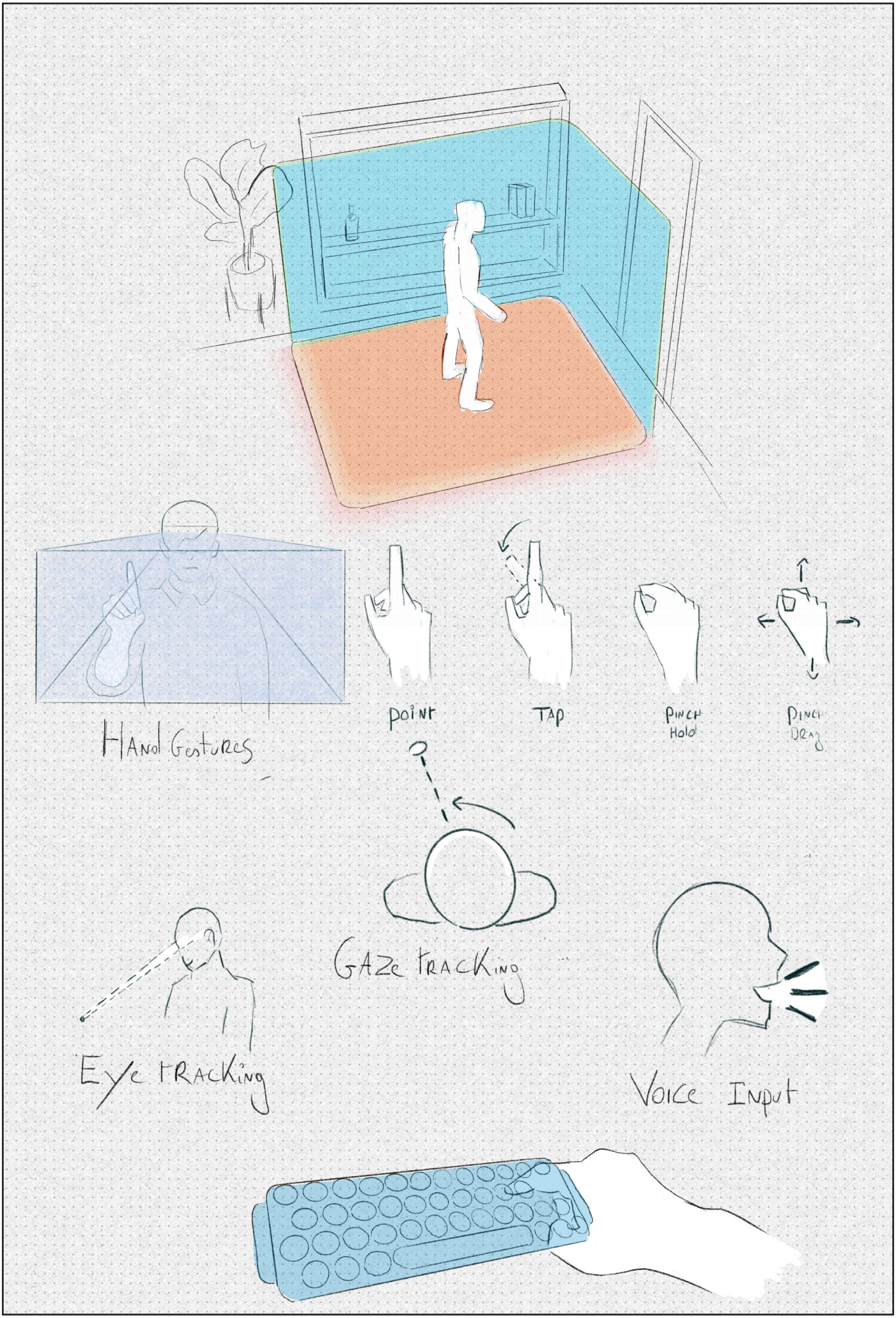


Fig. 33: MR interactions 2

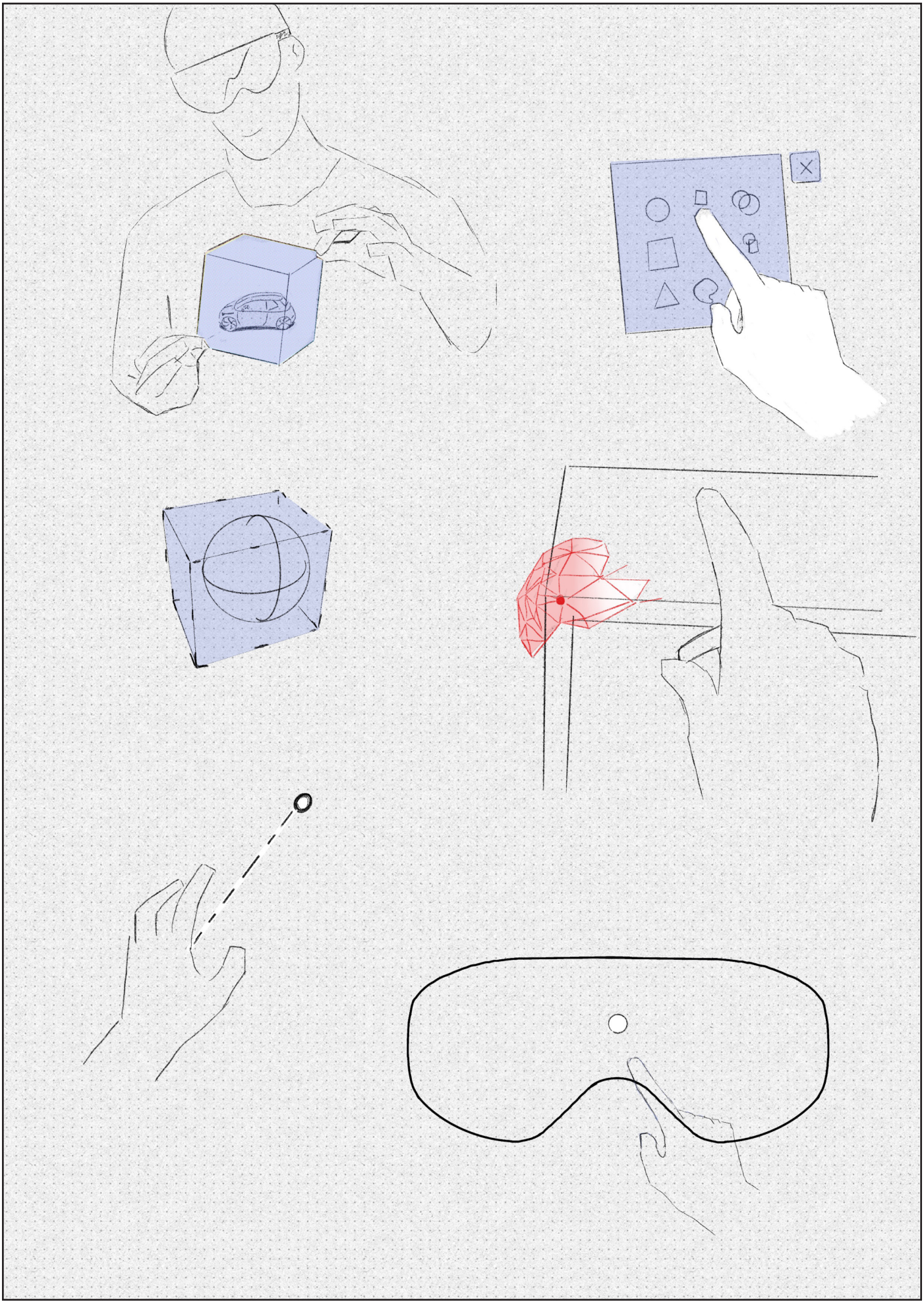


Fig. 34: MR interactions 3

Holographic form:

- Holographic object
- UI elements
- Bounding box
- spatial mesh
- Hand ray
- cursor

3D Sound:

- Feedback audio
- Spatial sound
- interaction cues

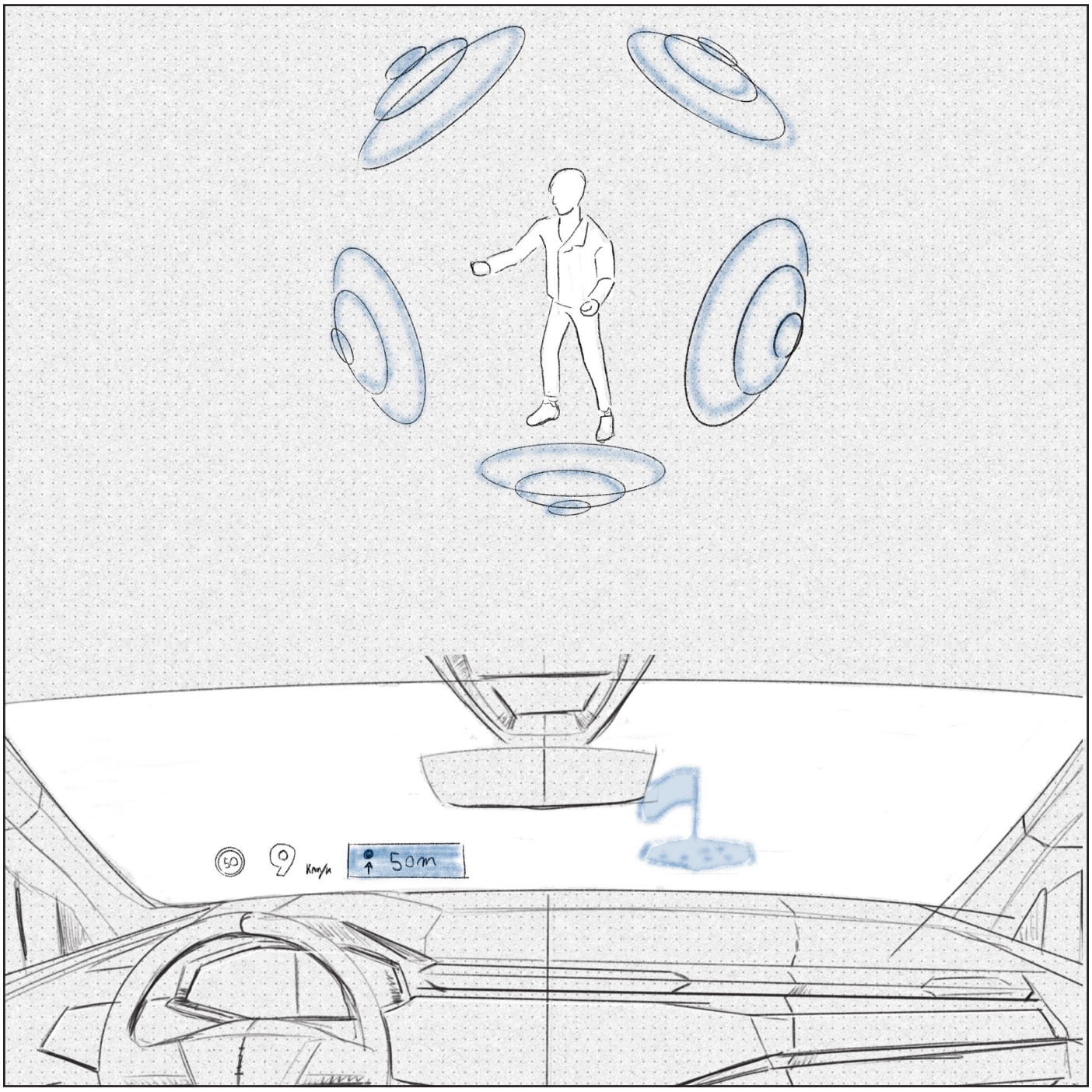


Fig. 35: MR interactions 4

HUD or Head up display.

Two-dimensional graphic overlay, like the viewfinder on a camera.

2.8 Scope:

Project core

- Communication: caller - dispatcher
- Medical emergency

In Scope

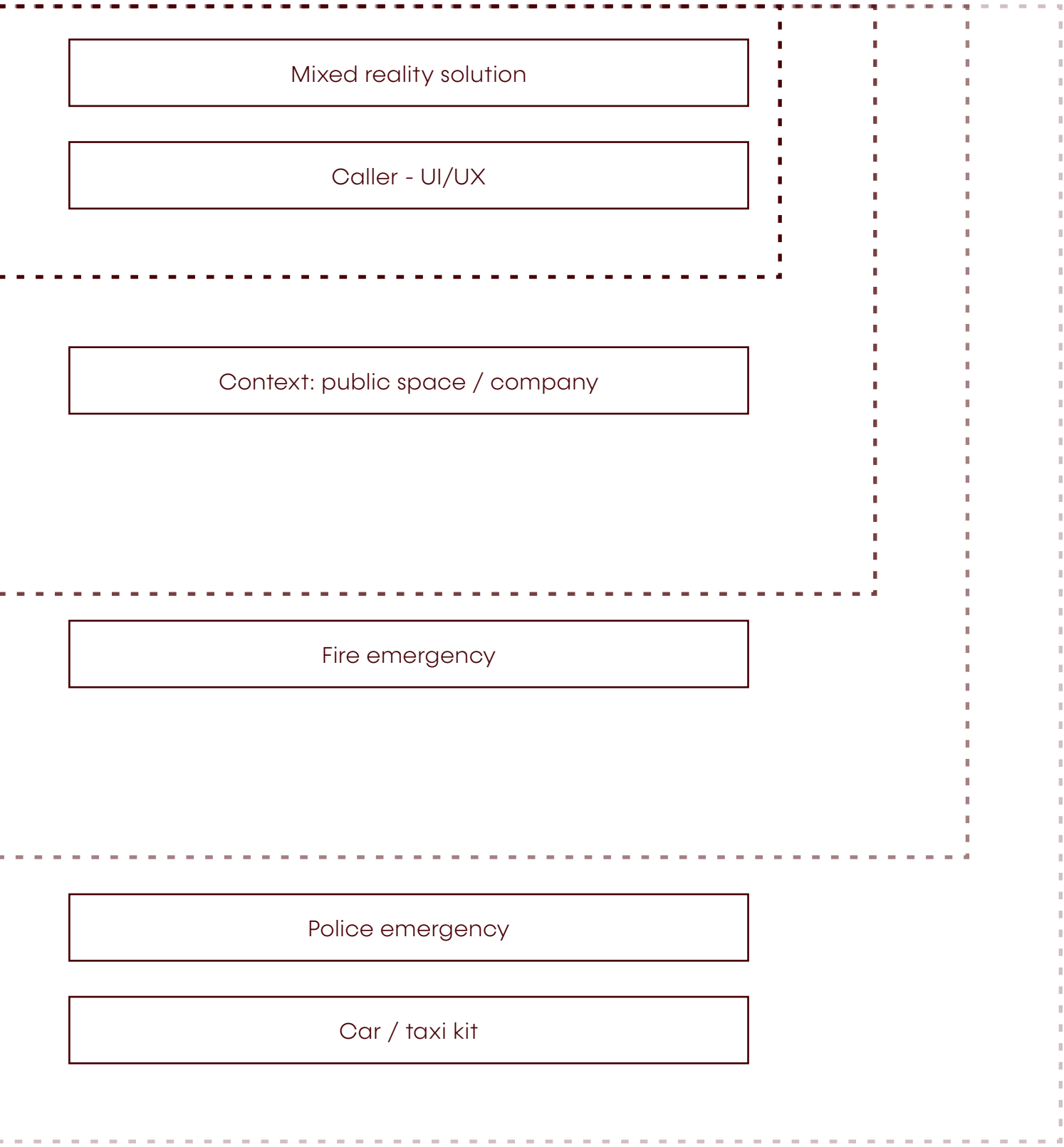
- Dispatcher - UI/UX
- Instructions dispatcher to caller

Nice to Have

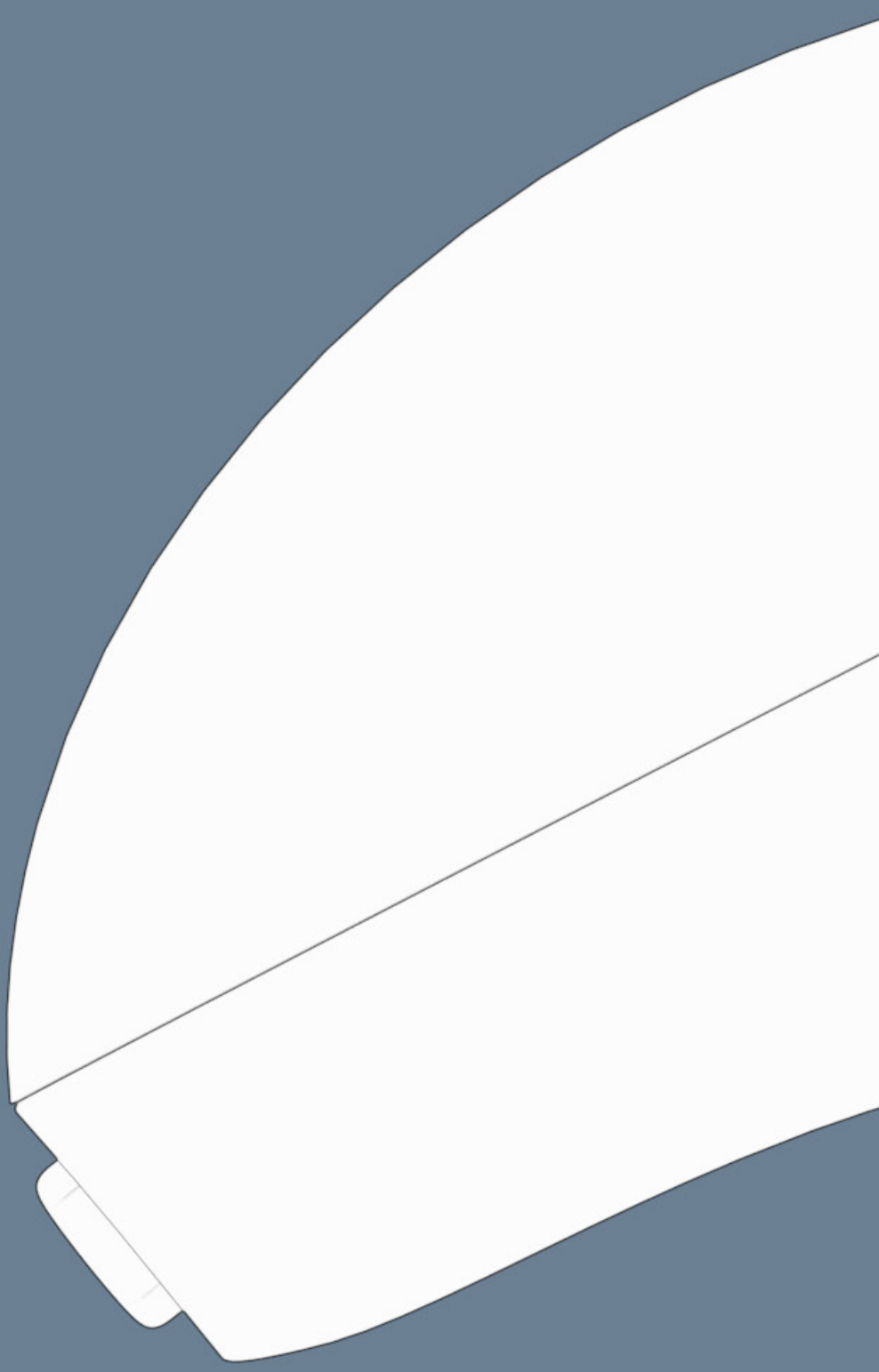
- Communication: dispatcher - provider
- Hololenst testing

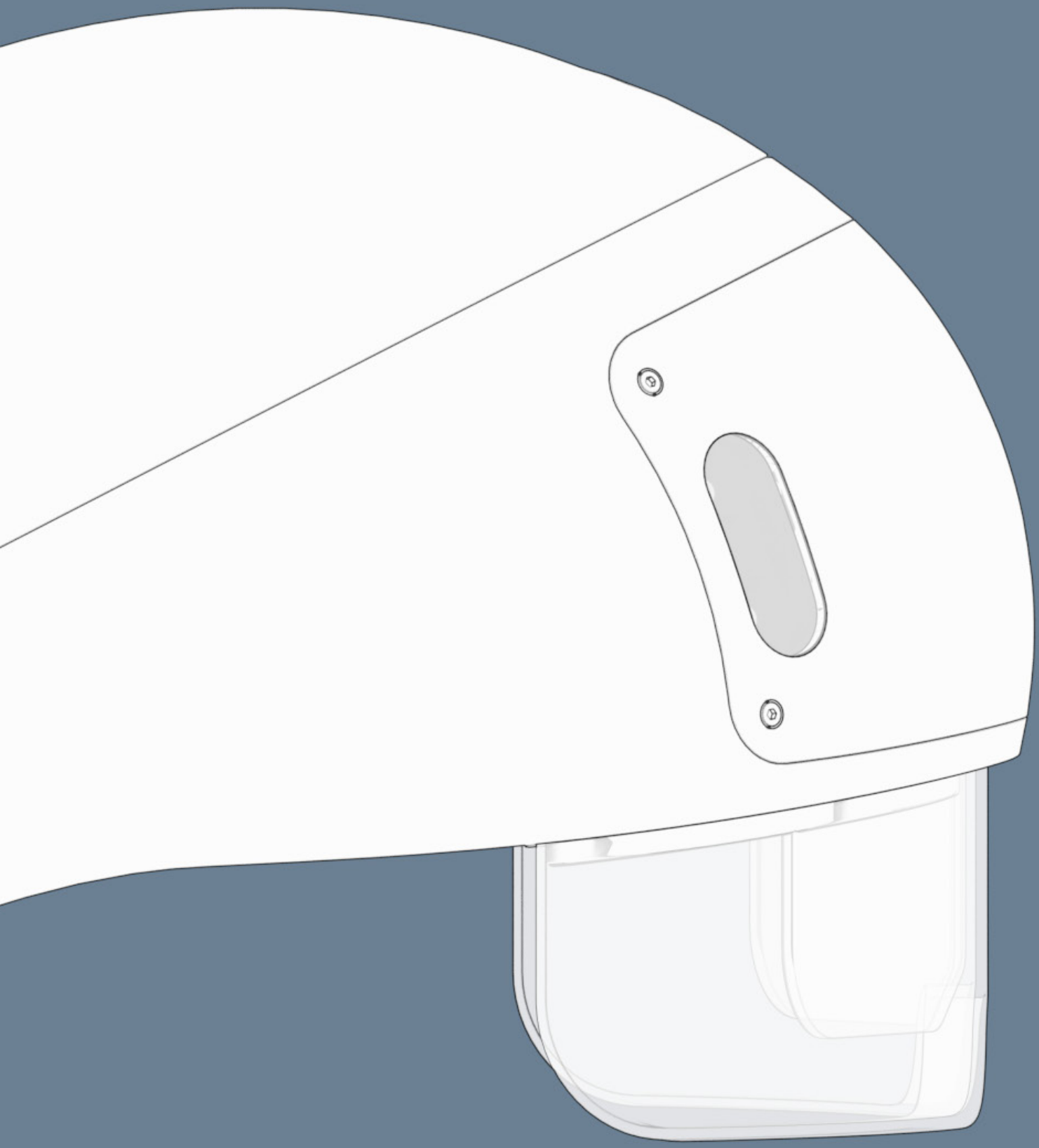
Out of Scope

- Artificial intelligence
- Technical design


Mixed reality solution
Caller - UI/UX
Context: public space / company
Fire emergency
Police emergency
Car / taxi kit

3 Define





3.1 Envisioned scenario

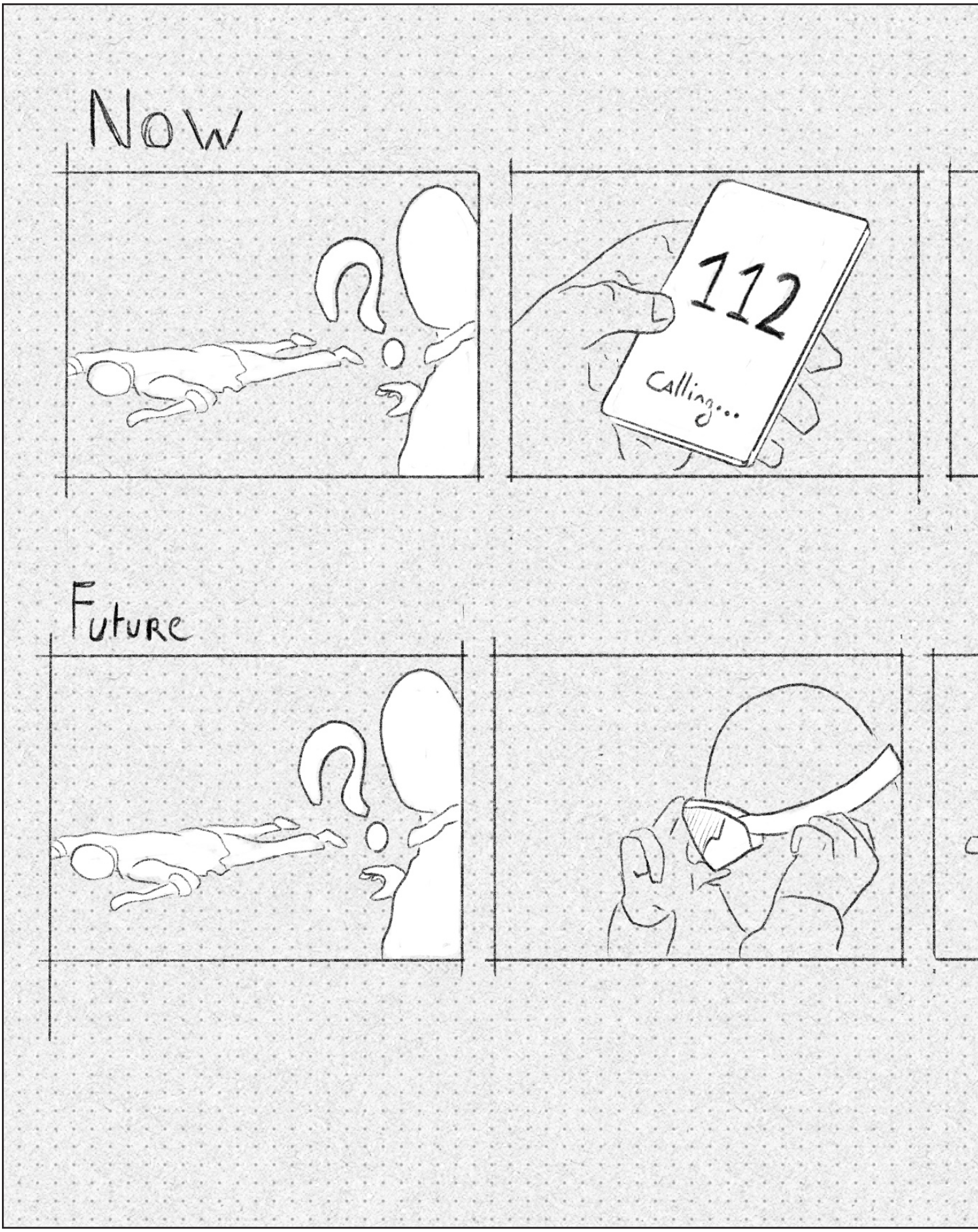
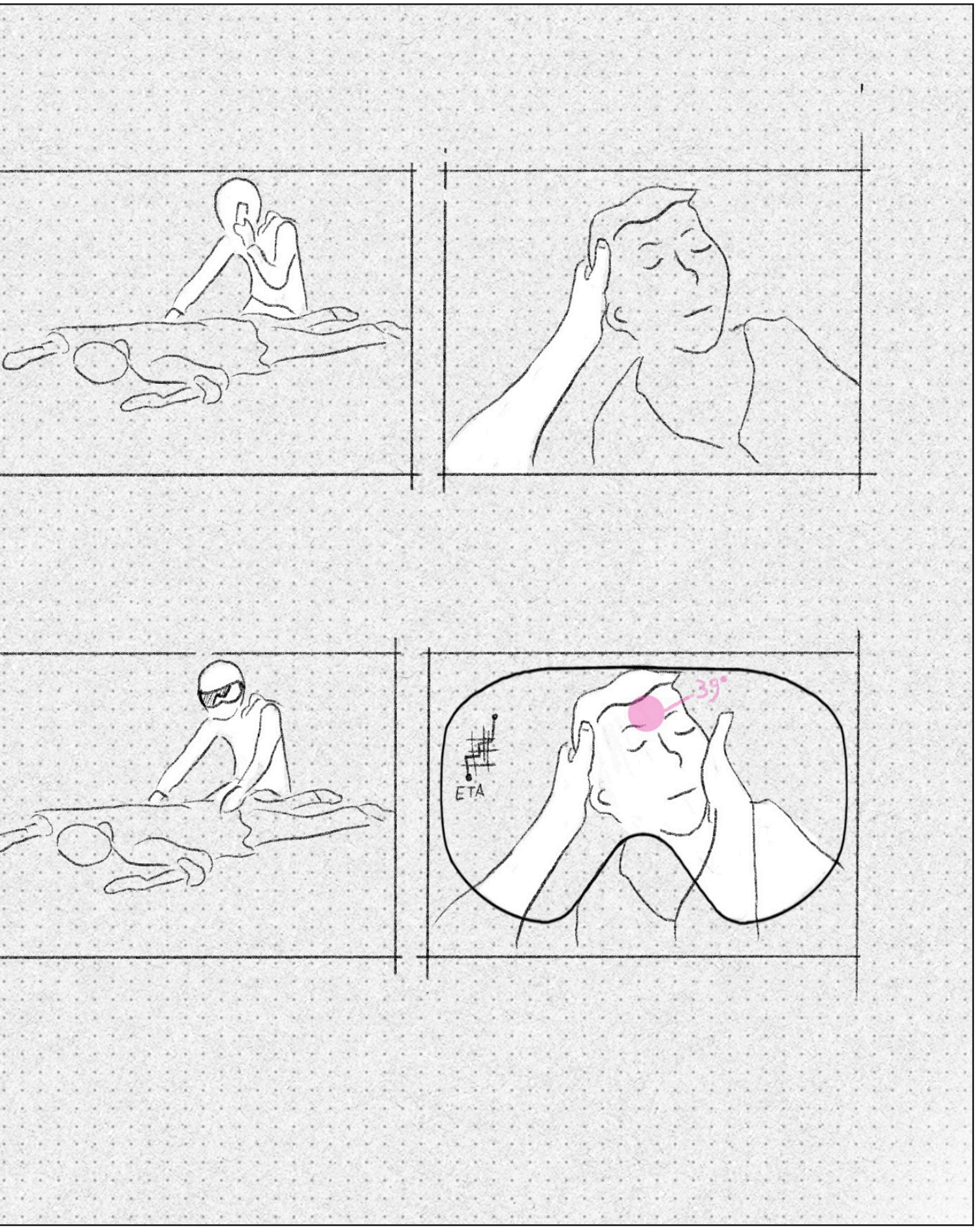


Fig. 36: Envisioned scenario


ETA
39°

3.2 List of requirements

Even in an exploratory concept design, there is a need for means of evaluation. A list of requirements (LoR) fulfils this need. It outlines the requirements for the performance and goals of this concept without locking on the looks of the product.

A list of requirements lays the basis of the development process and evaluation in a later stage.

- The device should allow the user to connect to the emergency services.
- The device should always be on when disconnected from its station.
- The device should always be fully charged when disconnected from its station.
- The device should automatically connect to the emergency services when disconnected from its station.
- The device should withstand the helmet standards described in EN 14458:2004.
- The device should withstand temperatures of 80C with no structural deterioration or change in appearance.
- The device must withstand UV degradation and colouring.
- The device should be packaged to ensure safe transport from the production facility to the location of deployment, considering the environment (high heat, humidity, dust) and rough transport
- The device should have two weeks of battery on standby when the dock loses power.
- The device should be self-explanatory in use.
- The device should have a comfortable fit for the majority of people.
- The device should be able to record and stream its feed-in use,
- The device should be able to make clear audio calls with background noise in its surroundings.
- The device should be able to capture heat imagery.
- The device should be able to perform spatial mapping on its surroundings and the objects within.

- From taking from its dock to automatically initiate an emergency call should be faster or should take as long as dialling in 112 on a smartphone.
- The dock should share the exact location of the device with the emergency services.
- The dock should initiate its emergency lights when an emergency alarm is engaged.
- The dock can store a fire extinguisher.
- The dock can store a defibrilator.
- The dock can store a first aid kit.
- The glasses need a minimum FOV (Field Of View)of 110° for displaying the mixed reality elements.
- The device should be able to enable people occlusion during the mixed reality experience.
- The UI elements transparency should change according to the light intensity.
- The optimal use region for maximal comfort determined by the maximum neck flexion is between 0 to 35 degrees below the horizon.

3.3 Design vision

PROVIDE INSTANT EMERGENCY RESPONSE ACHIEVABLE BY EVERYONE.

From the moment a bystander decides to help and uses the headset, he/she is able to perform aid under professional guidance.

The mixed reality overlay instructs the bystander so he/she can aid without doubting the actions.

3.4 Design drivers

Referring to the main question to be answered during this project, “Mixed reality: the next step in critical emergency calls? ” and the insights and design ingredients obtained in the research phase, concludes that the eventual design should be a holistic solution. That means that the design should focus on both the caller and the dispatcher.

Focusing on only one group or moment would probably not lead to a proper solution, as each phase of the call is crucial.
The civilian who calls and the professional emergency dispatcher are the target group for this design challenge.

Design drivers help formulate our list of requirements to define our aspirations and vision. That will make sure we don’t just check all boxes and miss the overall product experience.

Instant professional emergency care remotely.

Emergencies brought into view.

Impeccable state-of-the art-instructions.

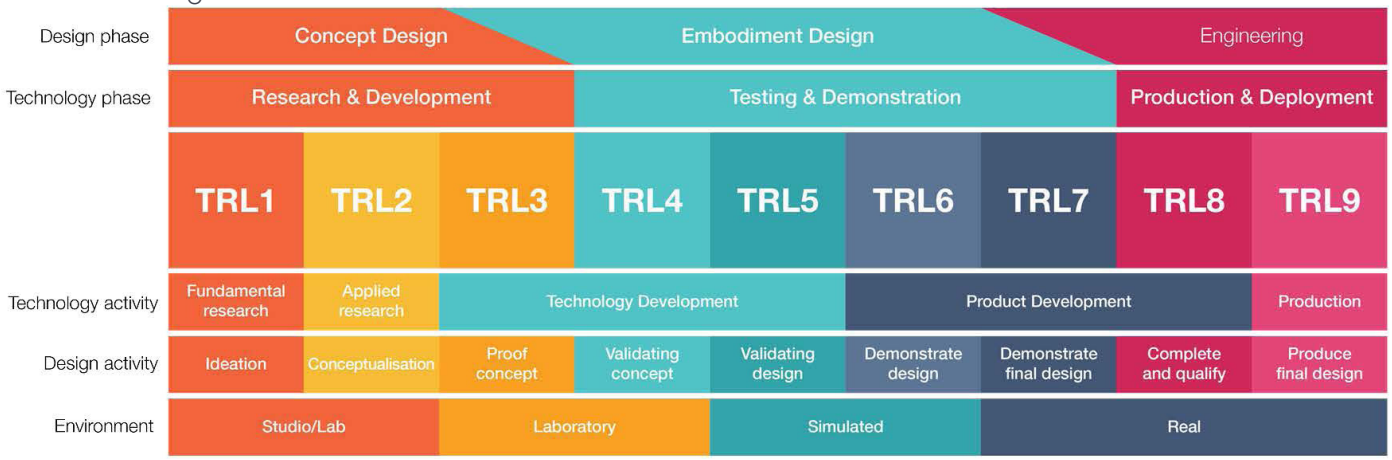
3.5 Design challenges

- The application of this project is currently non-existent. So everything has to be built from the ground up.
- Calibration of the mixed reality elements.
- What kind of visual support is needed.

3.6 TRL

Methodology:

Fig. 37: TRL overview



TRL stands for Technology Readiness Level. It is a visual tool to help you assess and map out the technology maturity.

It is used in the industry to determine milestones, track the completion of various steps, and identify gaps in testing and knowledge.

Scope:

System	UI	Audio	Visual Input	Housing	Chip	Cellular	Location	Buttons	sensor	battery
TRL 9										
TRL 8										
TRL 7										
TRL 6										
TRL 5										
TRL 4										
TRL 3										
TRL 2										
TRL 1										

3.7 System tree

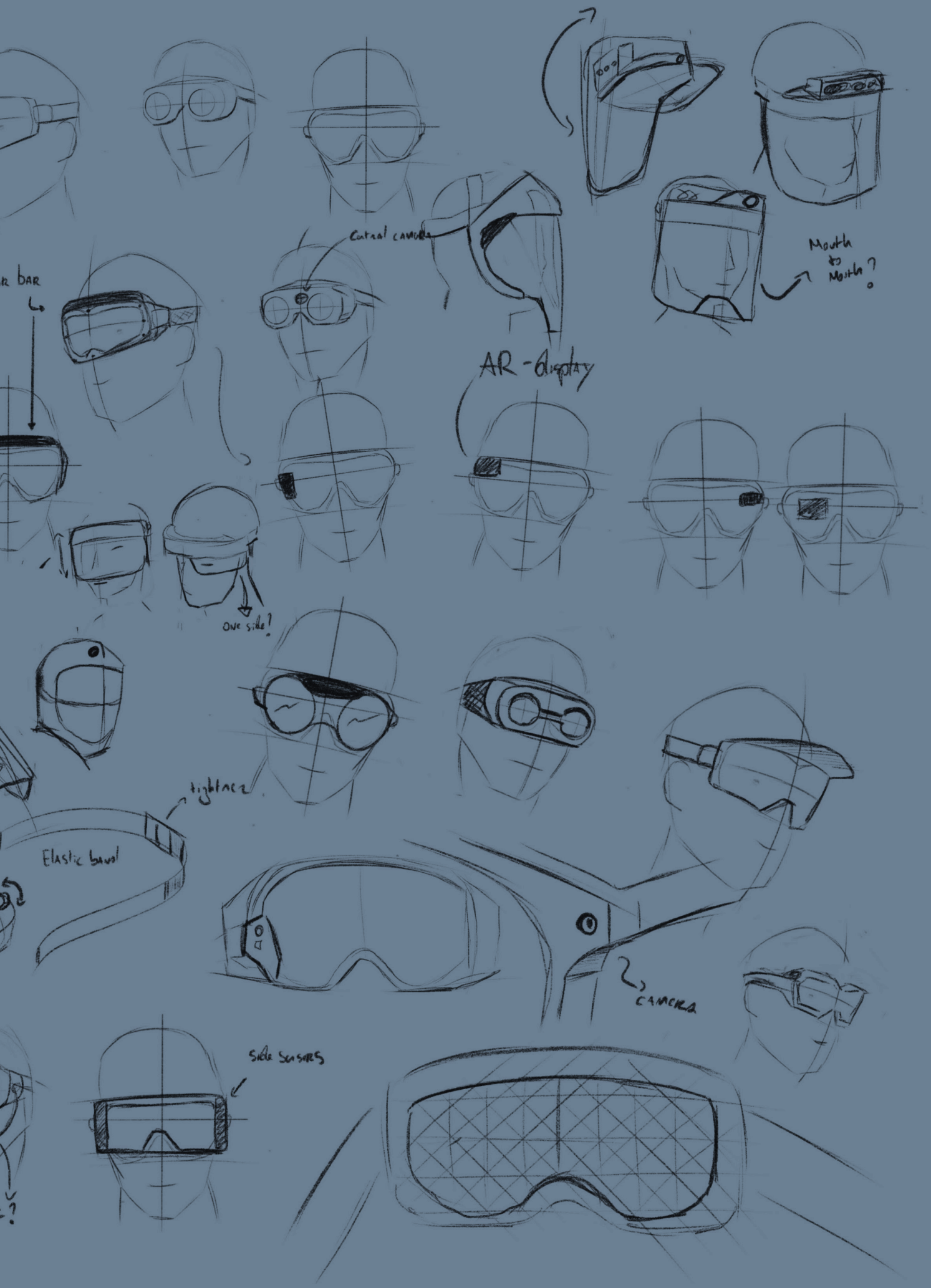
<table>
<tr><td>LEVEL 0:
Context level</td><td colspan="5">Emergency Re</td></tr>
<tr><td>LEVEL 1:
System overview</td><td colspan="5">DEA - unit (</td></tr>
<tr><td>LEVEL 2:
Part overview</td><td colspan="2">Housing</td><td>Audio input</td><td>Audio output</td><td>Visual input</td></tr>
<tr><td rowspan="5">LEVEL 3:
Parts</td><td rowspan="5">Electronics housing</td><td rowspan="5">Human fit housing</td><td>Microphone</td><td>Speaker</td><td>RGB camera</td></tr>
<tr><td rowspan="4" colspan="2"></td><td>Infrared</td></tr>
<tr><td>Thermal camera</td></tr>
<tr><td>Depth camera (near and far range)</td></tr>
<tr><td>Head tracking cameras (stereo and periphery + IMU)</td></tr>
</table>

esponse devices in public spaces

Direct Emergency Assistance)

Visual output	Chip	Cellular	Location	Buttons	Sensors	Battery
HUD		5G (sub-6 GHZ and mmWave)	Built-in GPS, GLONASS, Galileo, QZSS, and BeiDou		LiDAR scanner	
Waveguides		Gigabit LTE	Digital Compass		Barometer	
LEDs		Wifi 6			Three - axis gyro	
		Bluetooth 5			Accelero-meter	
					Ambient light sensor	

4 Create


Cutaal camera
AR - display
Mouth to Mouth?
bar
one side?
tightness
Elastic band
CAMERA
Side sensors

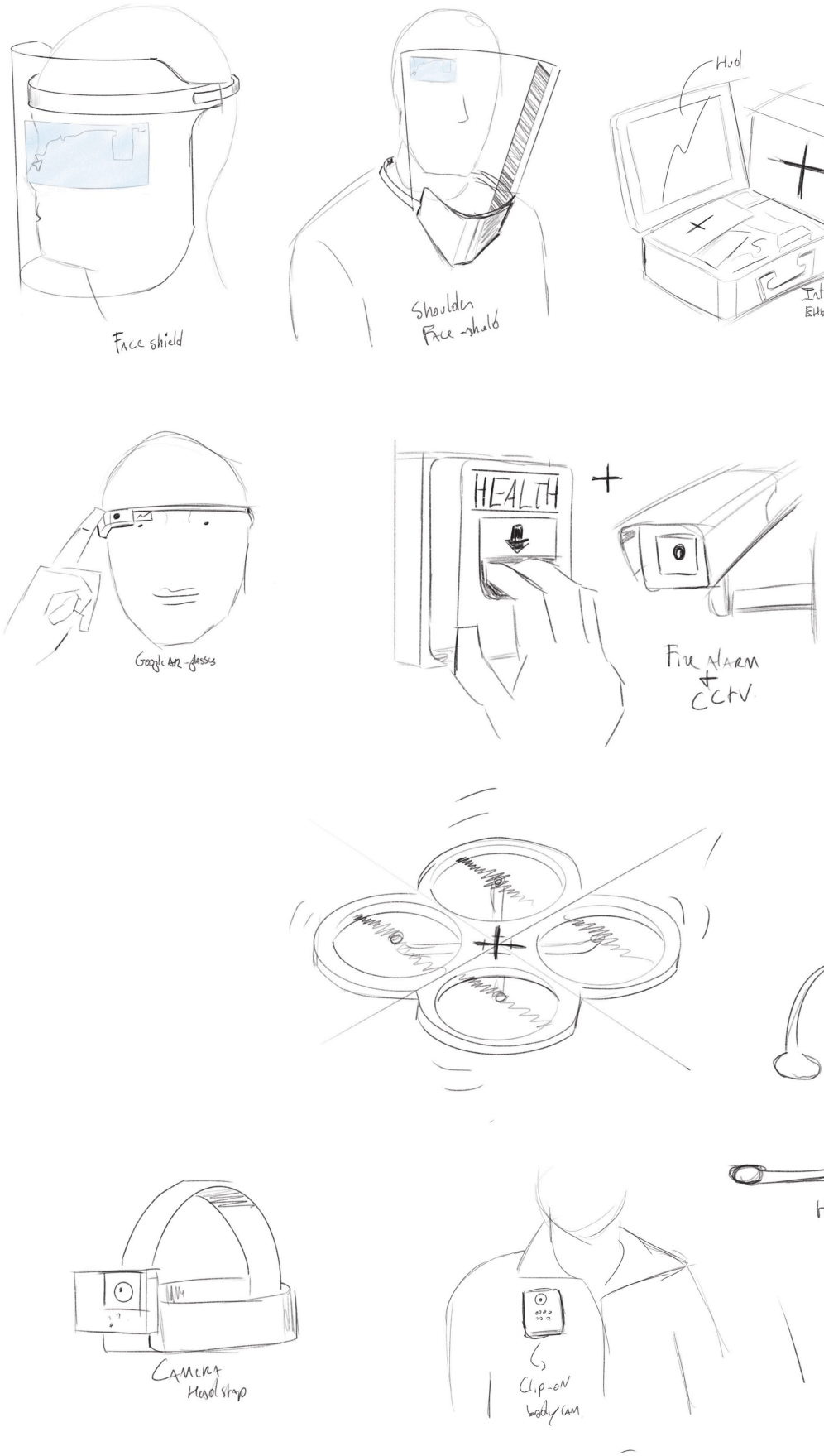
4.1 Idea harvest deck:

To kick off the creation phase, I set up an online whiteboard with Miro. I invited some colleagues and explained to them the problems and context of the project. After the short explanation, everybody participated in a brainstorm.

The brainstorm existed out of a mixture of brain writing and brain drawing according to the participant's confidence.

After the successful session, I set up the "Harvest deck". A harvest deck is made by visualizing all ideas from the brainstorm.

The sketches are simple but to a level that is suggesting the solution without being too designed. Just to show what the idea might be like.



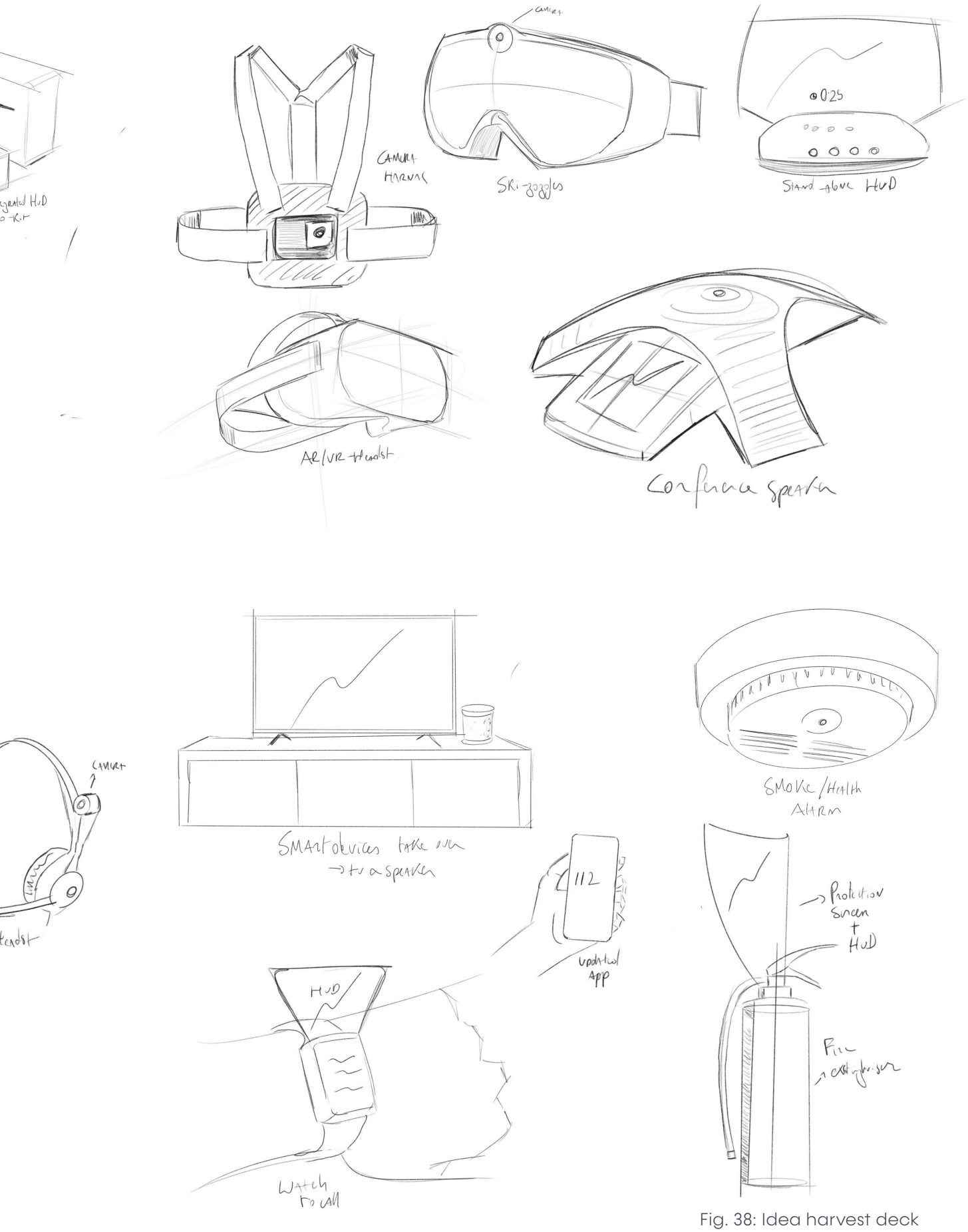


Fig. 38: Idea harvest deck

4.2 Datum method:

In order to evaluate the concepts created during the ideation phase, the ideas got a score following the Datum Method. (Boeijen, Daalhuizen, Zijlstra , & Schoor, 2013)

The ideas compare against a phone, the product of the current solution. The criteria used for grading are the speed to start a call, ease of use, sharing info, receiving info and location sharing possibilities.

Speed	.	+	Better
Ease of use	.	-	Worse
Share info	.	S	Same
Receive info	.		
Location share	.		
			End score

Face shield

Speed	.	S
Ease of use	.	-
Share info	.	+
Receive info	.	+
Location share	.	+
		2

Positive:
- AR-overlay
- Face protection
- Speaker / camera / microphone possible
- Can show visual data to caller

Negative:
- Fit needs (little) adjustment
- Do people want to put something on their head
- Time to install it on your head

Shoulder face shield

Speed	.	+
Ease of use	.	S
Share info	.	+
Receive info	.	+
Location share	.	+
		4

Positive:
- AR-overlay
- Face protection
- Speaker / camera / microphone possible
- Rest on shoulder / chest

Negative:
- Doubt about universal fit
- Do people want to put something on their head

Smart EHBO kit + HUD

Speed	.	+
Ease of use	.	+
Share info	.	S
Receive info	.	+
Location share	.	+
		4

Positive:
- Medical gear / tools directly available
- No dress up
- People that go for the kit already want to help

Negative:
- Camera positioning on victim

AR-glasses

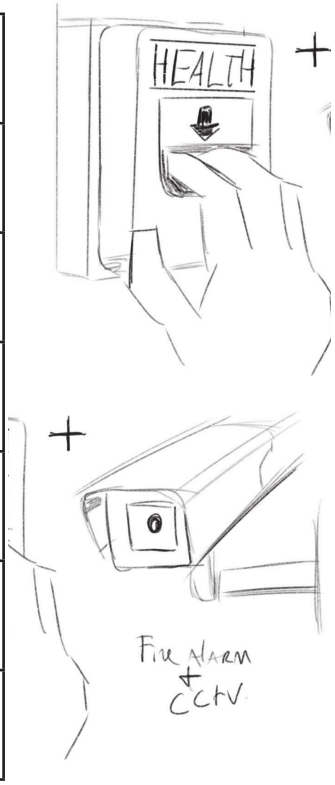
Speed	.	+
Ease of use	.	+
Share info	.	+
Receive info	.	+
Location share	.	+
		5

Positive:
- POV
- Can show visual data to dispatcher
- Fast dress up

Negative:
- Fit everyone?

Emergency alarm + CCTV

Speed	.	+
Ease of use	.	+
Share info	.	+
Receive info	.	**S**
Location share	.	+
		2

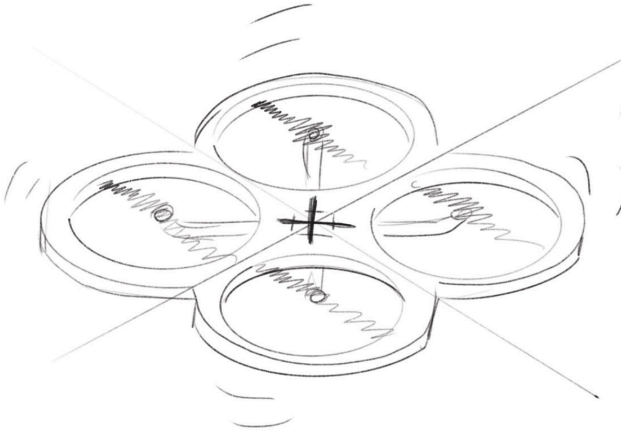


Positive:
- Exact location known
- Overview of the scene

Negative:
- Still needs an extra device to have a direct call
- Room / space dependent

Emergency drone

Speed	.	**S**
Ease of use	.	**S**
Share info	.	**+**
Receive info	.	**S**
Location share	.	**+**
		2



Positive:

- Dispatcher full control over POV

Negative:

- Dangerous
- noise
- achieved chaotic

360 cam + tripod

Speed	.	**-**
Ease of use	.	**-**
Share info	.	**+**
Receive info	.	**S**
Location share	.	**+**
		0

Positive:

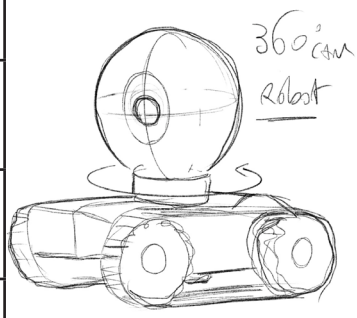
- Overview situation
- 360 view
- Higher lookout postition

Negative:

- Instalment

360 - camera AGV

Speed	.	**S**
Ease of use	.	**-**
Share info	.	**+**
Receive info	.	**+**
Location share	.	**+**
		2

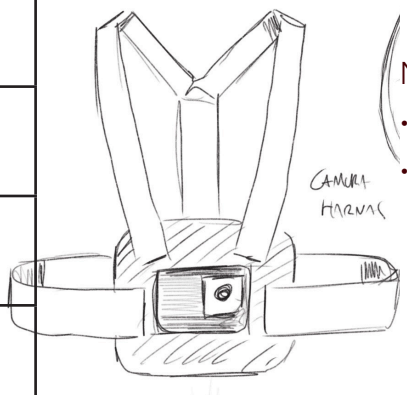


Positive:
- Dispatcher sees what he/she wants.
- Too low POV

Negative:
- Overkill
- Complex
- use case depends on physical capabilities

Camera harnass

Speed	.	**S**
Ease of use	.	**-**
Share info	.	**+**
Receive info	.	**S**
Location share	.	**+**
		1

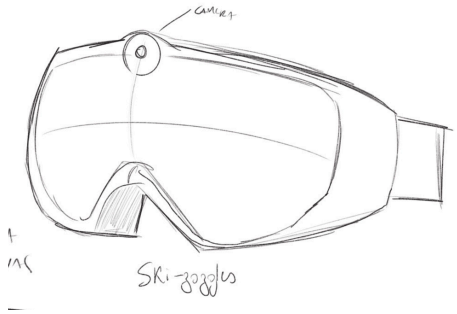


Positive:
- POV

Negative:
- Time to dress up
- Audio output and input

AR ski -goggles

Speed	.	+
Ease of use	.	+
Share info	.	+
Receive info	.	+
Location share	.	+
		5



Positive:
- POV
- AR overlay with visual data
- Fast dress up
- Easy fit

Negative:
- Fit almost everyone
- Wearable?

Stand Alone HUD

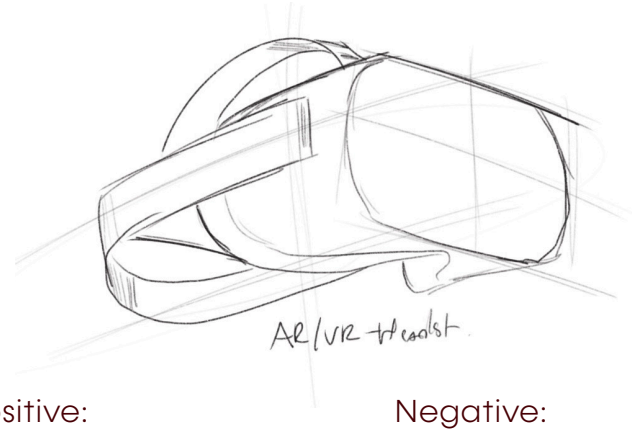
Speed	.	+
Ease of use	.	**S**
Share info	.	**S**
Receive info	.	+
Location share	.	+
		3

Positive:
- No wearable

Negative:
- Camera POV
- HUD allignment
- positioning

MR Headset

Speed	.	+
Ease of use	.	-
Share info	.	+
Receive info	.	+
Location share	.	+
		3

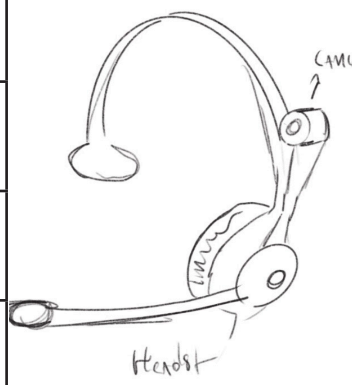


Positive:
- POV
- Can show visual data to dispatcher
- Fast dress up

Negative:
- Comfort

Headset

Speed	.	+
Ease of use	.	+
Share info	.	+
Receive info	.	**S**
Location share	.	+
		4

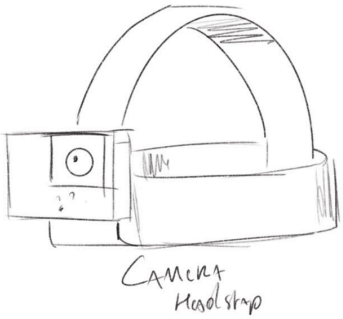


Positive:
- No setup
- Fit most people
- POV

Negative:
- No visual feedback caller

Camera headstrap

Speed	.	-
Ease of use	.	+
Share info	.	+
Receive info	.	S
Location share	.	+
		2

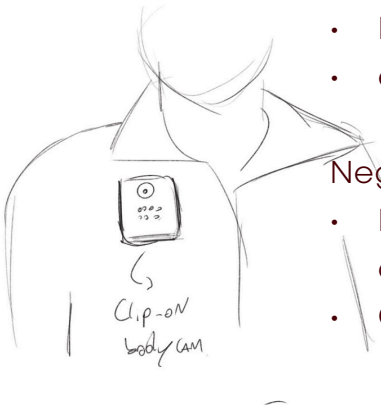


Positive:
- POV

Negative:
- No visual feedback user

Body cam

Speed	.	S
Ease of use	.	+
Share info	.	+
Receive info	.	S
Location share	.	+
		3

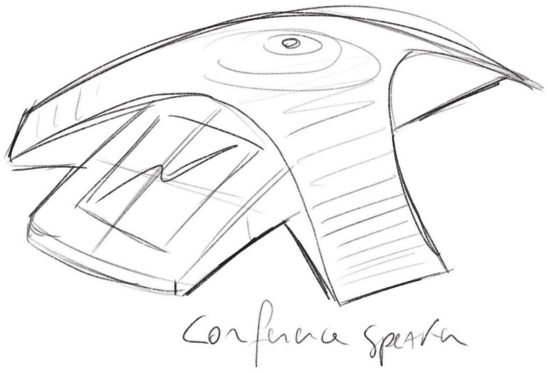


Positive:
- POV
- No headset
- easy setup

Negative:
- No visual feedback caller
- Camera positioning

Meeting speaker

Speed	.	+
Ease of use	.	+
Share info	.	S
Receive info	.	+
Location share	.	+
		4

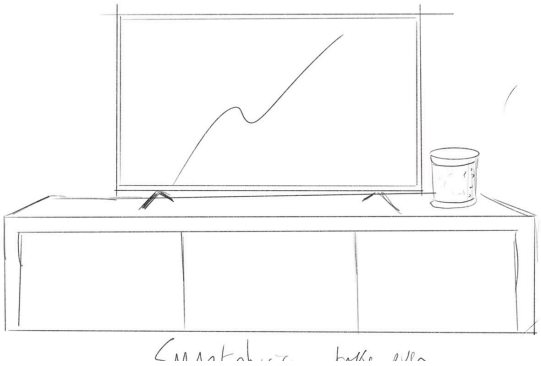


Positive:
- No wearable

Negative:
- No visual feedback
- No camera

Smart devices emergency connection

Speed	.	+
Ease of use	.	-
Share info	.	+
Receive info	.	+
Location share	.	+
		3



Positive:
- Availability
- Multi - network

Negative:
- Different tech products
- Software

Smart smoke health alarm

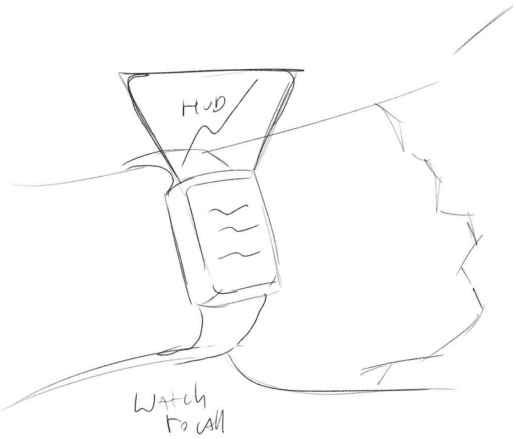
Speed	.	+
Ease of use	.	+
Share info	.	+
Receive info	.	+
Location share	.	S
		4

Positive:
- Alarm
- overview

Negative:
- Limited view
- still needs phone or extra device

Smart watch / strap

Speed	.	S
Ease of use	.	-
Share info	.	S
Receive info	.	+
Location share	.	+
		1



Positive:
- Close to the action

Negative:
- Usecase

Emergency application

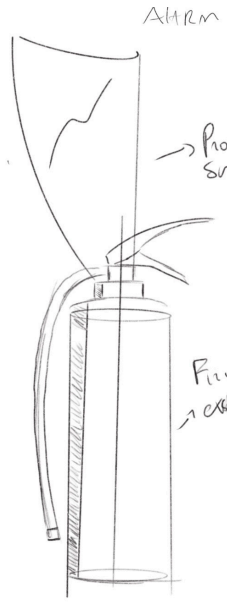
Speed	.	-
Ease of use	.	-
Share info	.	+
Receive info	.	+
Location share	.	+
		1

Positive:
- Alarm
- chat
- availability
- cost

Negative:
- Locked
- more time then calling

Smart fire exstinguisher + HUD

Speed	.	+
Ease of use	.	+
Share info	.	+
Receive info	.	+
Location share	.	+
		5

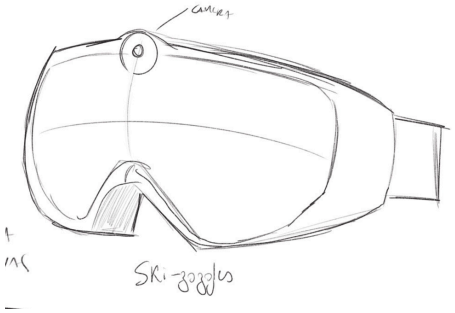


Positive:
- Combined with emergency gear

Negative:
- Only one usecase
- Usability
- Fire

Ideas with the top score:

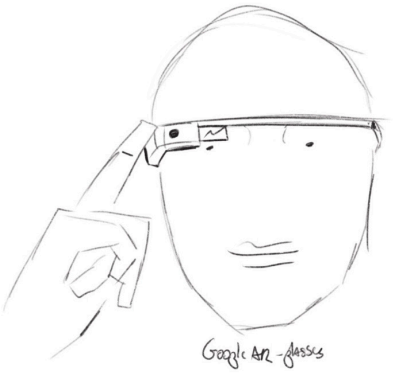
According to the scoring system, these three ideas received the highest scores. Two of them are goggles/glasses. Goggles can display an extra layer of visual information in combination with a camera point of view of the user.



The goggles scored higher than a full-on headset, which is more inclusive and heavier to wear.
The third top contented was a fire extinguisher, combined with a visual output possibility, like a HUD, specified for the job with only one goal in mind.

These results don't show the final best solution. However, they tell which qualities the concepts need:

- MAYA, most advanced yet acceptable
- A visual layer of information
- POV of the user for the camera feeds.
- Concept specified for the job



4.3 Method 3-6-5:

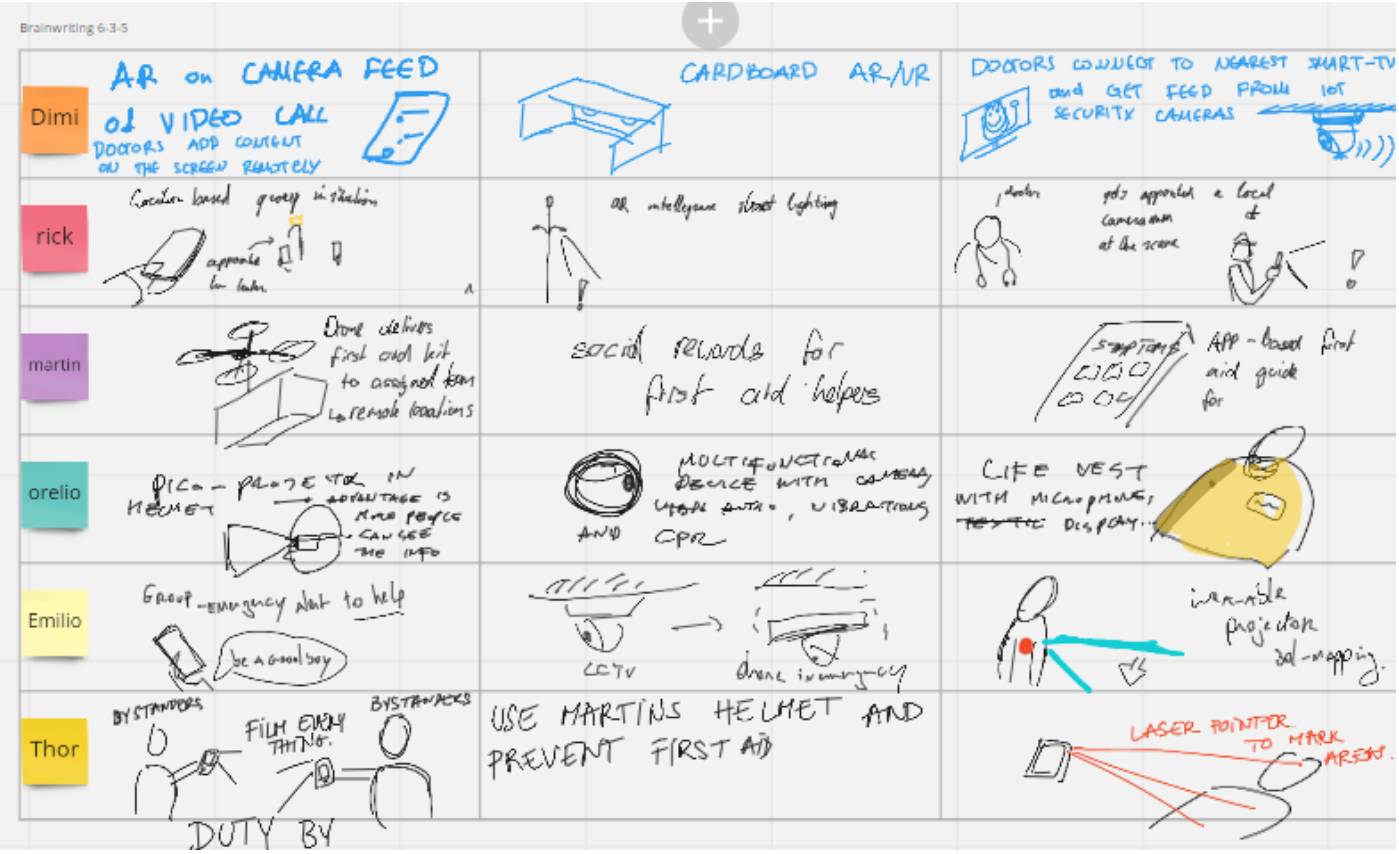


Fig. 39: Method 3-6-5

After the initial brainstorming phase, it felt like we were too blinded with already existing solutions, products on the market. A new round of ideation was done with the 6-3-5 method to generate some ideas and explore possibilities for better emergency communication.

Besides creating ideas, the method also acts as an exercise in getting insight into each participant´s design style and way of thinking.

Method explanation:
The participants all fill in three ideas in 5 minutes, afterwards each paper is passed along all participant, each having 5 minutes per paper to elaborate on the first three ideas.

Interesting ideas of the session:
- (Breathing) visuals to guide breathing and calm down the caller
- entrance/emergency tablet
- mapping blanket for patient + scanning
- emergency box + communication included
- extra sensors for vitals. CCTV with vital readings
- AI integration
- 3d mapping of situation + projecting
- gamification of first aid training
- holographic display
- colour shift in glasses to calm down
- nearby group message alert

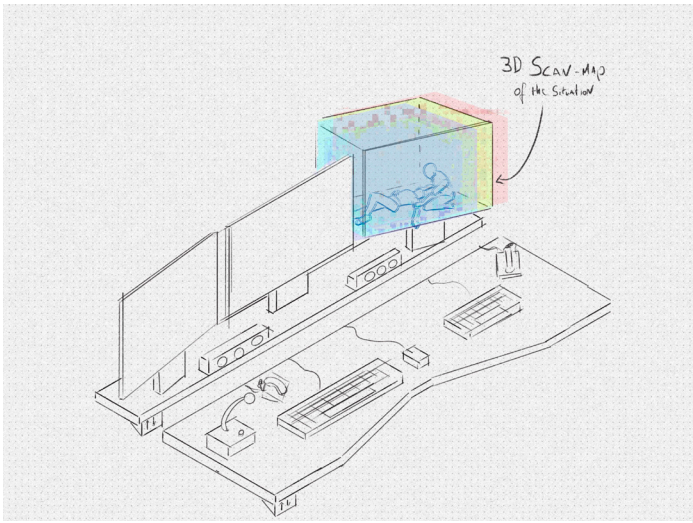
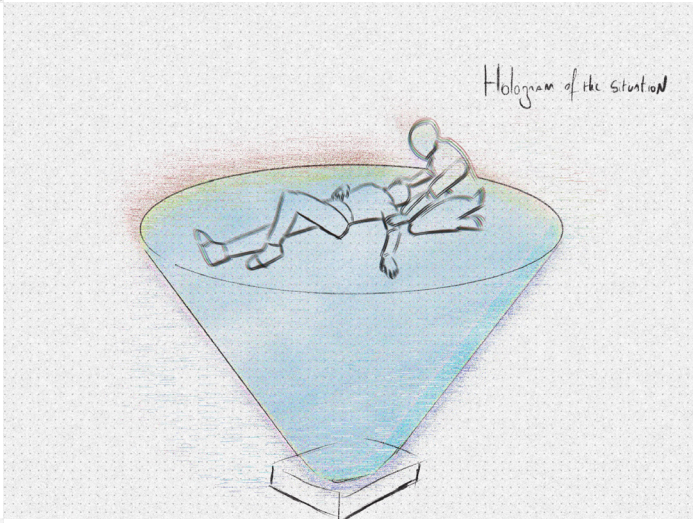


Fig. 40: 3-6-5 – highlight 1

Highlights of ideas:
By live 3D-scanning the environment, the situation is mapped in 3D. The scan gives the dispatcher the possibility to pan around and observe the emergency from different sides and views.

Fig. 41: 3-6-5 – highlight 2

The same principle as the previous example. However, instead of on a screen, the situation is visualised as a rotating hologram.



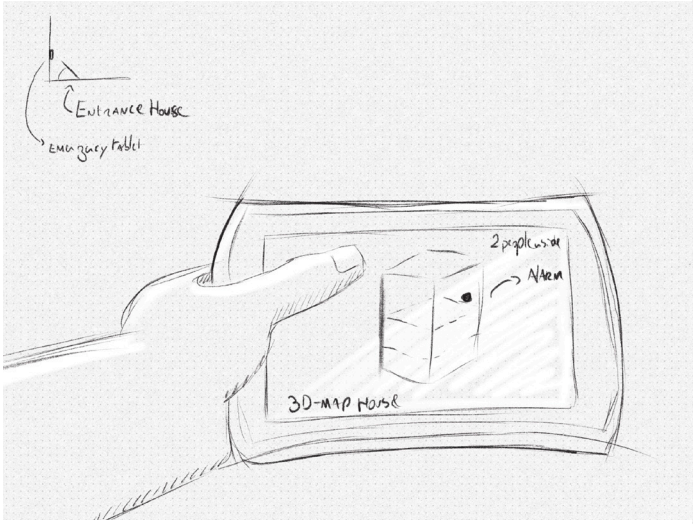


Fig. 42: 3-6-5 – highlight 3

This idea is an emergency tablet at the entrance of the building. Similar to emergency maps at the entrance of ships or public buildings. It shows the in-building location, where the alarm went of plus optional data to fight the danger.

Mapping the patient and its condition on a rug, the rug helps to easily communicate exact conditions and helps the digital mapping.

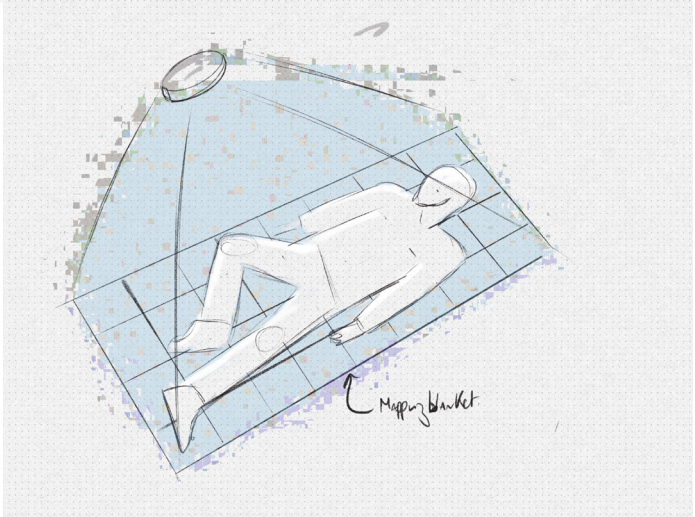


Fig. 43: 3-6-5 – highlight 4

4.4 Concepts:

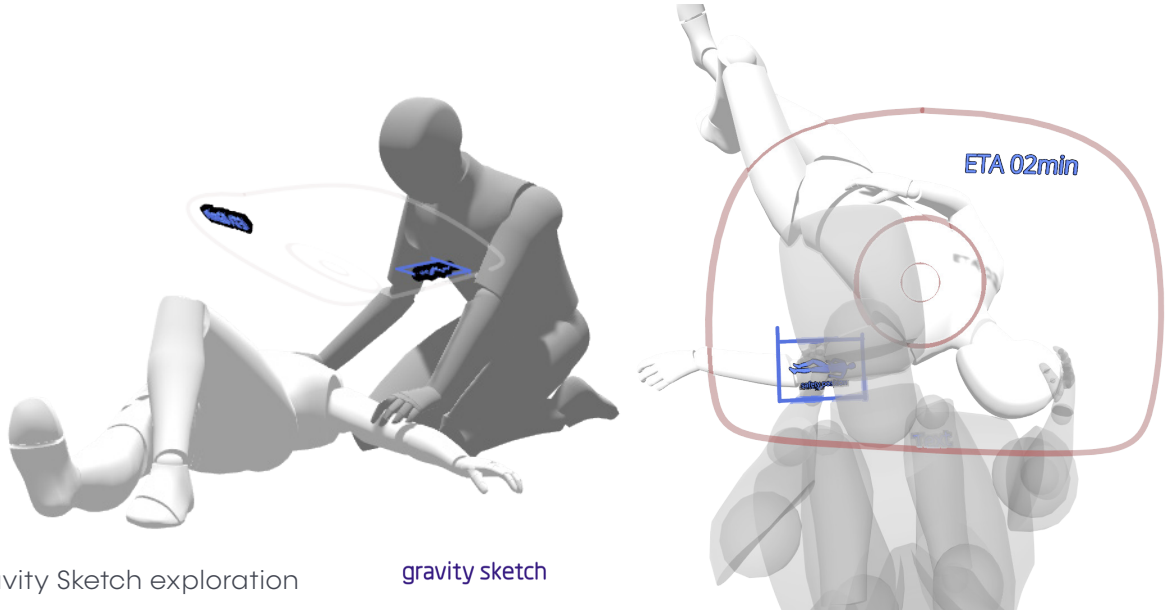


Fig. 44: Gravity Sketch exploration

After the brainstorming phase, initial research and knowing which qualities the concept needs, a first scenario was created in virtual reality.

All scenes and VR concepts were created in Gravity Sketch. It's a versatile 3D program that allows for quick iterations of one on one scale.

Creating in VR allowed to rapidly map the mixed reality user interface without the need for expensive sensors or knowledge of coding.

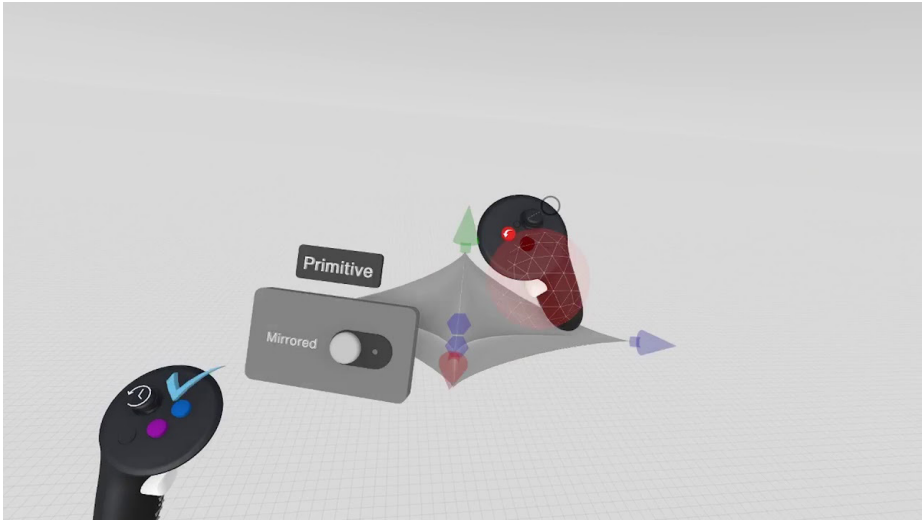


Fig. 45: Gravity Sketch tool

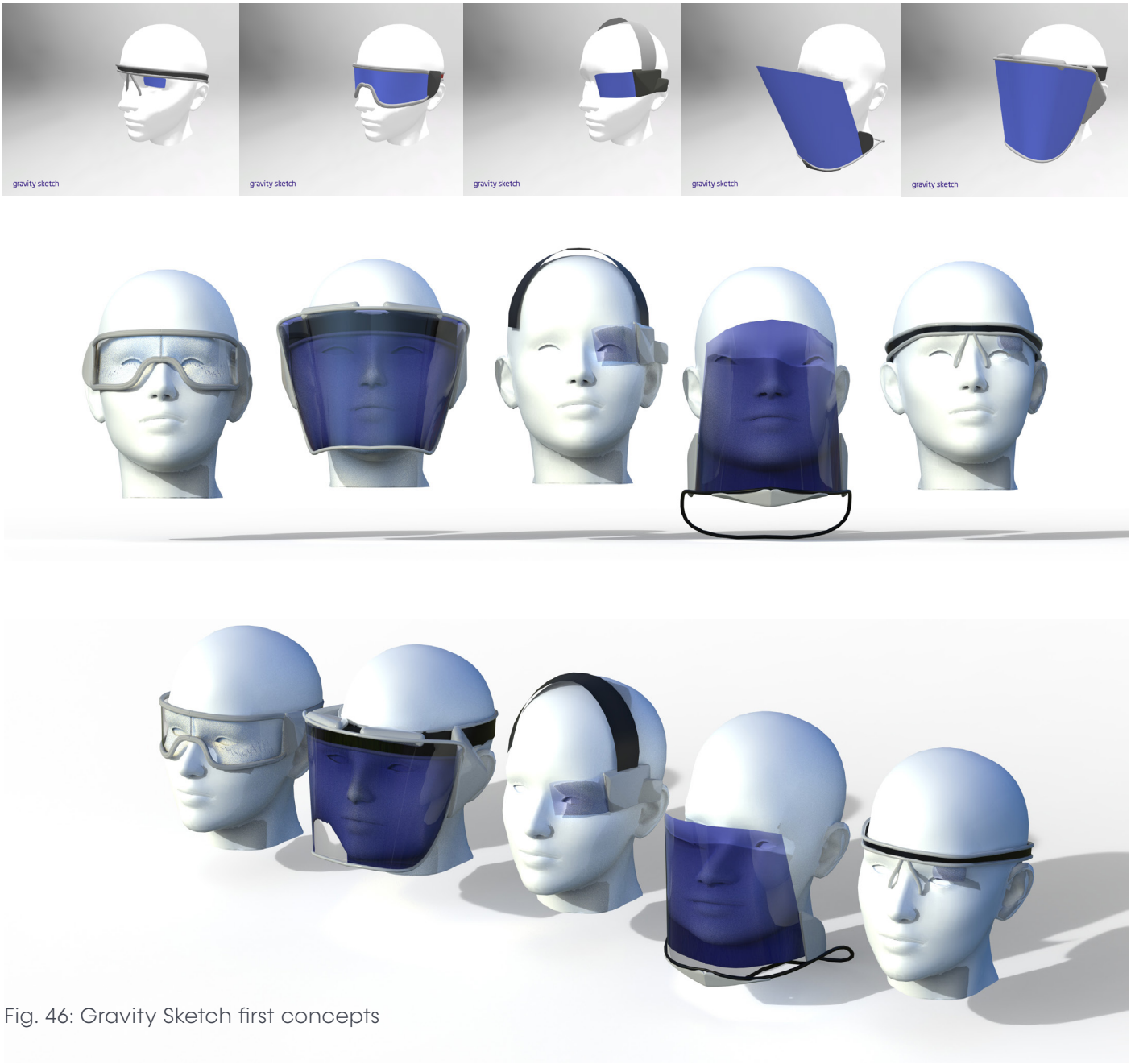


Fig. 46: Gravity Sketch first concepts

These are some early concepts iterations designed in GravitySketch. As to be seen in the picture above it are all solutions fitting the goggles or face mask category. They offer unobstructed easy movement, while the hands are free.

A mask or goggles allows a visual layer of information in combination with a first-person camera point of view.

Medical emergency concepts:

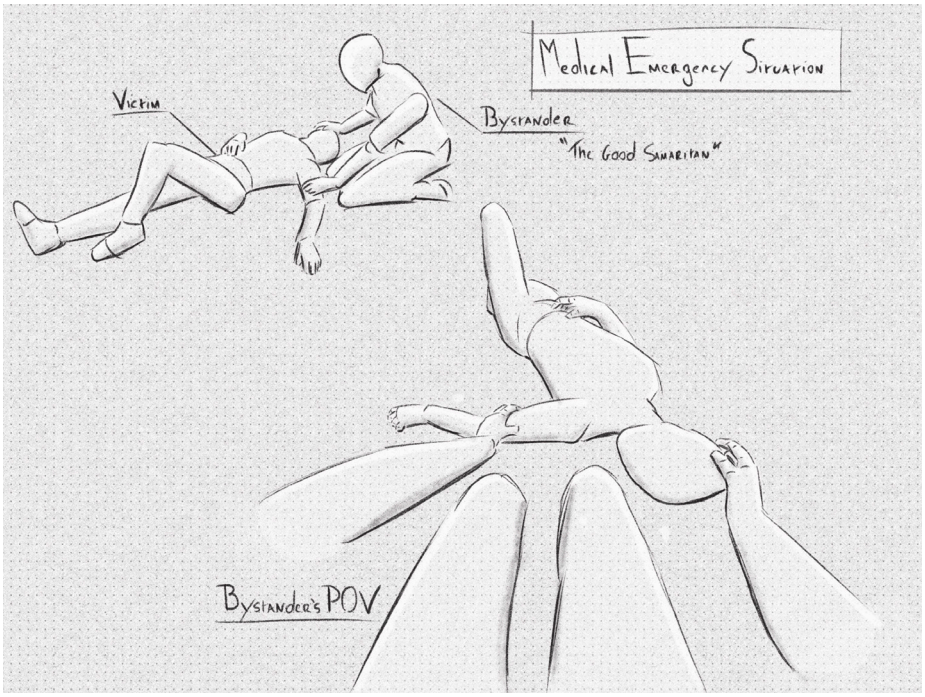


Fig. 47: Medical emergency – situation sketch

Situation sketch:
A bystander encounters a victim in an unknown condition. The bystander decides to help the victim by reaching out to the international emergency number.

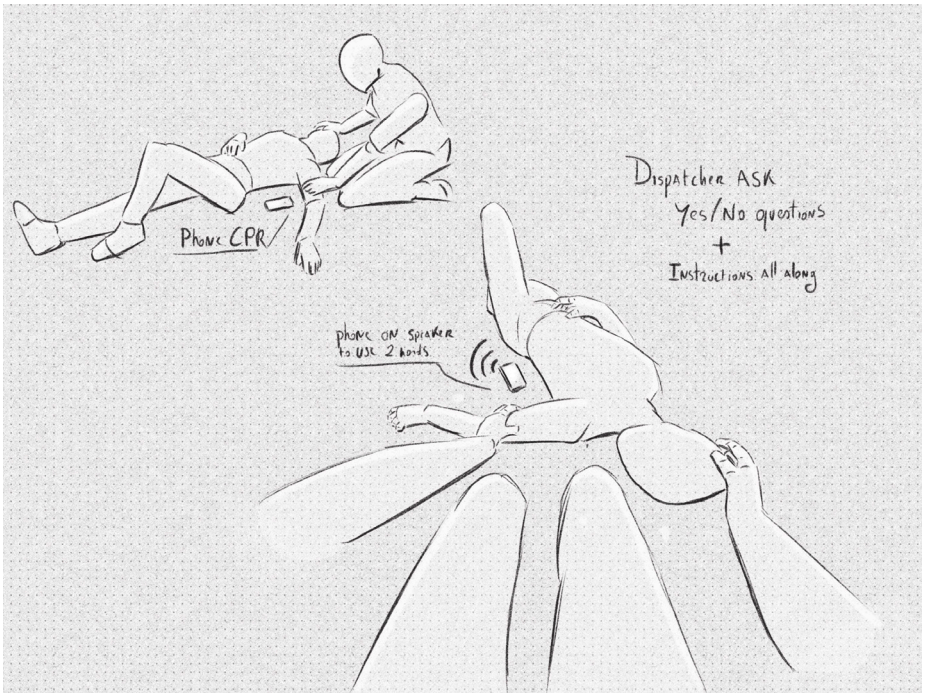


Fig. 48: Medical emergency – current solution

Current solution:
The emergency service is contacted by phone. The communication is auditory-only. The bystander will verbally describe what he/she sees and will answer the dispatcher's questions. If instructions are is given, such as CPR, the bystander will follow them while the phone is on speaker. The speaker phone allows the caller to use its two hands but negatively influences the quality of the call.

Concept 1:
This concept consists out of a full face screen. This allows a lot more screen estate to map extra visual elements. However, the extra surface area is not the most suitable place for visual information. The content (red area) is behind the inner frame area. This could be used for complementary content but it is the least suitable place for information. The full-face screen gives the user a more protected feeling(especially during the current pandemic). However, it makes giving CPR impossible without removing the mask first.

Concept 2:
Similar to the first concept, except that instead of a face screen, it is goggles. These allow the user to keep them on while performing CPR.

Concept 3:
This concept is a first aid kit with integrated visual communication means. Less obtrusive as a headset but more restricted in possibilities to visually improve the current ways of communication.

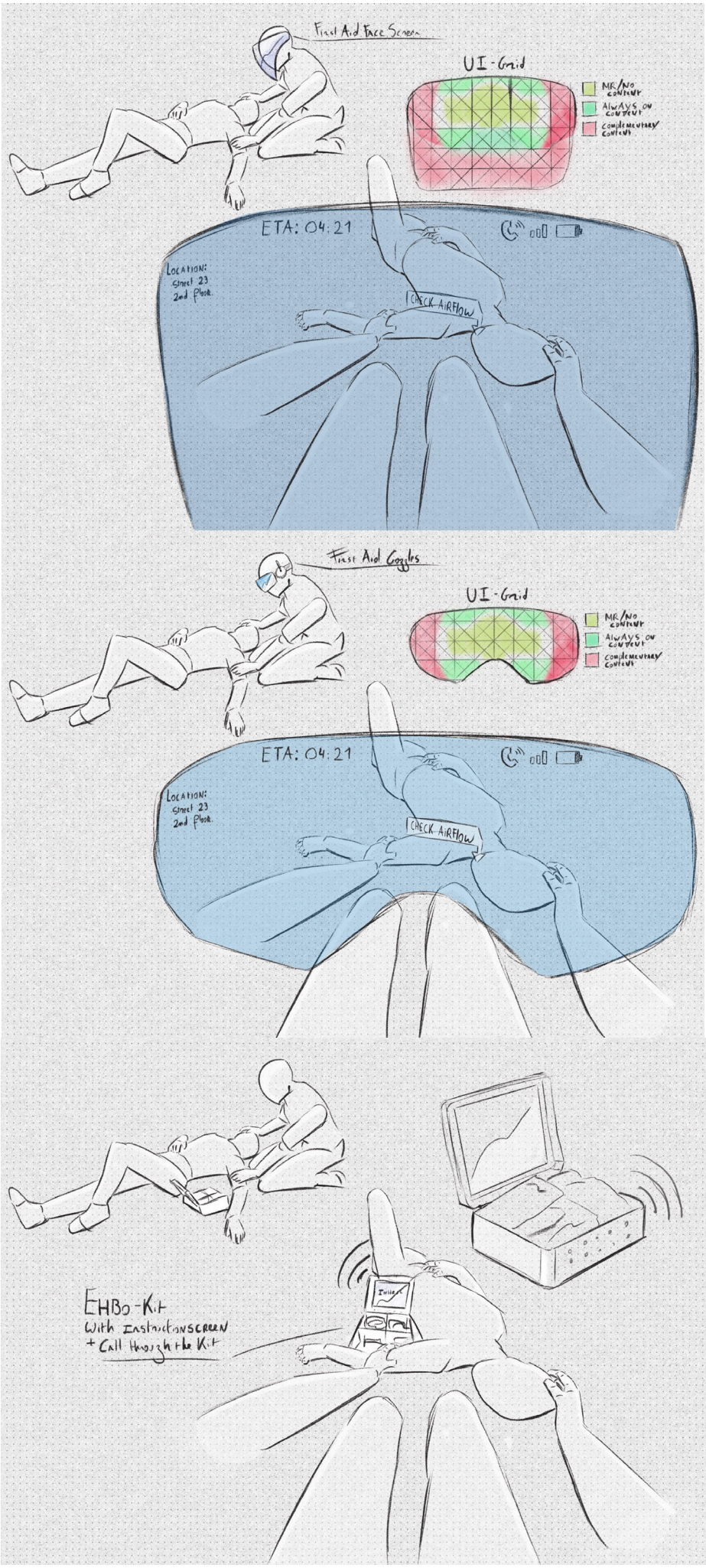


Fig. 49: Medical emergency – concept 1 – 3

Fire emergency concepts:

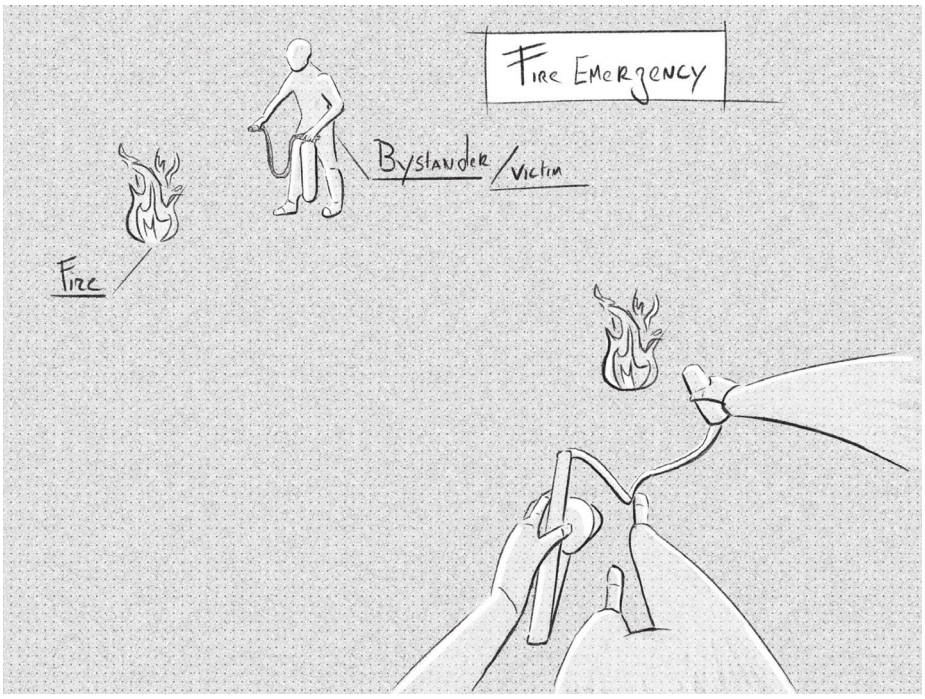


Fig. 50: Fire emergency – situation sketch

Situation sketch:
A citizen reacts to a fire alarm or witnesses one. He/she makes use of the available fire extinguisher and tries to stop its spreading. The start of a fire can go uncontrollably fast, causing the citizen to react first before reaching out to the fire department or calling 112 and letting the fire spread before taking action.

Current situation:
Calling 112 or citizen handles by itself. Instructions are given over the phone, however, things can go wrong quickly when judging the auditory information only
(see page 50-51.)

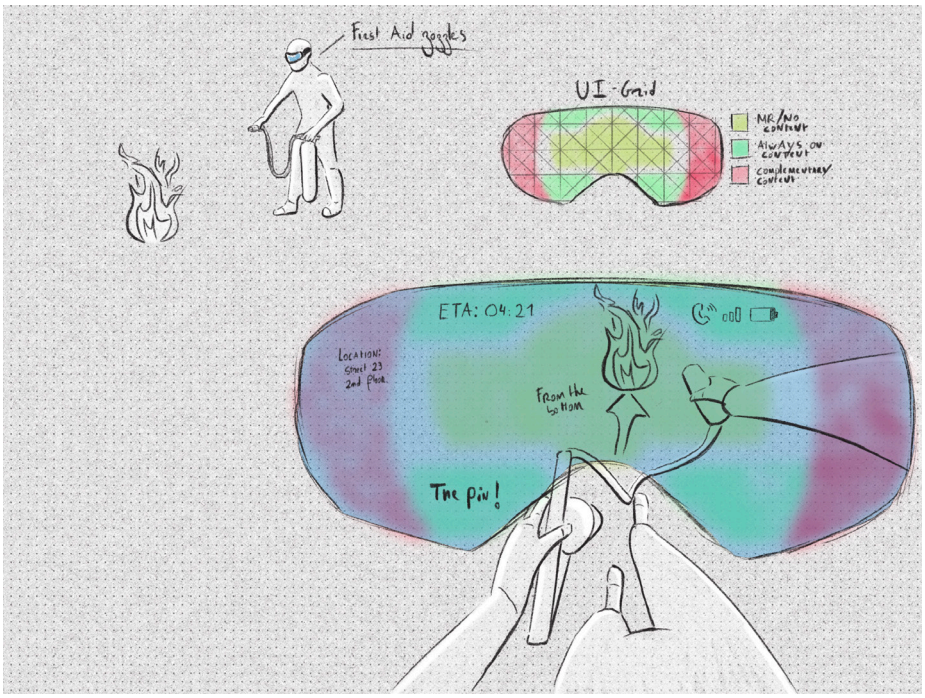


Fig. 51: Fire emergency – concept 1

Concept 2 and 3:
Similar in ideas, only different mapping areas, goggles versus a face screen. The concept exists out of a headset that enables direct auditory information with visual overlay elements. The dispatcher will have access to the camera feed of the user to have more information available when guiding the caller and dispatching resources.

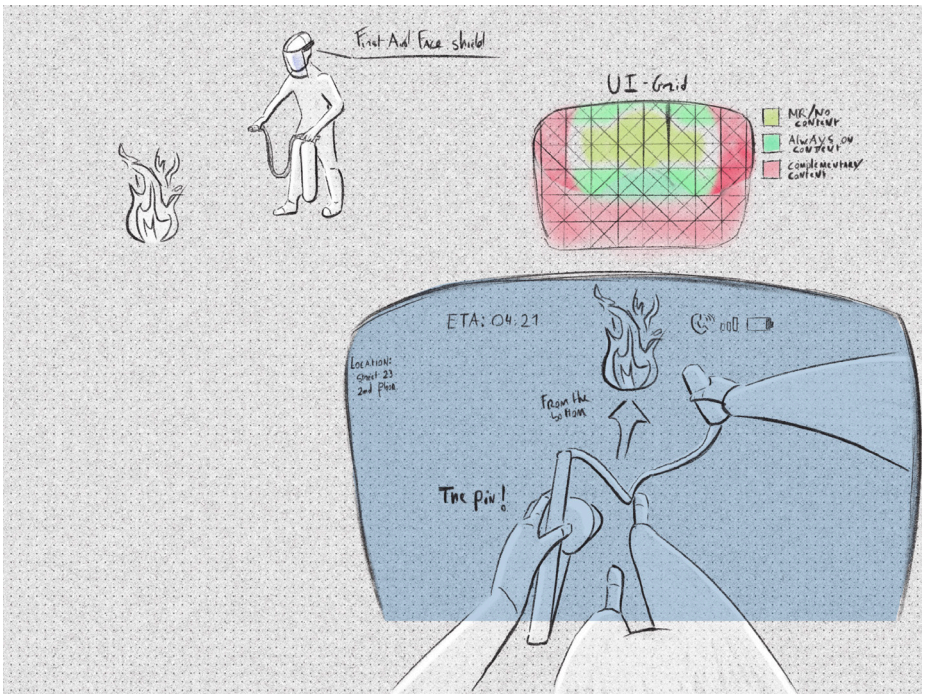


Fig. 52: Fire emergency – concept 2

Concept 4:
This concept combines a Head-Up Display (HUD) on top of a regular fire extinguisher. It allows mixed reality instructions to be mapped out while fighting a fire. On top of extra information, it partly protects the user from heat radiation.

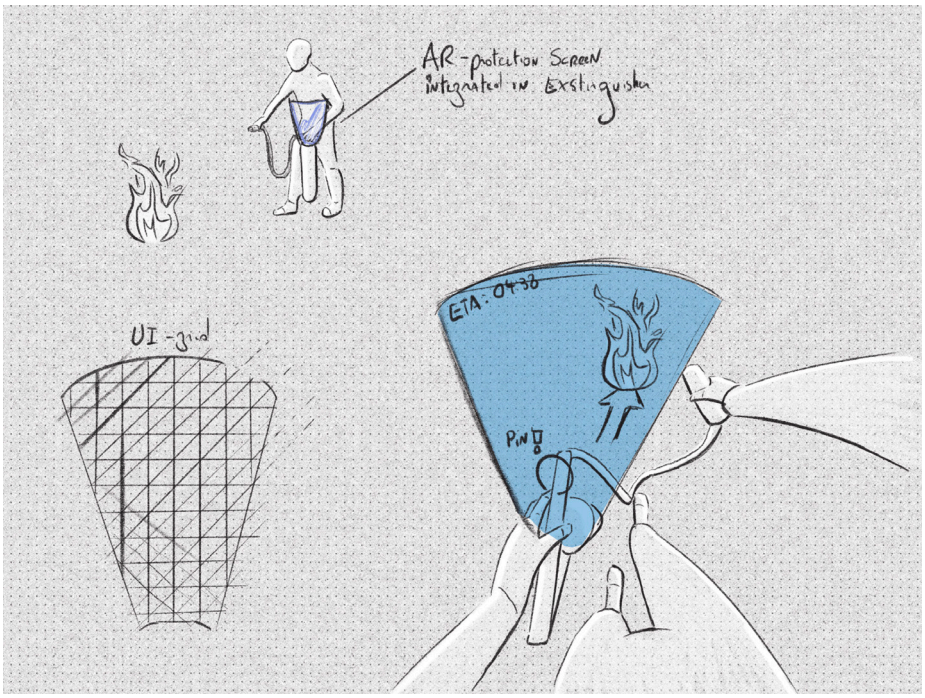


Fig. 53: Fire emergency – concept 3


Short
only camera feed
or Goggles!

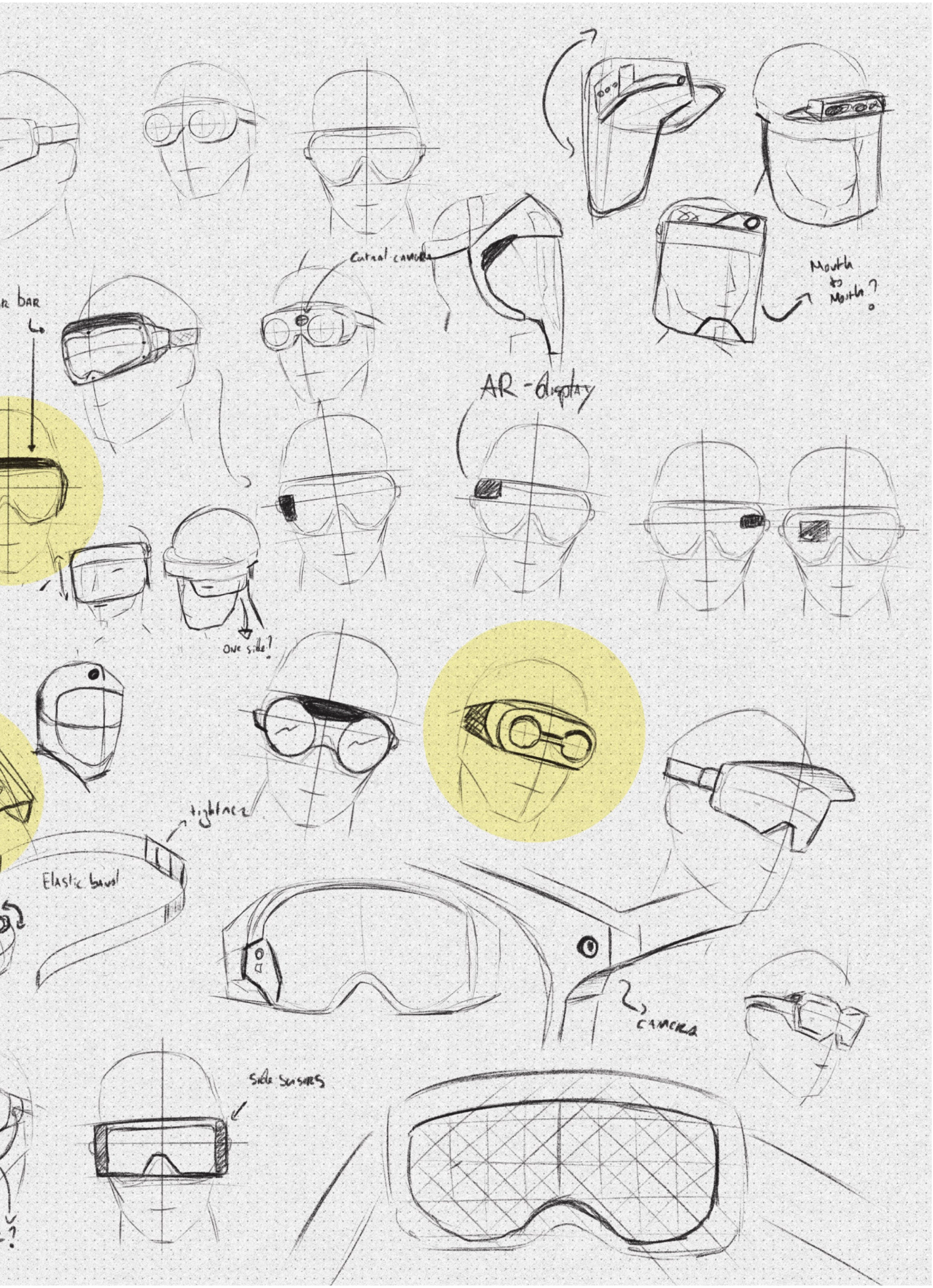
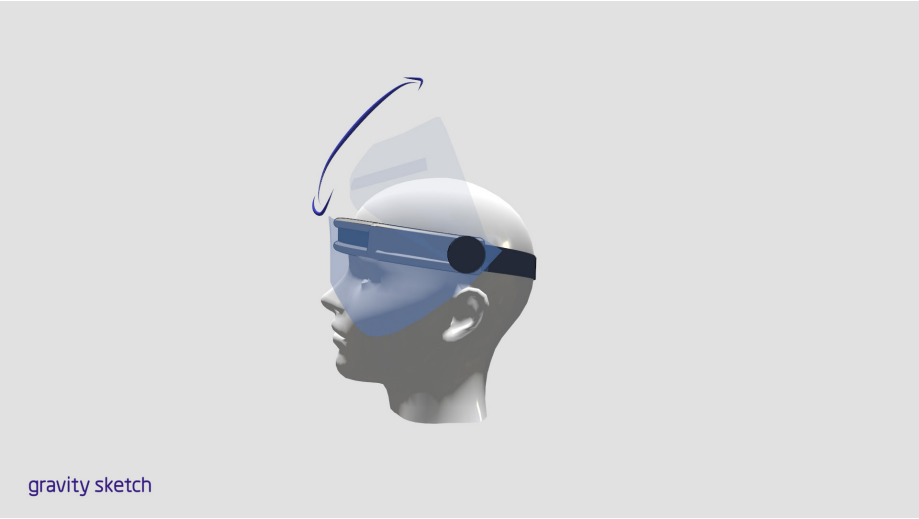
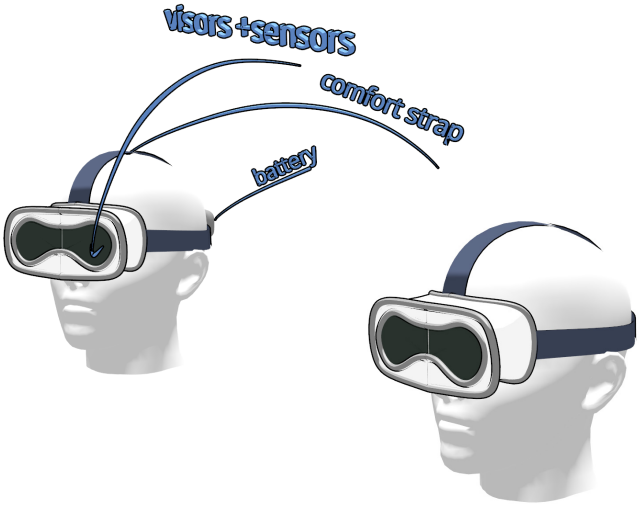


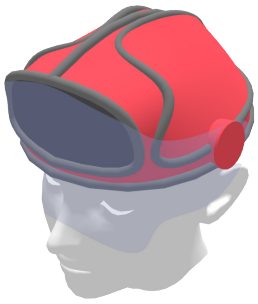
Fig. 54: Form exploration sketches

 Fig. 55: Quick Mock-up models



gravity sketch





gravity sketch

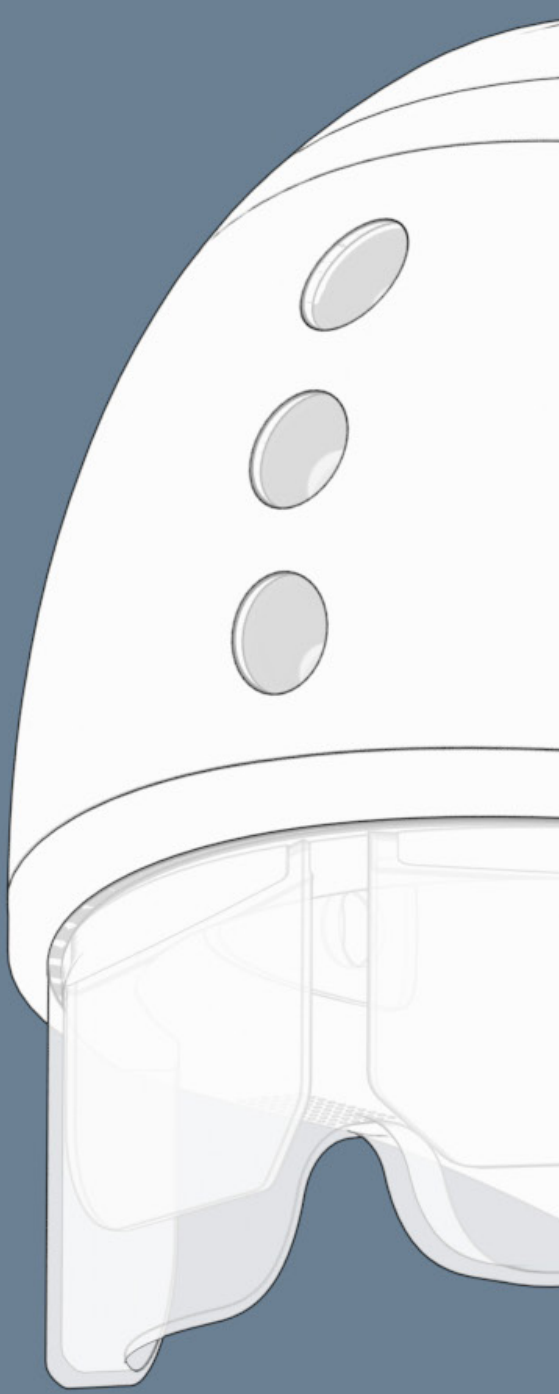
Fig. 56: Gravity sketch form search

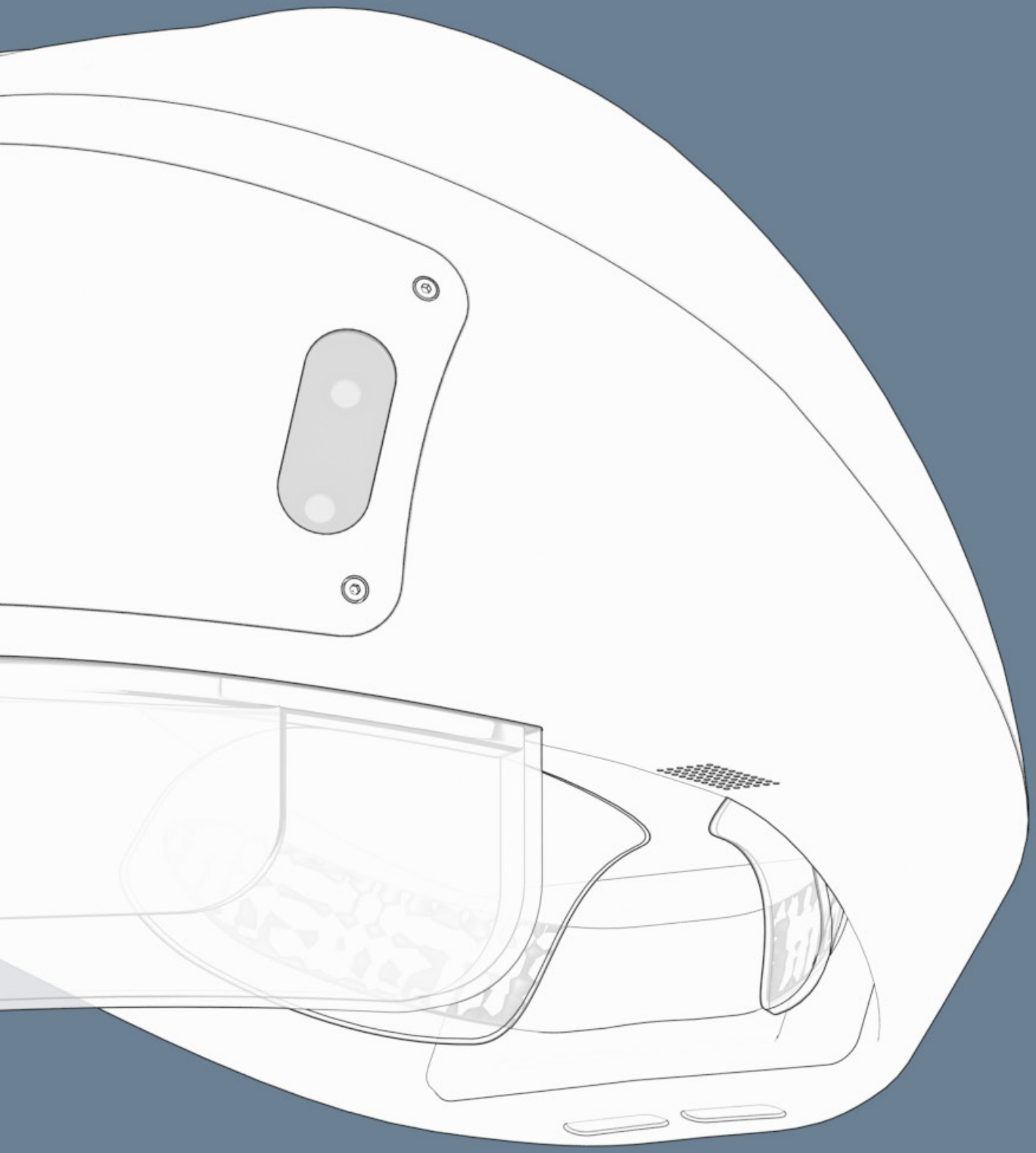
After some more quick test in virtual reality and discussions, a head-mounted display was the concept to develop further. One of the main requirements from the research was that it is easy to use and inclusive for everyone. In order to test these requirements, some quick mockups and existing devices were tested.

A helmet came out of the test the strongest:

- It allows the possibility for different sensors and the movement of the technical components.
- The weight distribution is a large factor with headsets, a helmet allows distribution all around the head.
- Almost everyone is familiar with a helmet it is not as advanced for example the Oculus quest.
- A helmet also functions as an element of recognition in a crowd.

5 Detailed design



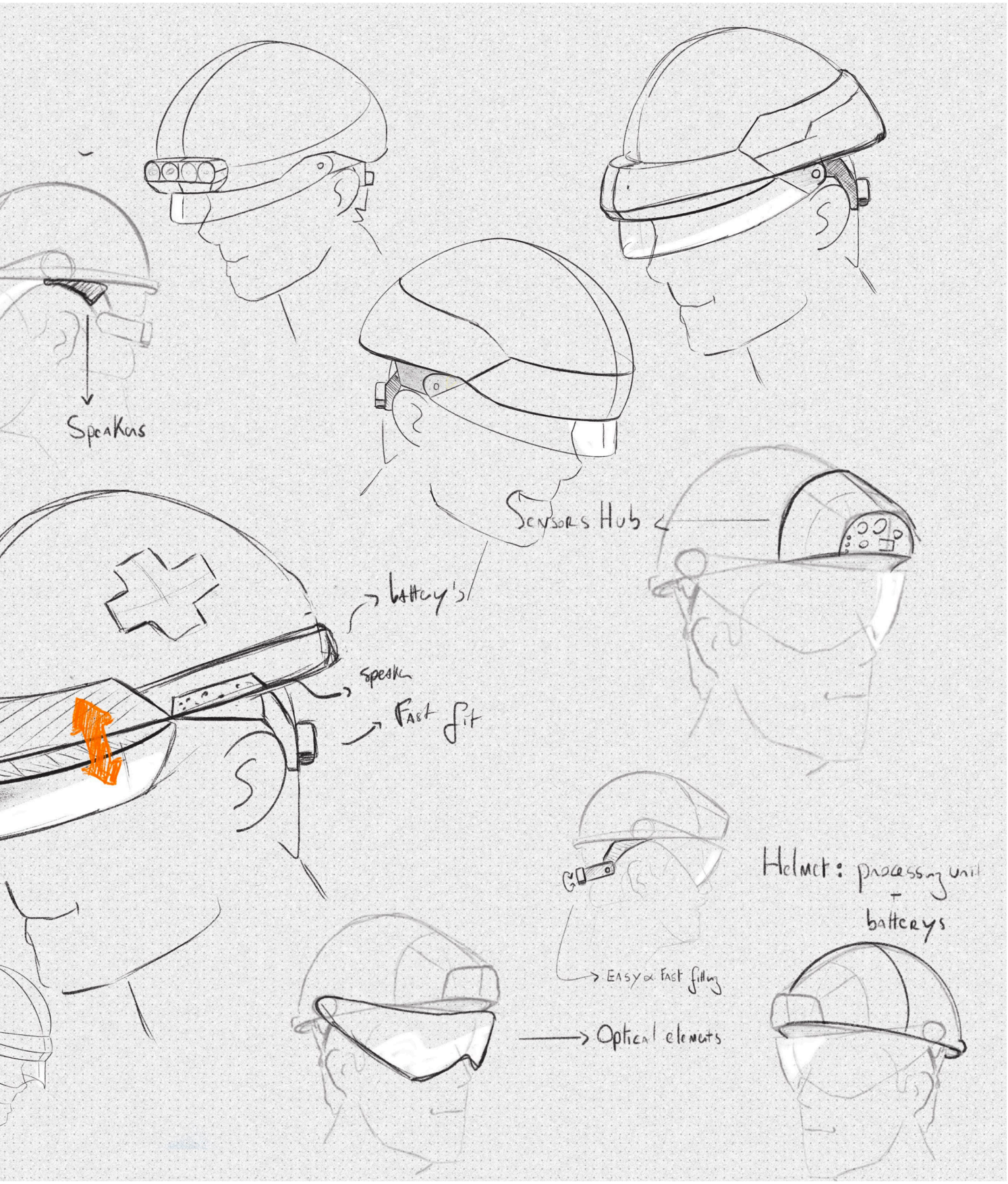


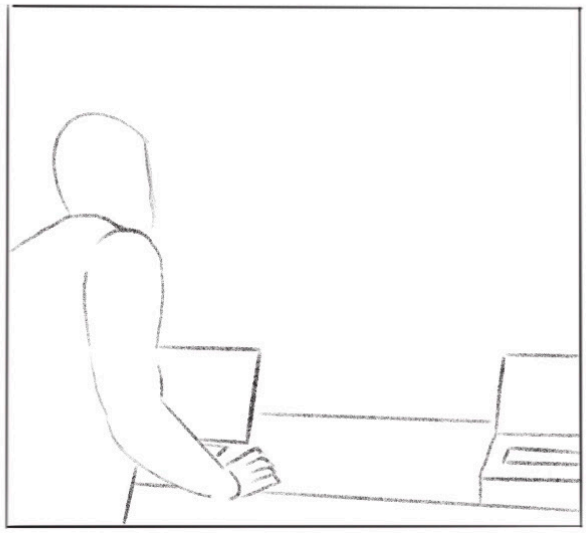
5.1 Process:

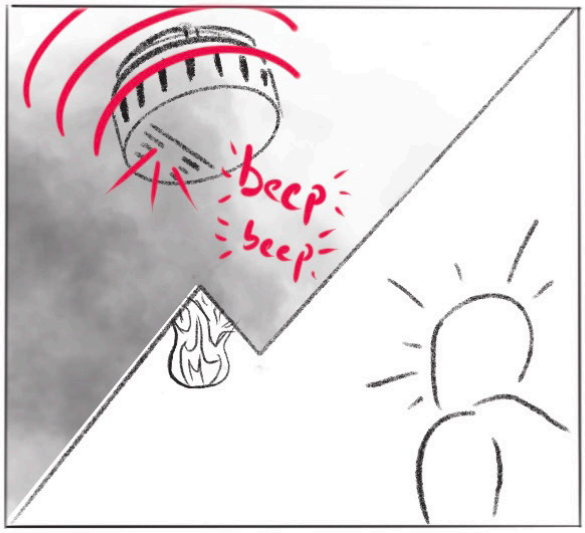
Fig. 57: Helmet detailed form sketches

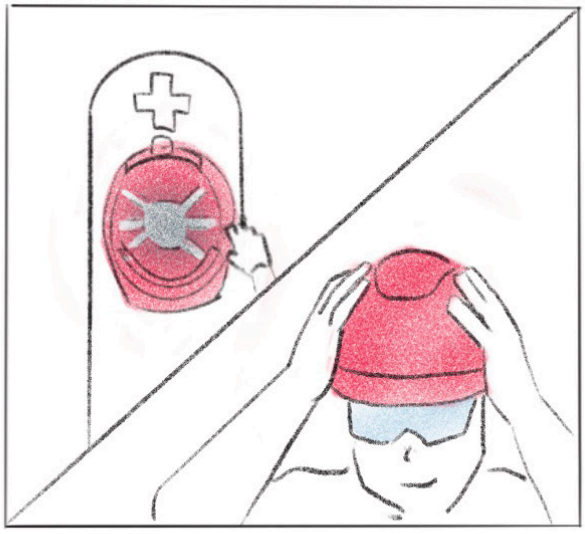
Helmet design:

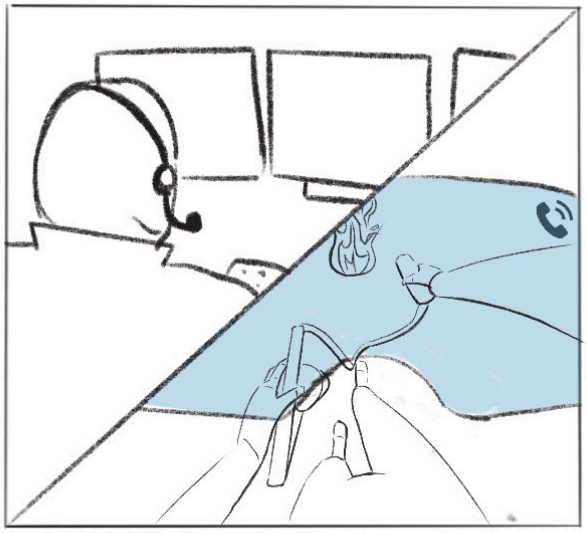
After locking the direction of a helmet as a preferred concept, sketching made it possible to quickly iterate on the design.
The main inspiration was a combination of construction helmets and rescue helmets.

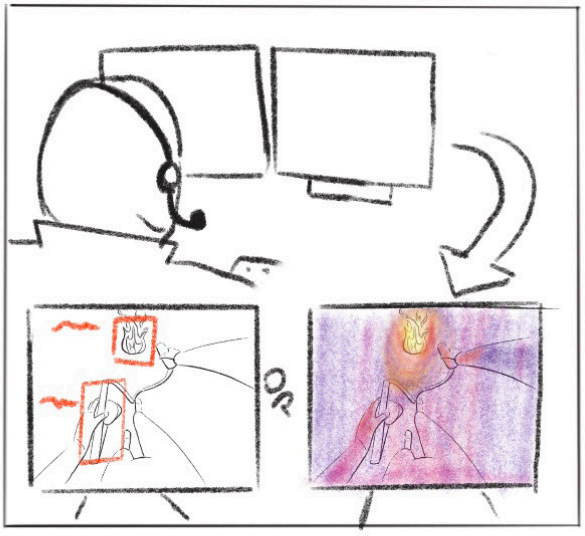

Speakers
Sensors Hub
battery's
speaker
Fast fit
Helmet: processing unit + batterys
Easy & Fast fitting
Optical elements

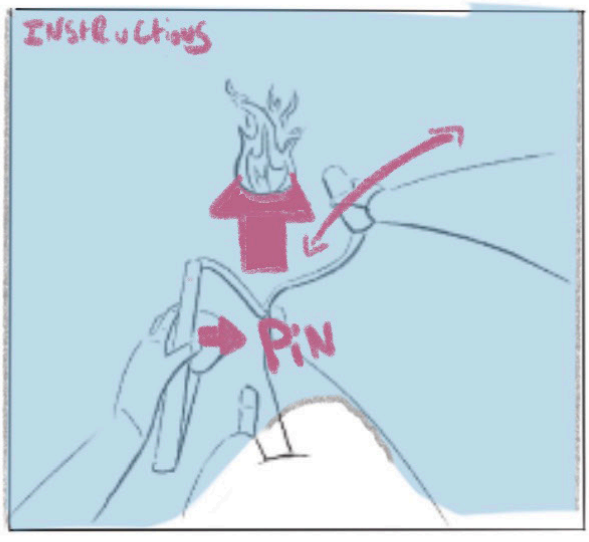



beep
beep






OR


INSTRUCTIONS
PIN

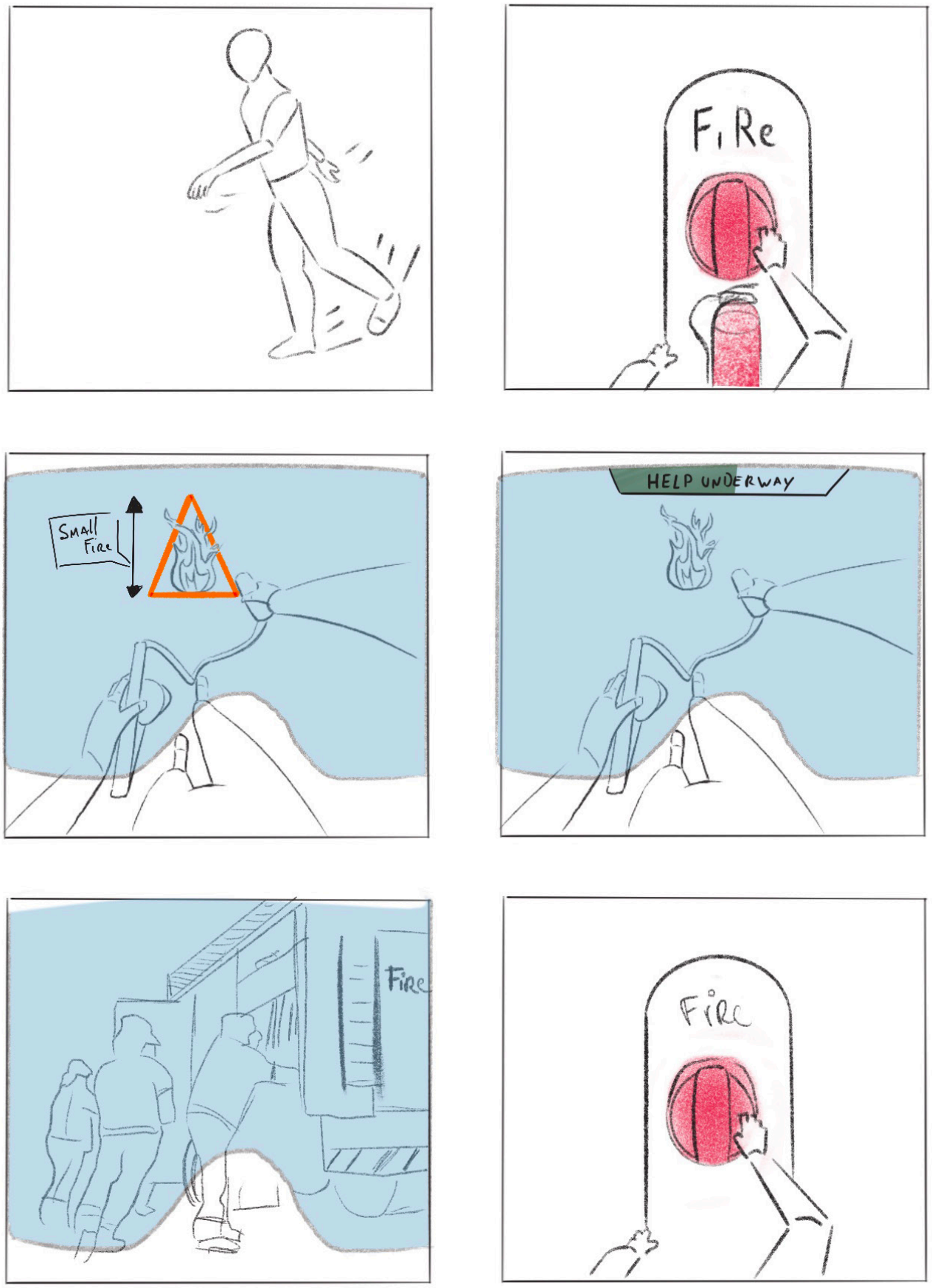
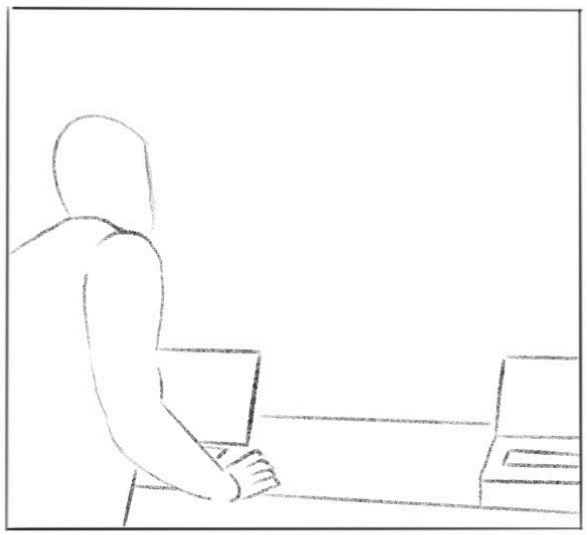
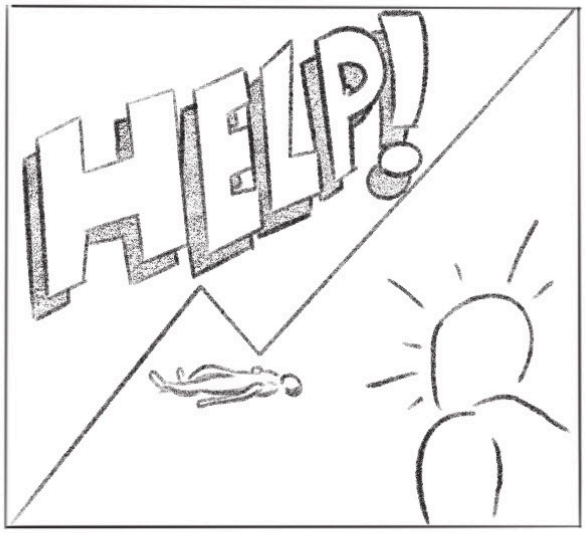
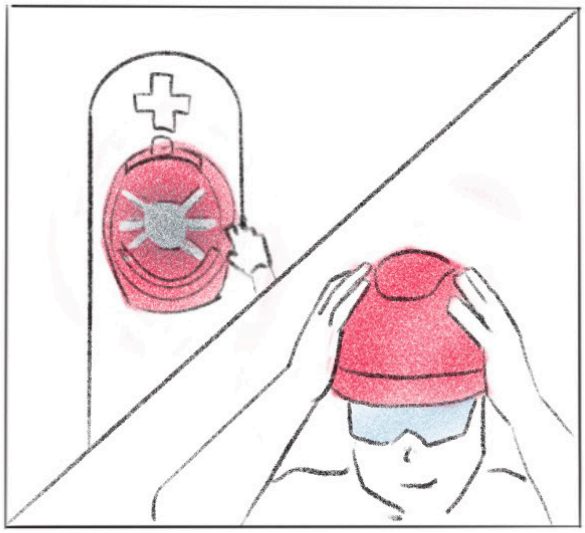
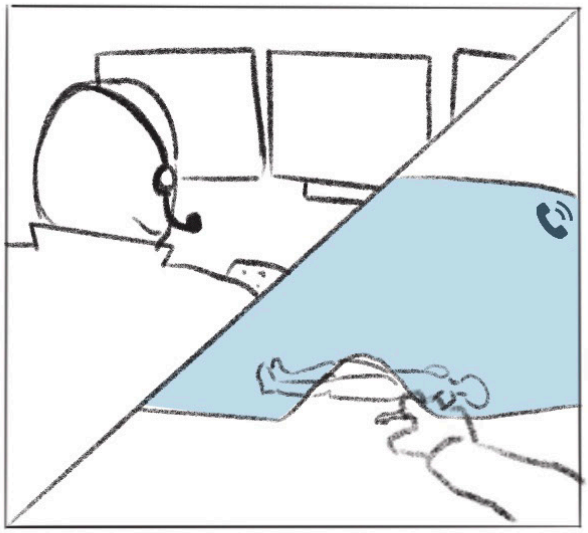


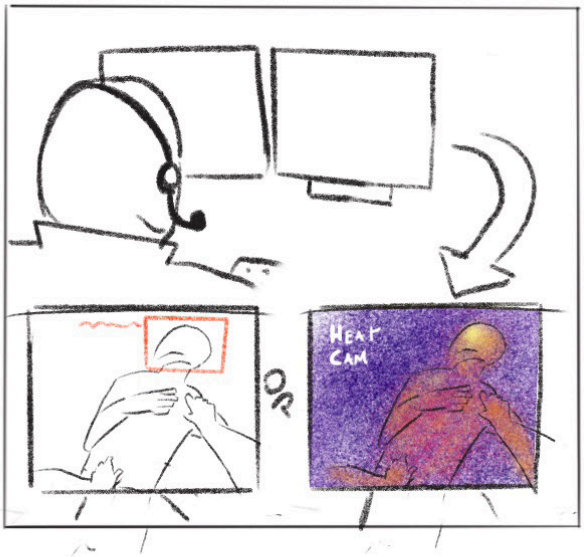
Fig. 86: storyboard




HELP!






Heat
Cam


FIRST AID CPR

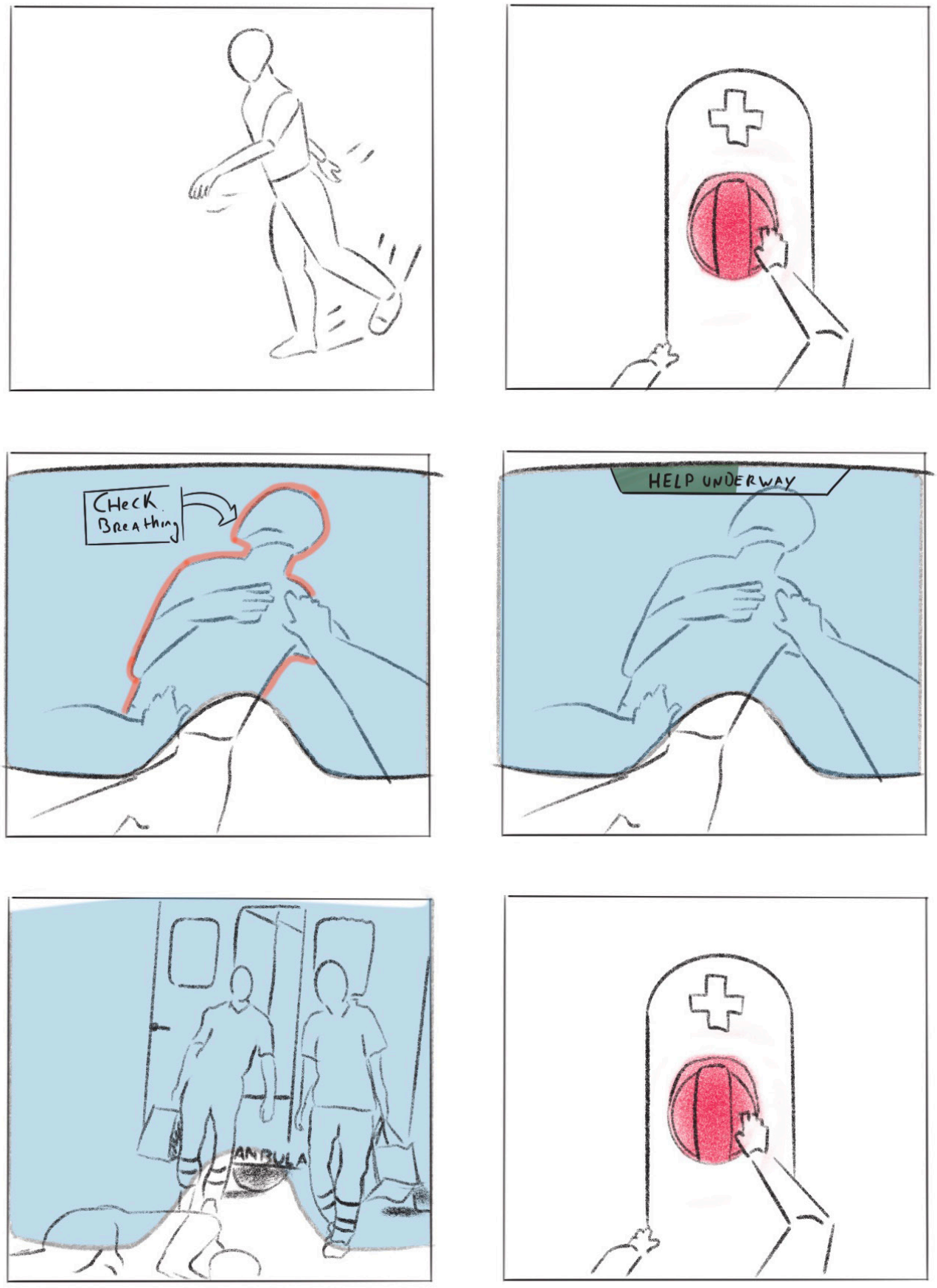
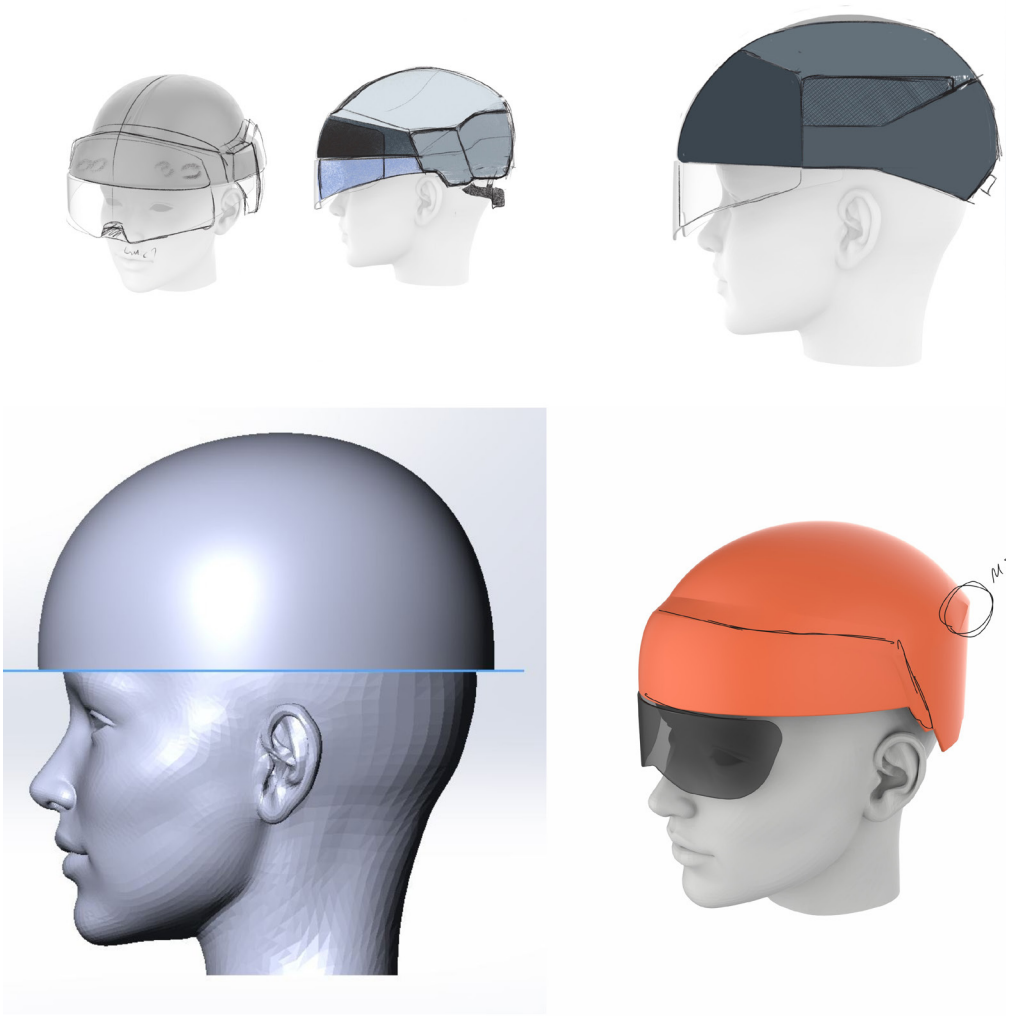


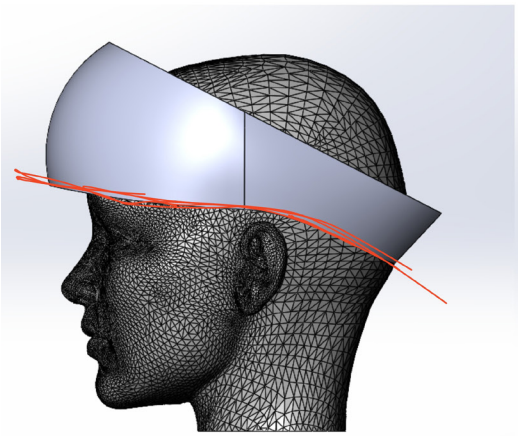
Fig. 86: storyboard

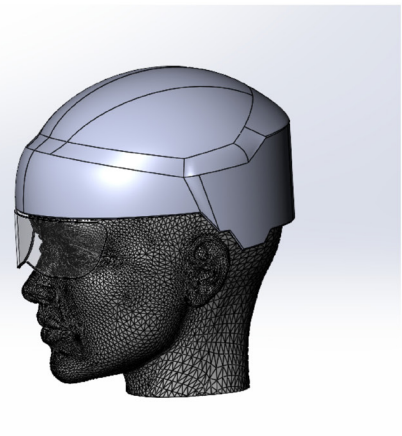
Fig. 58: CAD-forms as part of form exploration

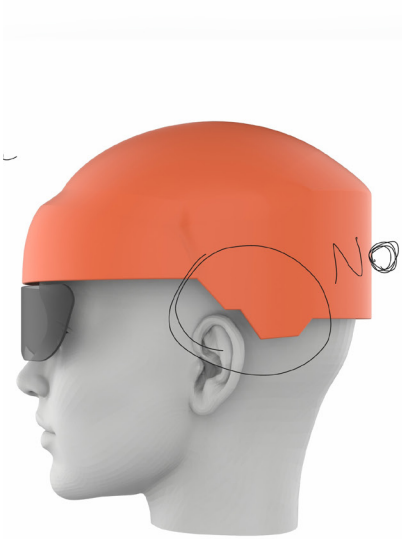


A helmet is a complex product to design, to avoid staying trapped in the two-dimensional design techniques, rough CAD mockups were made with a 3D head as reference for the proportions and dimensions.

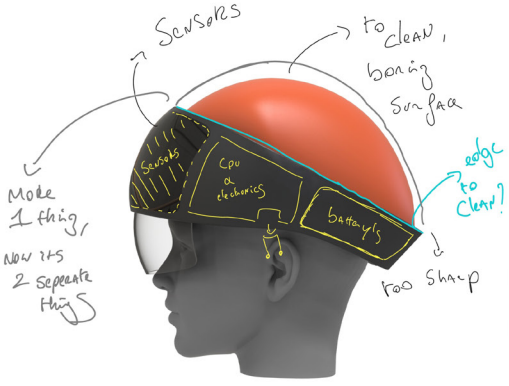
Scribbling over screenshots of 3D models allows efficient iterations and improvements during the design process.






No

too Medical!


Sensors
to clean, boring surface
Make 1 thing,
Now its 2 seperate things
Sensors
CPU & electronics
battery's
edge to clean!
too Sharp

UI and UX:

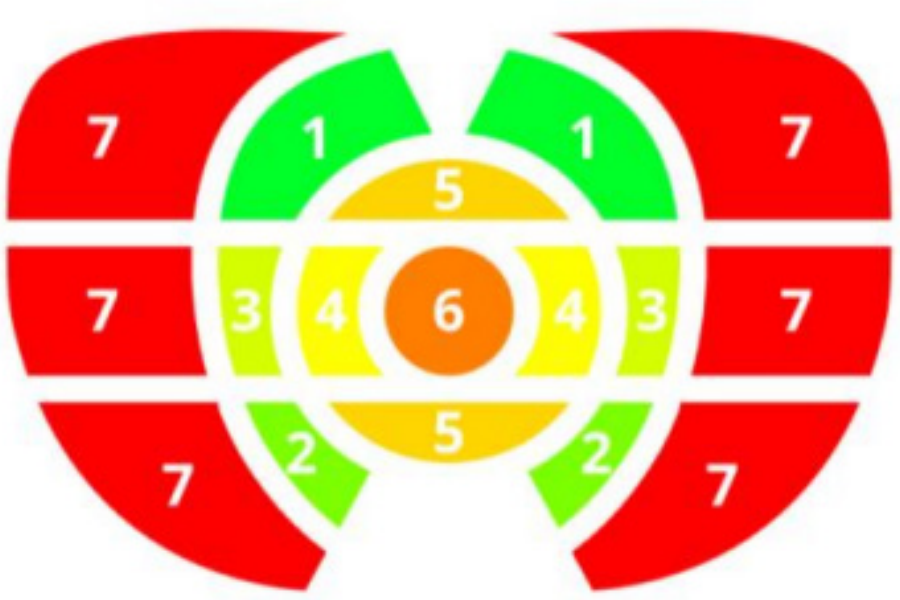
The UI/UX of this concept consists of two main parts. The **head-up display** displays content that is always visible and the **mixed reality elements** that react with the environment according to the situation.

What content is visible and when? The content on the HUD is similar to the notification bar on current smartphones. The time, battery and connection are displayed. On top of this information, the ETA of the responders is shown through a suggestive loading bar. The HUD also displays an animation when the user speaks.

The ETA reassures the user that help is on the way, so they don't continuously repeat this question. The sound animation visually shows that the caller is being listened to and serves to calm down.

Not all areas on glasses or screens are equally suited to displaying information. Below is an overview of the zones on a screen and how suitable they are.

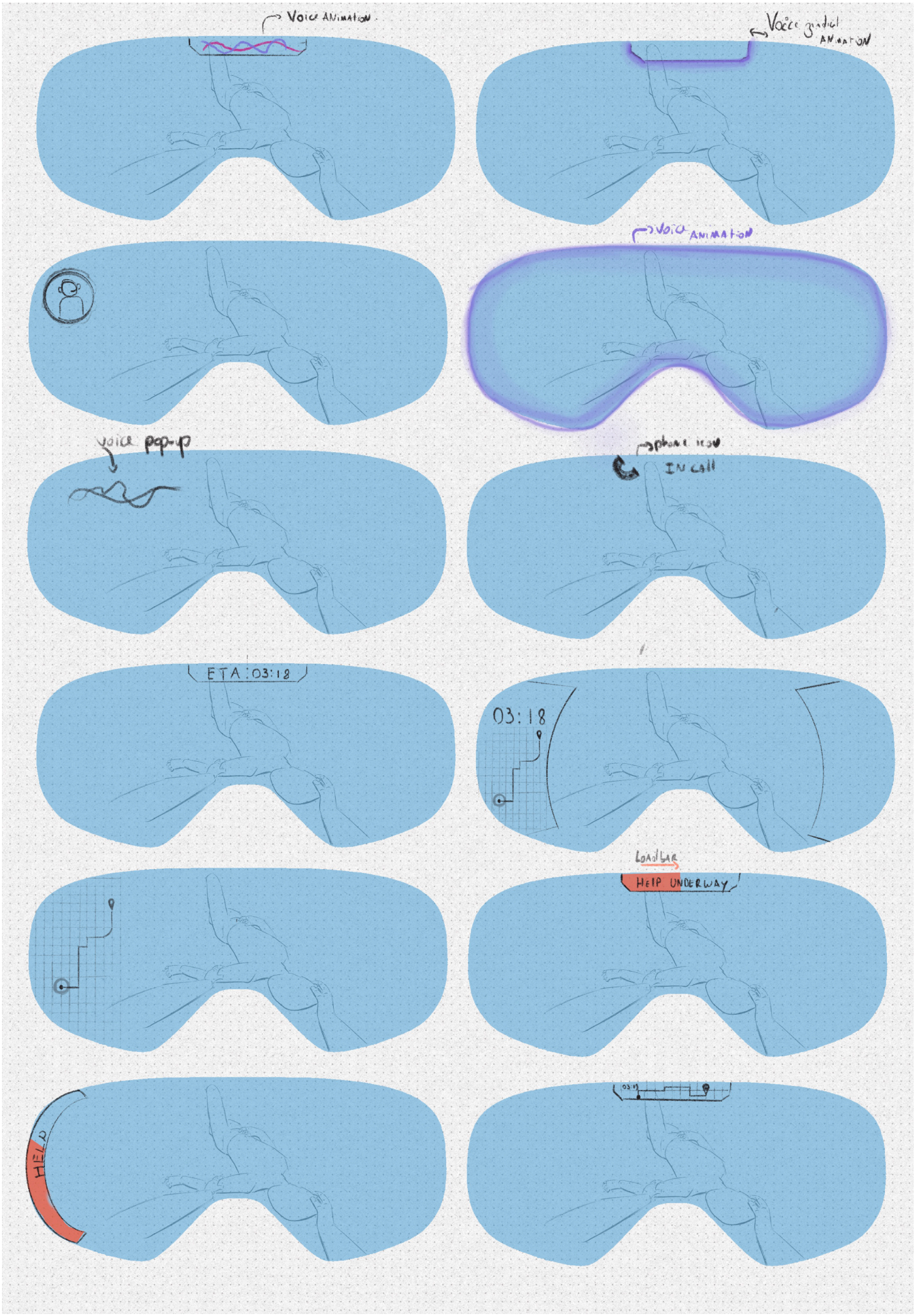
On the following pages, you will find the process sketches. From simple line sketches to mixed reality elements photoshopped together in emergency scenes.



1. This area is the least insistent area and most accessible. This is a great place for content that should be always visible.
2. The second less insistent area is a fine place for frequently visible content.
3. Zone number three is the third least insistent area. Occasionally content should be placed here.
4. Moving closer to the centre, the areas start to be more insistent. This area should be used for important information only.
5. Insistent zone, perfect area for the mixed reality elements.
6. This is the most insistent area of the goggles. Like zone 5, most suitable for mixed reality.
7. Zone 7 is behind the inner-frame area. The information here will be very inaccessible. This area could be used for complementary information.

Fig. 59: Insistent areas for MR

Fig. 60: HUD – exploration sketches



Later in the process, the percentage number was removed. So the that the user doent get fixated on the numbers.

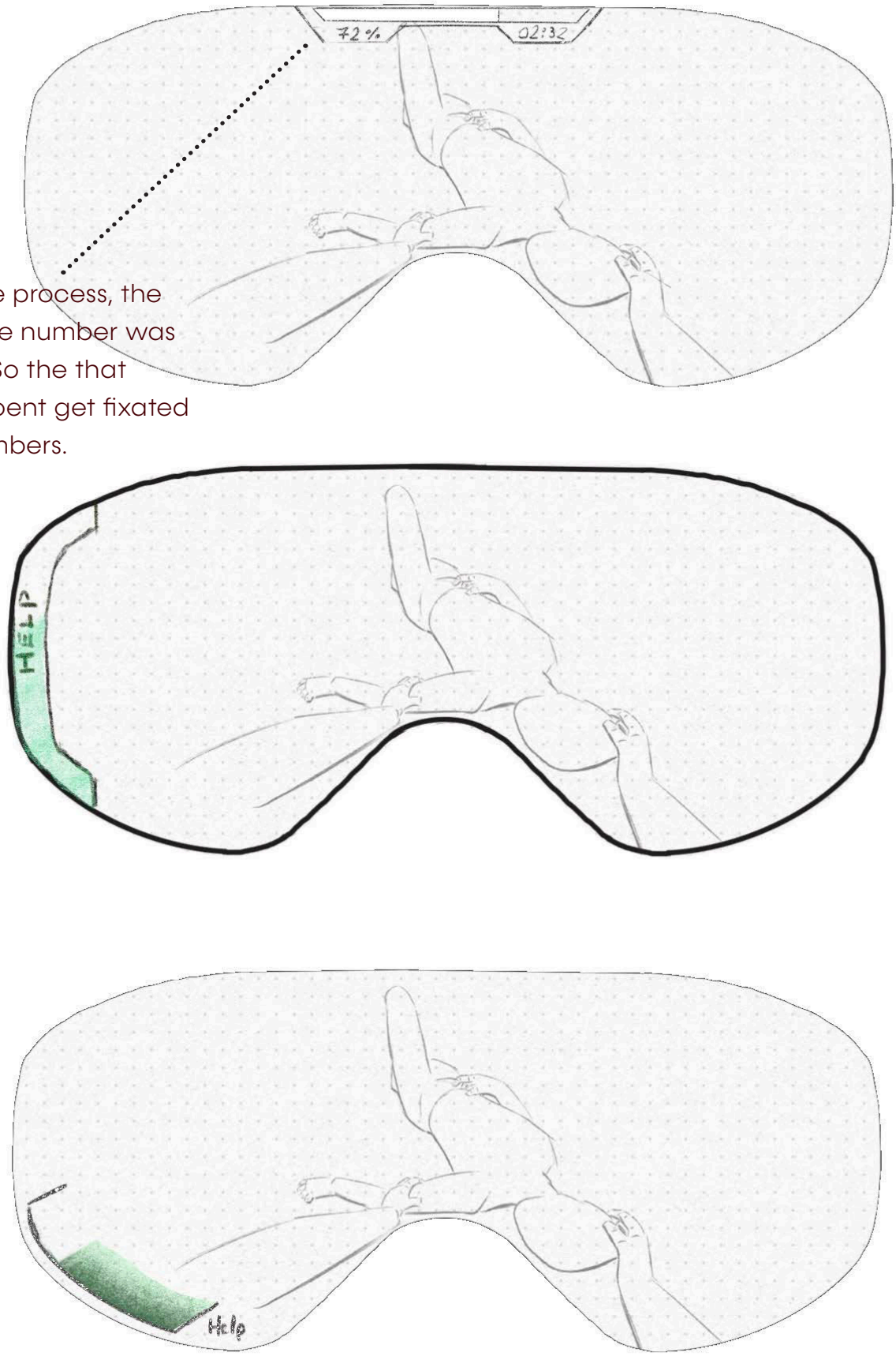
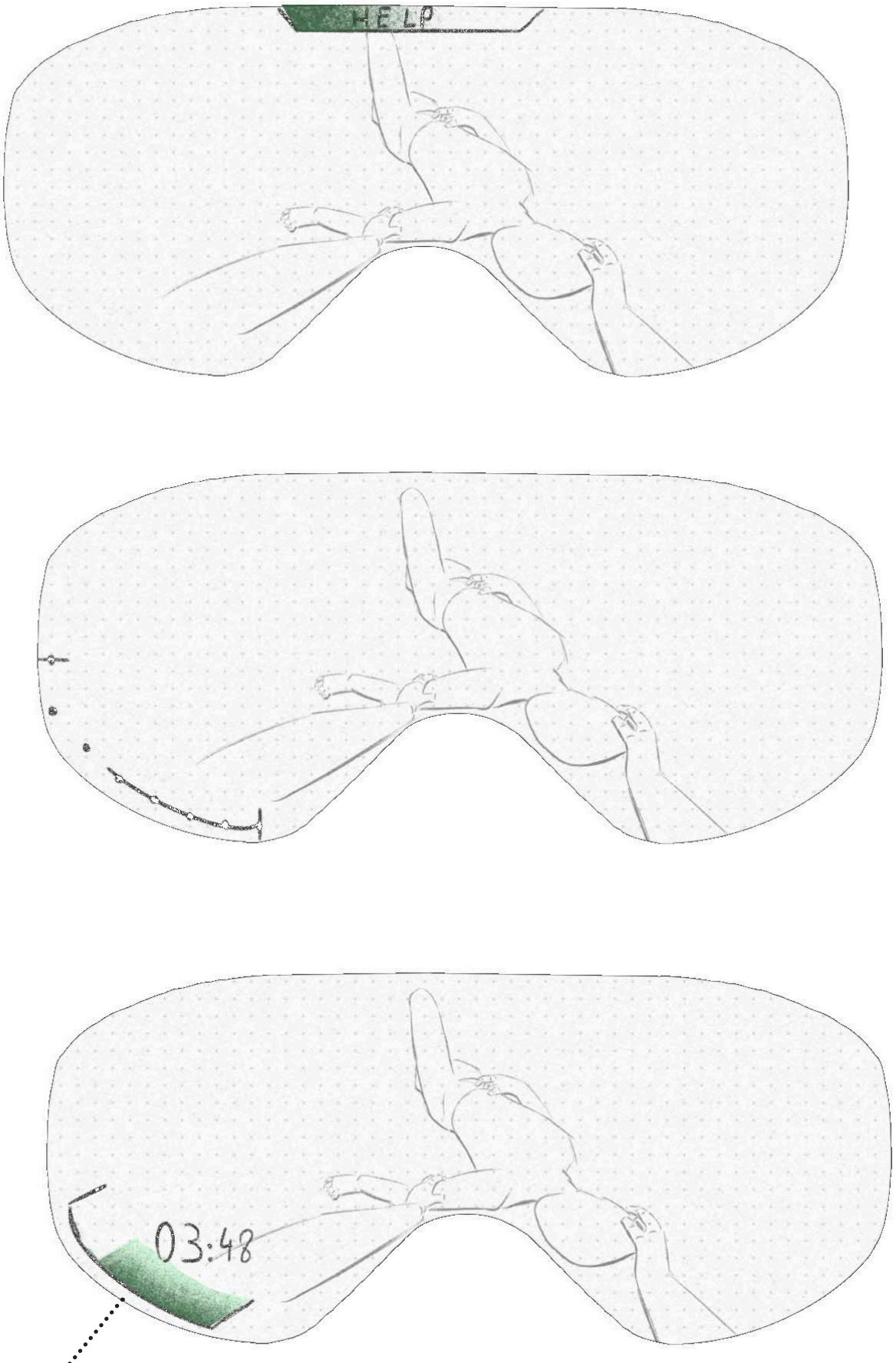


Fig. 61: HUD – exploration sketches 2



The positioning of the ETA on the side was considered, because it's complementary information. However, as it was the most recurring question, it was moved to the top again.

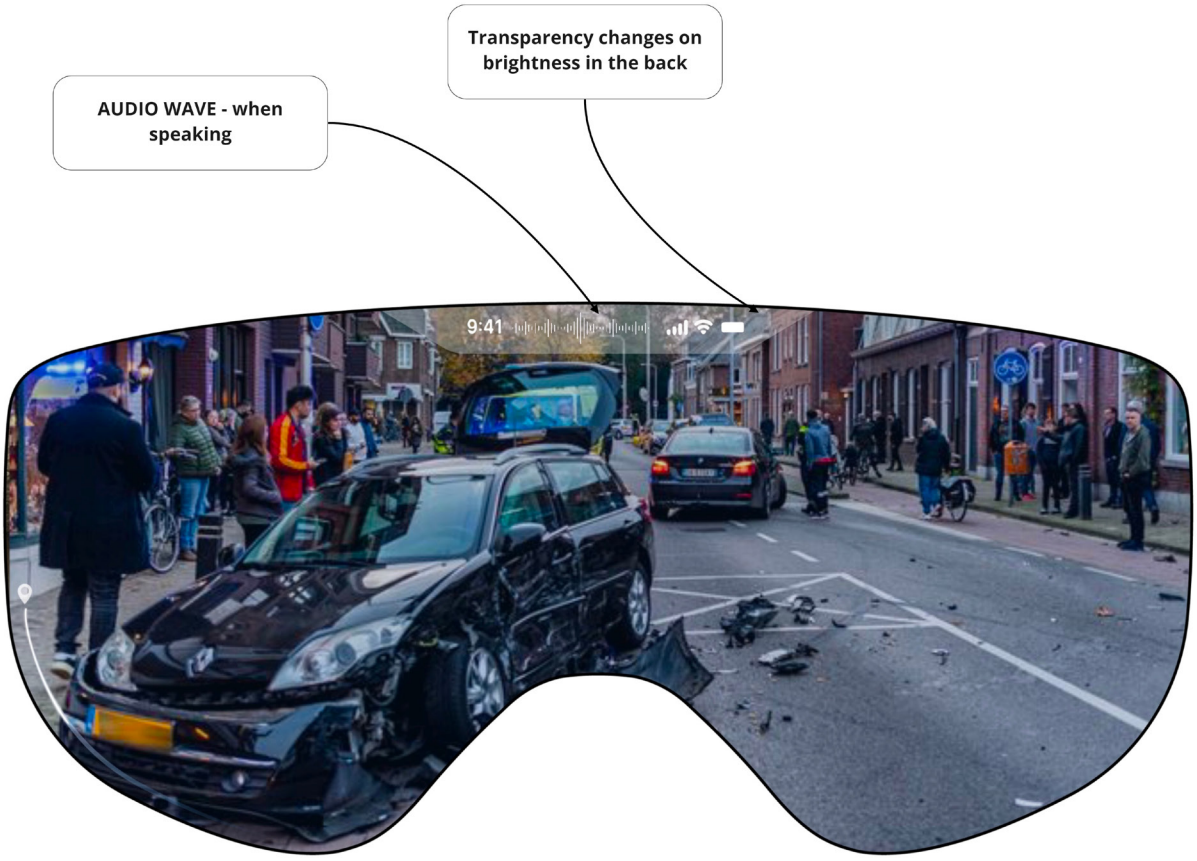

Firefighters arrival

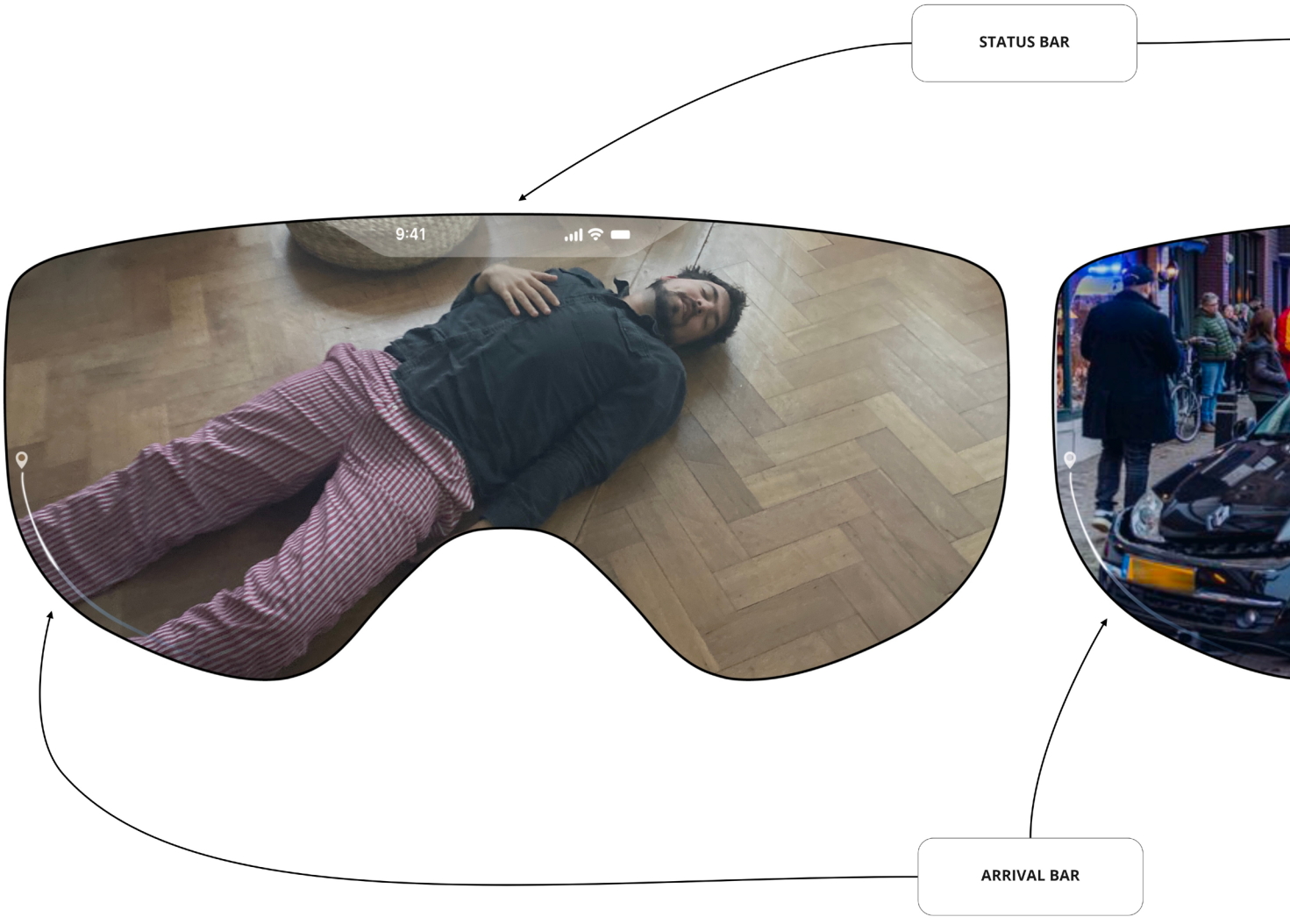

Paramedics arrival


12:32
74°


12:32
74°

Fig. 62: HUD -exploration sketches 3


Transparency changes on brightness in the back
AUDIO WAVE - when speaking
9:41


STATUS BAR
9:41
ARRIVAL BAR

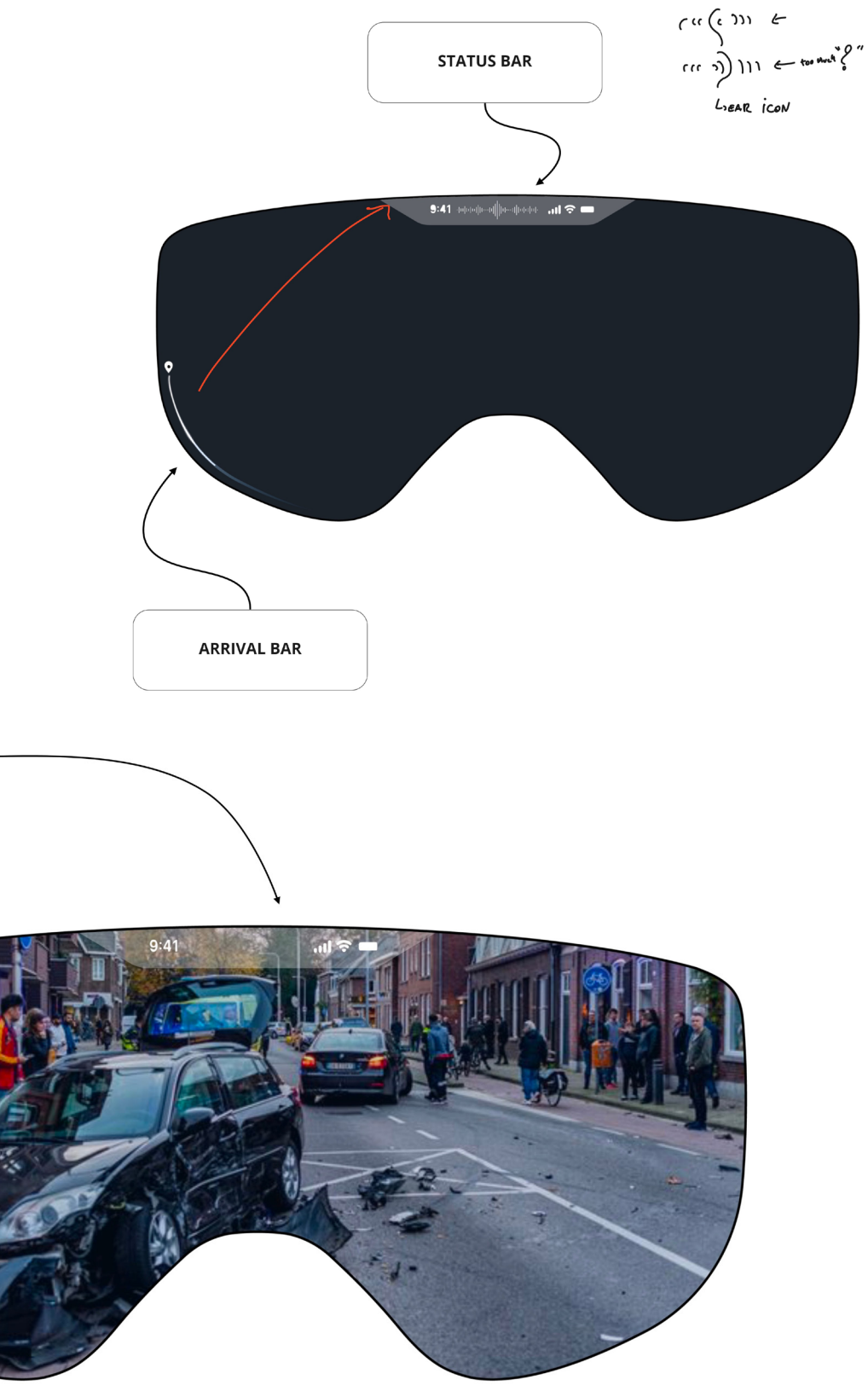


Fig. 63: HUD – exploration sketches 4:

Elements in mixed reality:

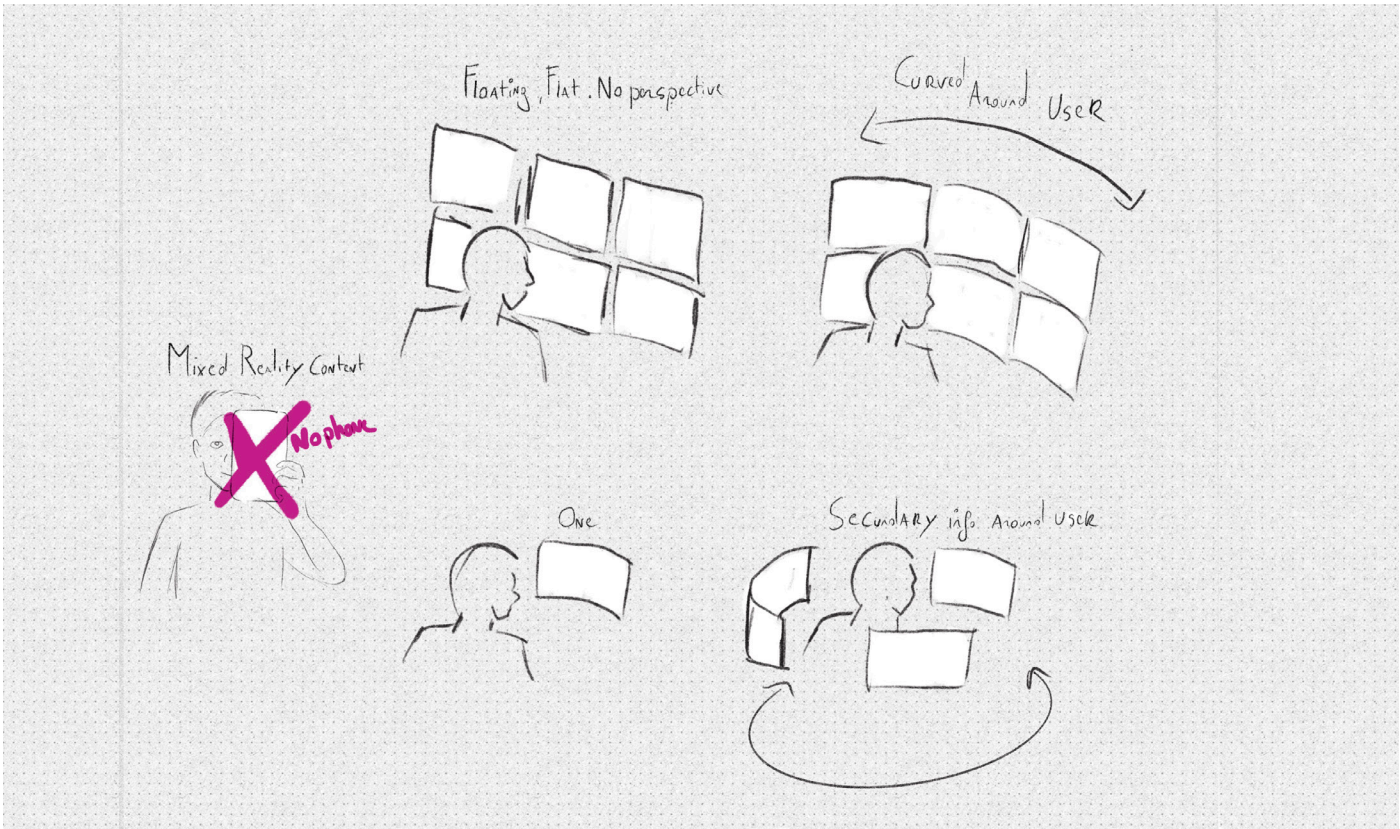
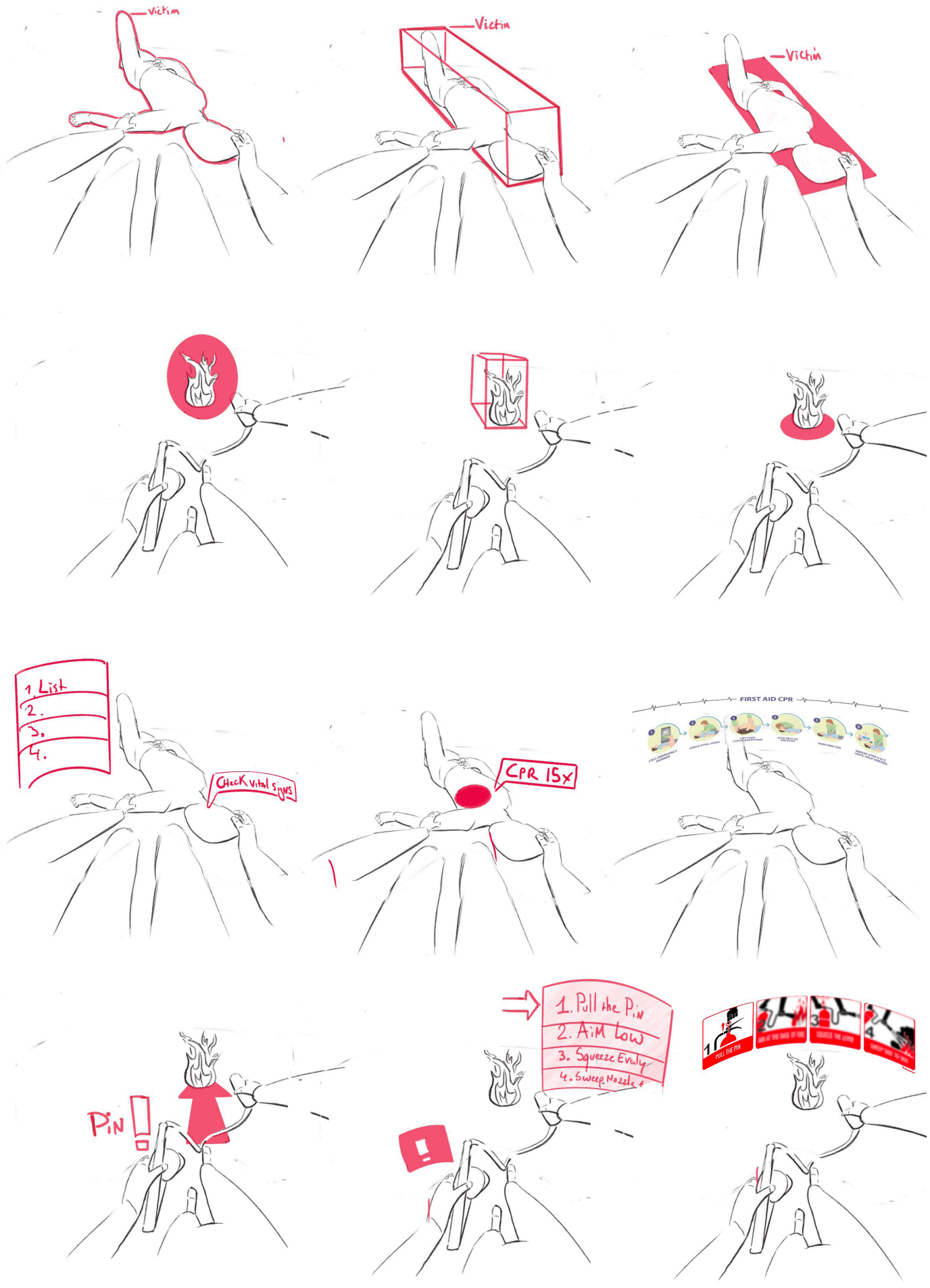


Fig. 64: Mixed Reality UI/UX

The task of designing the MR elements was more challenging. Current mixed reality solutions are often a two-dimensional design placed in a 3D environment. Usually, they arrange the elements floating in space or around the user.

When you re-create these situations in virtual reality, you notice that these solutions are not yet the ideal ones. VR experiments, combined as an underlay for sketches, were used to come up with new solutions.

The hard part was figuring out how the virtual elements should interact with the physical ones. It's more than just placing a virtual object in a physical environment.



FFig. 65: MR interactions exploration

Fig. 66: MR instructions 1

With these mockups, I thought I was on the right track. But these did not make full use of the possibilities in mixed reality. Here the instructions were mapped two-dimensionally over the user's feed.

The instructions were not clear enough or lost in the background. The instructions must be free from uncertainty such that no confusion is possible.

Fig. 67: MR instructions 2

Spatial mapping

While using the headset, the sensors will scan the environment. This process is called spatial mapping or 3D construction. It gives the ability to instantly create a 3D map of the environment and recognize elements and understand how to interact with them.

The scanning happens behind the scenes without the user noticing but, the dispatcher can consult this 3D environment. So that he/she too gets a better knowledge of the situation and its dimensions.

Without spatial mapping, it would be impossible to place virtual elements and anchor them in the user's world.

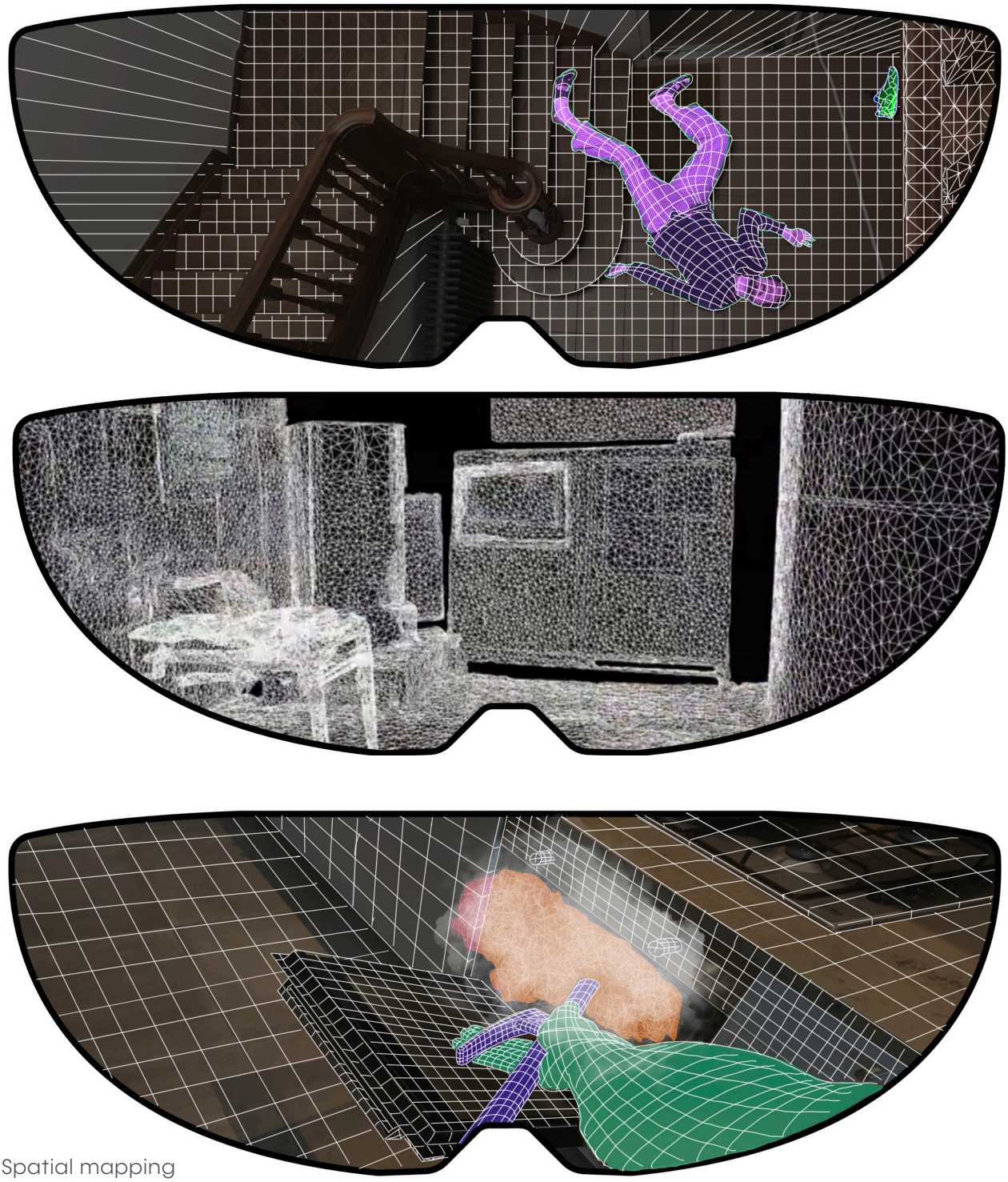
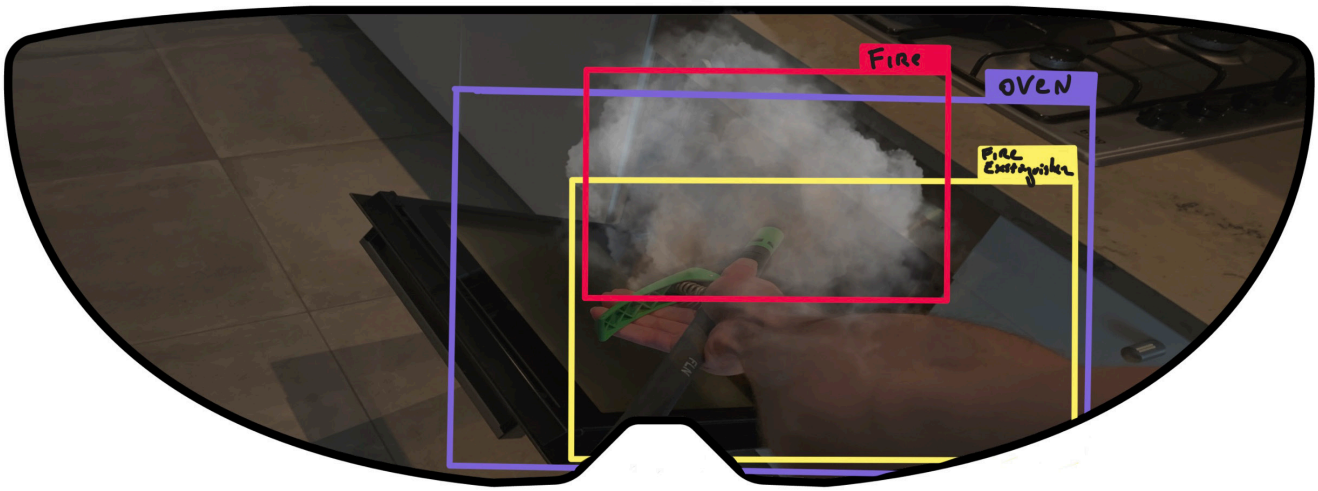
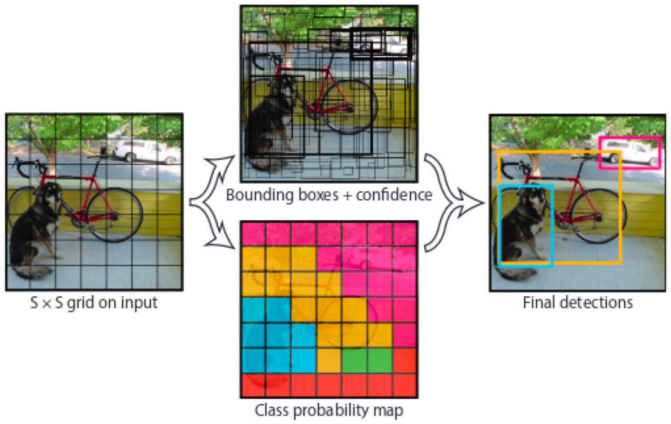


Fig. 68: Spatial mapping

Fig. 69: Object detection





Object detection

Object detection to identify what is all visible in the user's surroundings. It can be achieved with (free) software such as YOLO (You Only Look Once), a ConvNet (Convolution Neural Network).

How it works:
YOLO can support up to 9000 object classes and there are usually thousands of filters and multiple types of layers. First YOLO takes an image and predicts hundreds of bounding boxes around the objects within the picture. The brighter the area, the more the feature is present in that area. Then it uses a ConvNet to analyse each of these bounding boxes. The ConvNet begins with general features such as lines, gradients and colours. Then it combines these features into an emergent feature such as edges and surfaces. The thickness of the lines represents the amplitude of how much they impact the other filters. From this, even more, emergent features can be identified such as shapes and parts. It keeps doing this until it can produce a set of confidence levels for certain object classes. If the confidence percentage of the proposed object class is above a predetermined threshold, like 30%, then the bounding box is recognized as an instance of the object class.

This feature would only be visible for the dispatcher to help analyse the imagery for critical details and dangers such as hazard signs.

Since emergencies are complex situations, the exploration started from the construction of a Lego model. By adding virtual elements such as bounding boxes and hands, it was investigated which 3D details are the most understandable for virtual instructions. The following pages contain mockups of these explorations.

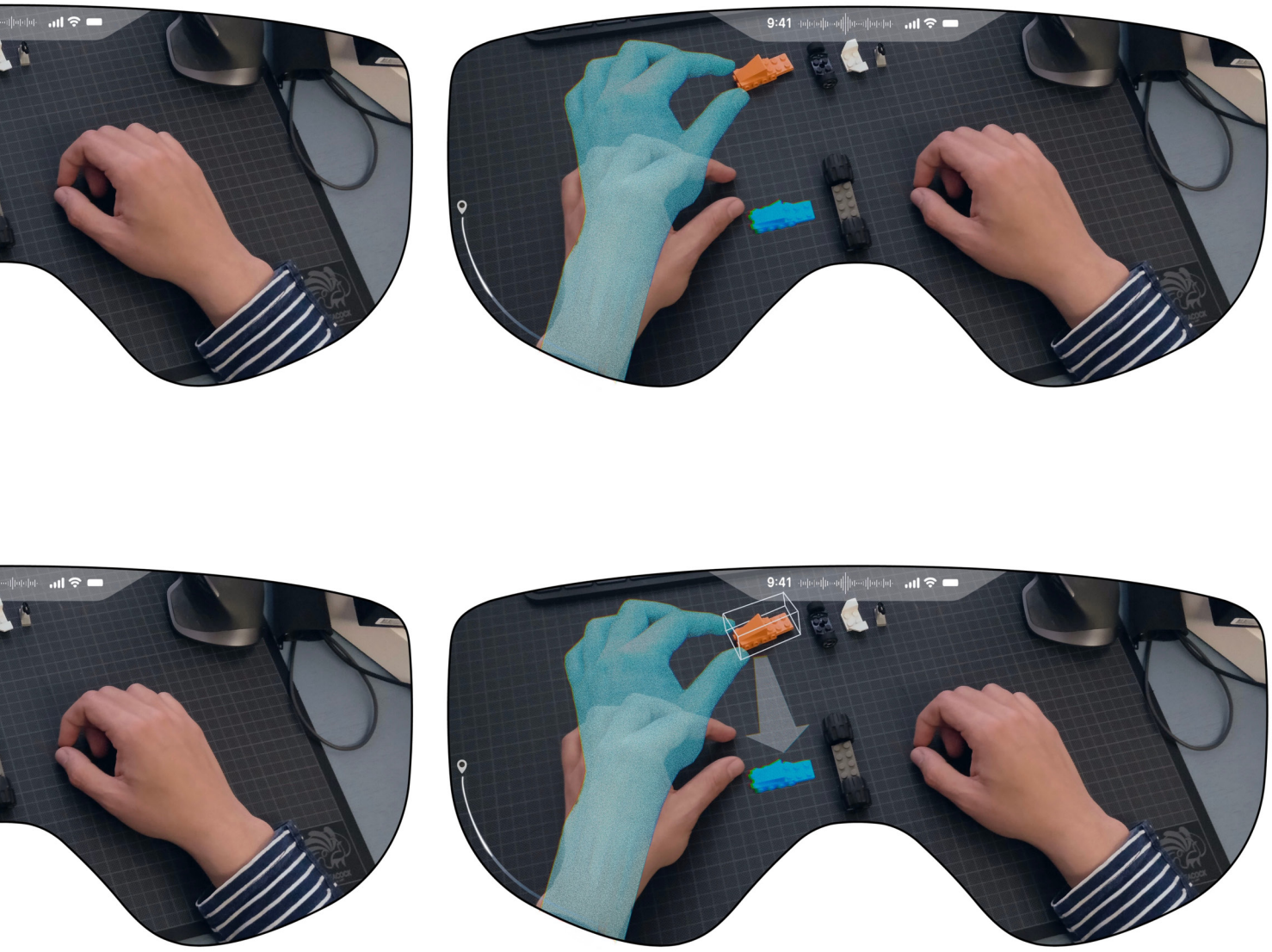


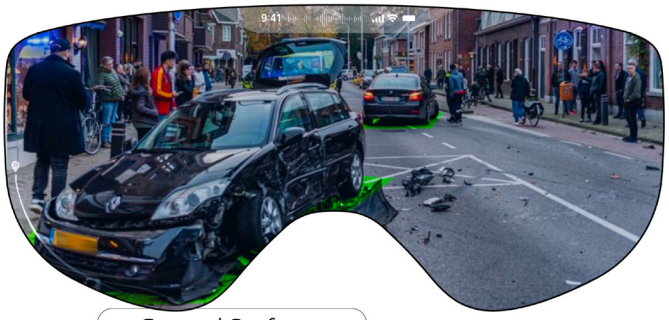
Fig. 70: MR test – instructions

Fig. 71: MR test – highlights 1

NORMAL POV (no MR)

BLUR

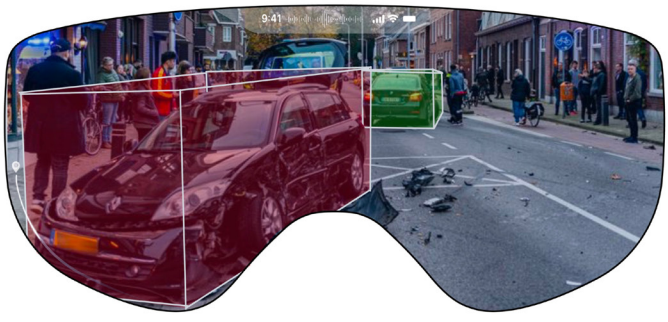
OUTLINE



Ground Surface - rectangle

OVERLAY

Ground Surface - Circle

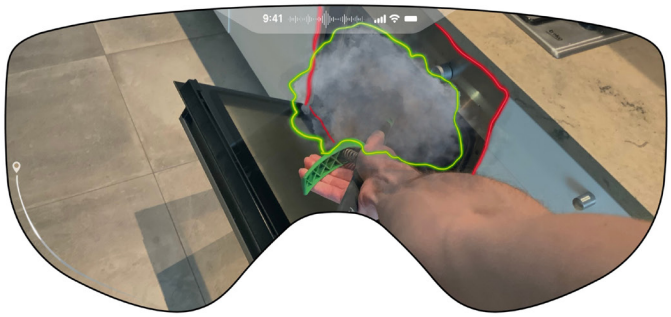


BOUNDING BOX + overlay

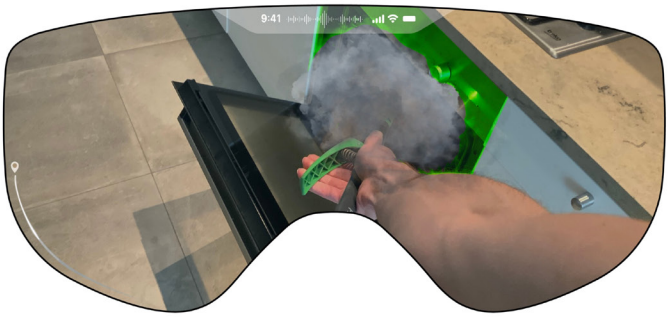
BOUNDING BOX

NORMAL POV (no MR)

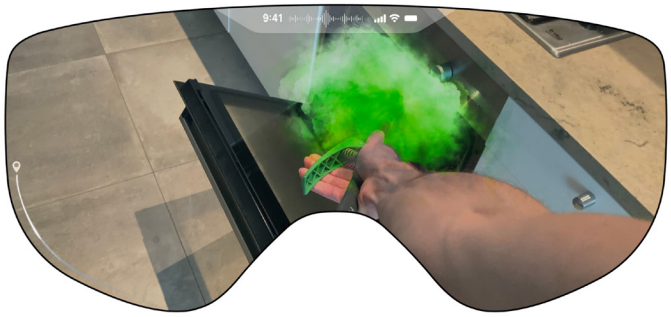
BLUR



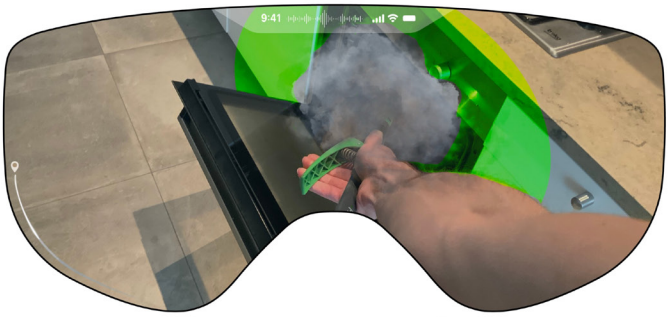
OUTLINE



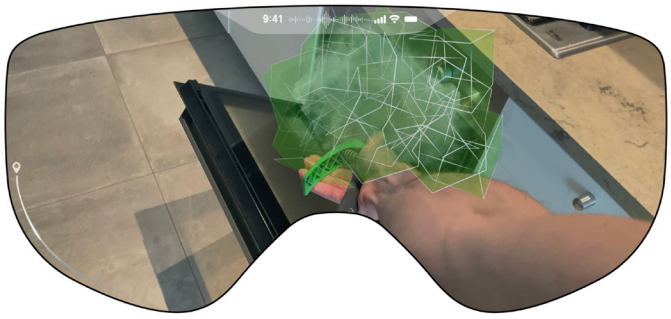
Ground Surface - rectangle



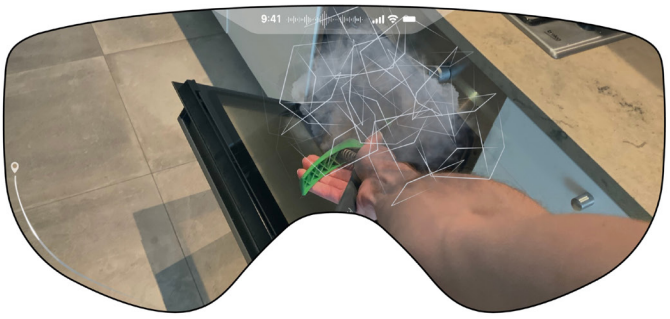
OVERLAY



Ground Surface - Circle



BOUNDING BOX + overlay



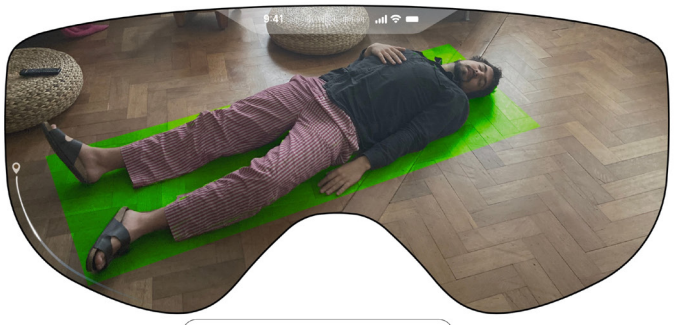
BOUNDING BOX

Fig. 72: MR test – highlights 2

NORMAL POV (no MR)

BLUR

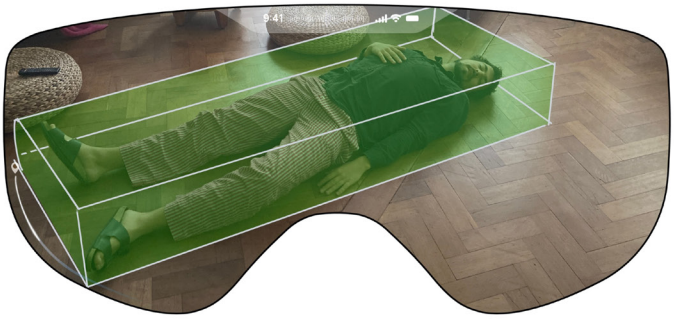
OUTLINE



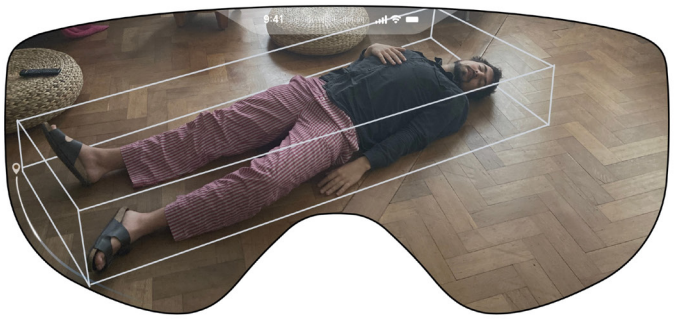
Ground Surface - rectangle

OVERLAY

Ground Surface - Circle



BOUNDING BOX + overlay



BOUNDING BOX

NORMAL POV (no MR)

BLUR

Outline + Ground surface

OUTLINE

Ground Surface - rectangle

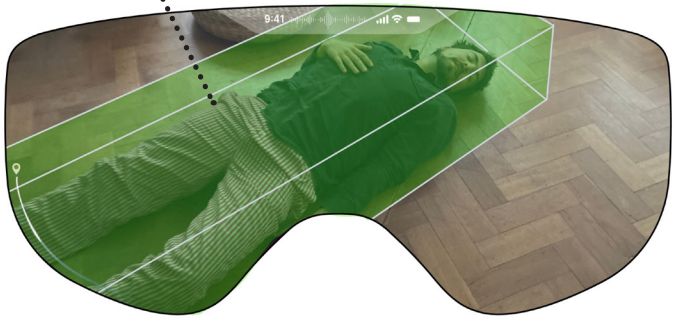
2

OVERLAY

1

Ground Surface - Circle

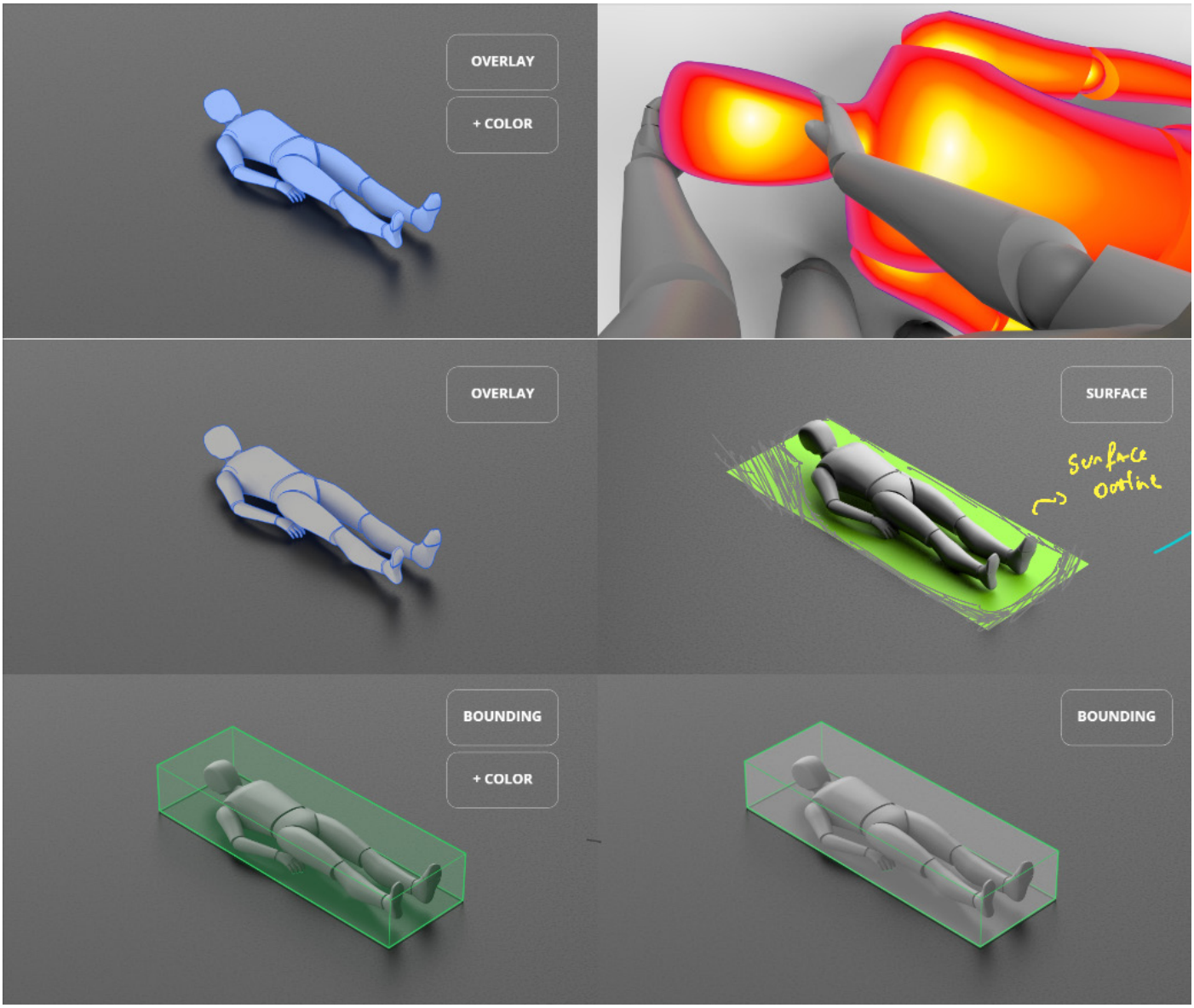
Looks like a coffin according to older people.



BOUNDING BOX + overlay

BOUNDING BOX

3



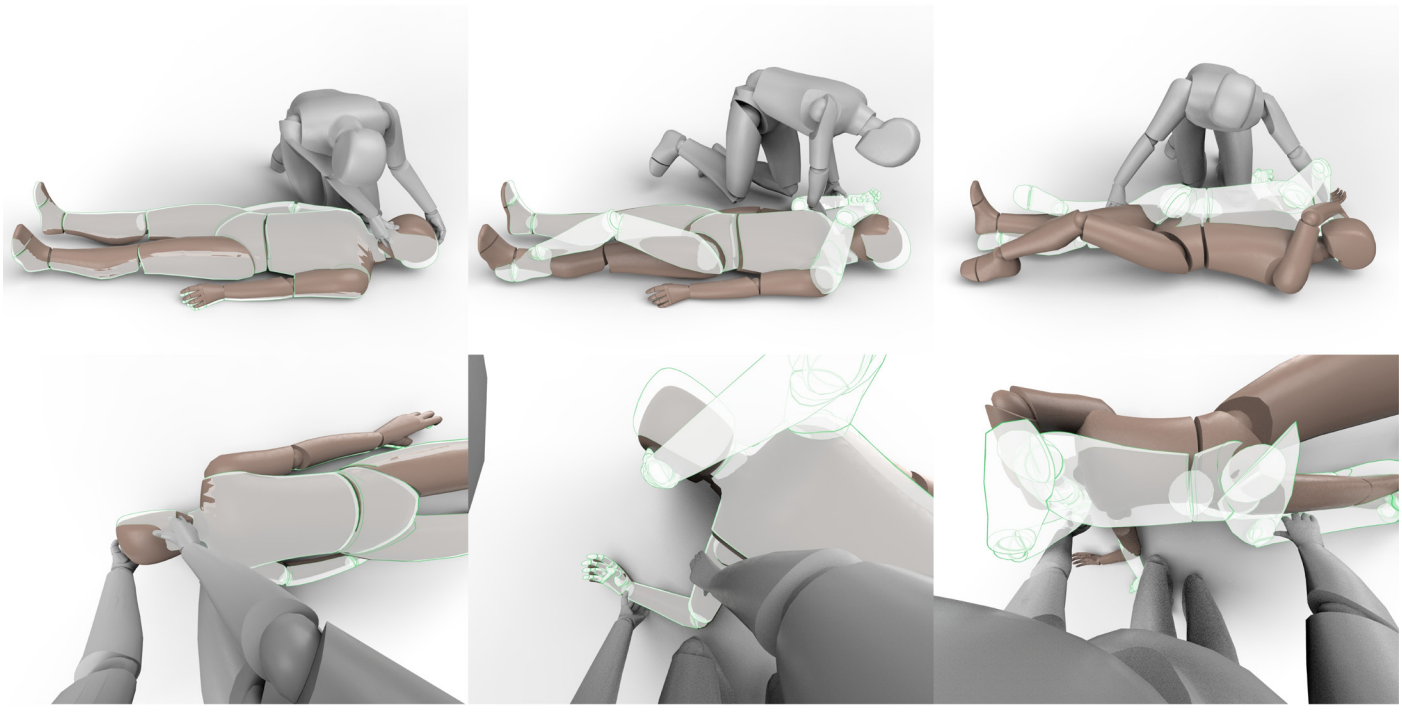
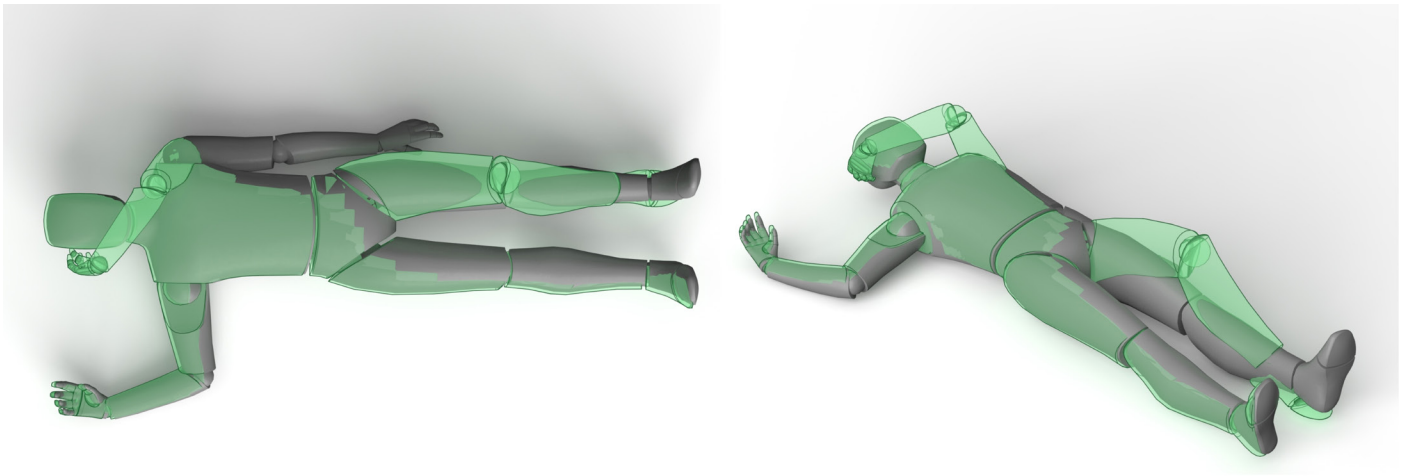
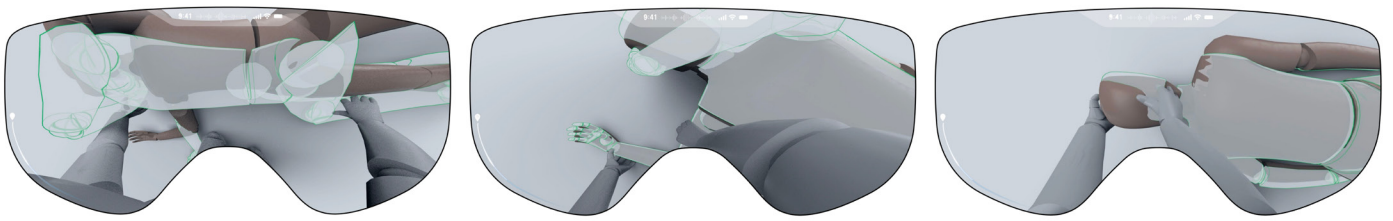
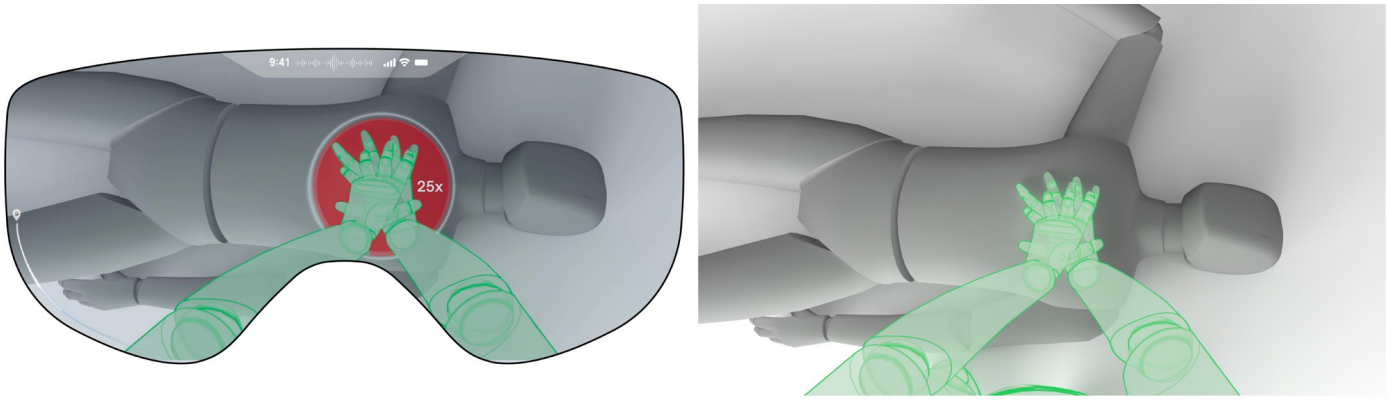
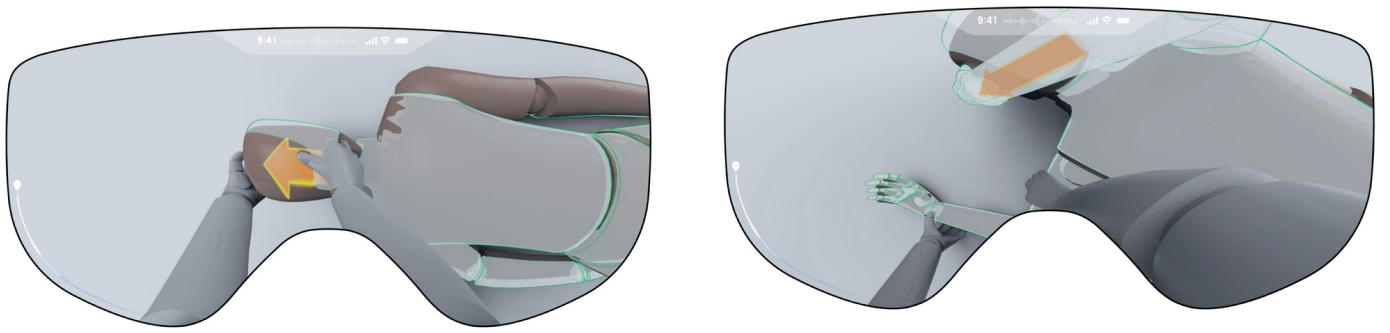


Fig. 73: MR final solutions









The evaluation of these mockups was done through conversation with other students and interested people from different generations.

The surface outline was the most preferred solution to highlight objects. Followed up with the bounding box. However, older generations linked the looks of it with coffins with isn't ideal in this context.

To instruct complex handling a transparent overlay of the hands or the victim in the right position was voted as most understandable.

5.2 Final concept:

Fig. 74: EVU – render 1

Unfortunately, accidents and emergencies happen every day. Today, emergency services only rely on auditory information from the caller; to dispatch the right tools and instruct the caller.

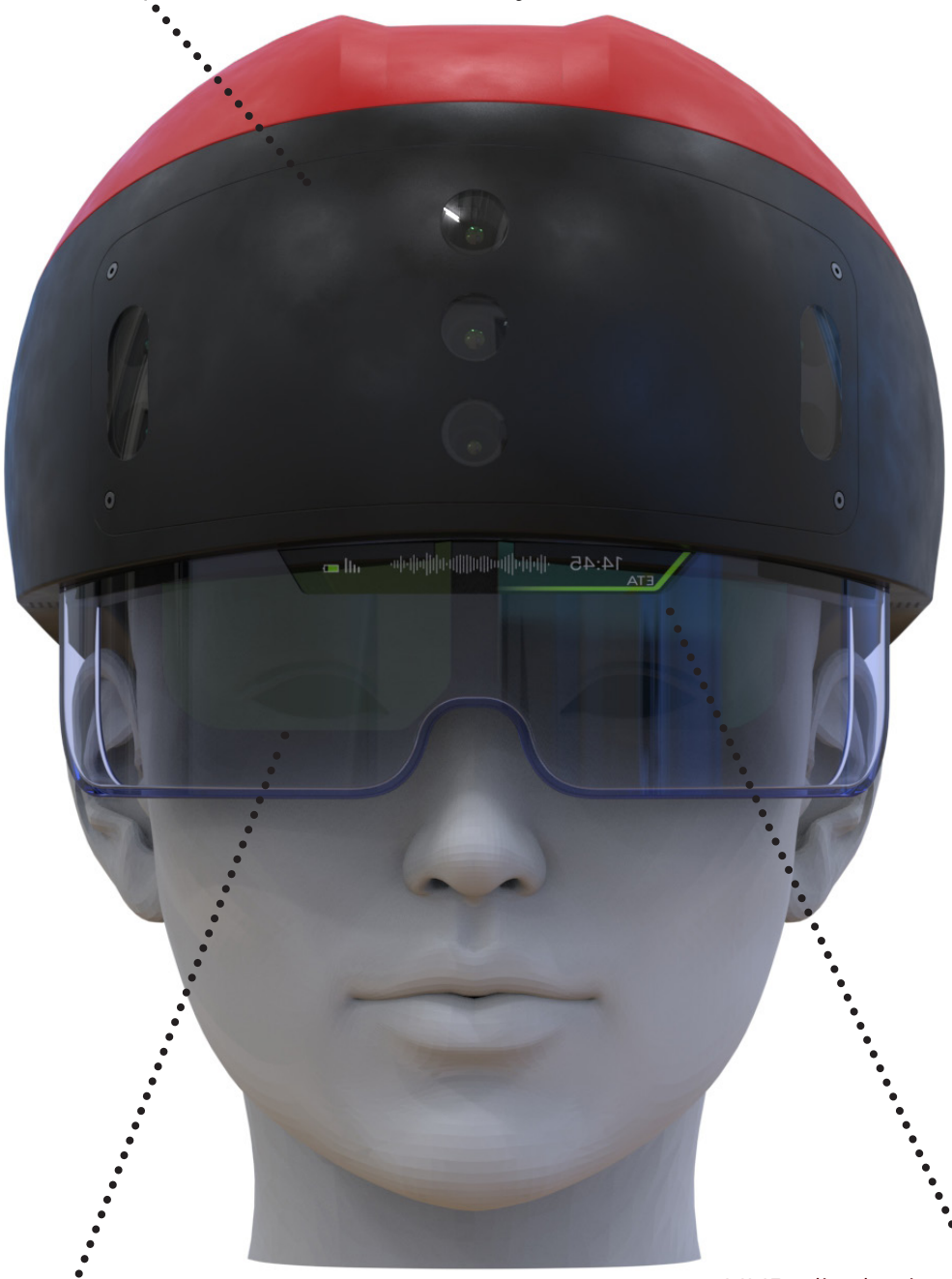
Imagine if the dispatcher gets extra visual information and sensors to their disposal. Or that the caller receives immersive, self-evident instructions right in front of their eyes. So they can provide aid without taking their hands or their attention away from the emergency.

That is all possible with EVU. EVU, Emergency Vision Unit is a mixed reality helmet to professionally deal with critical emergency calls while the first responders are on their way.

EVU provides visualisation of instructions in real-time to the caller during an emergency and gives the dispatcher real-time visual information to assist.

Sensors and cameras to analyse the situation in real-time.

A helmet is accessible for everyone and works as visual identification point during a stressfull emergency situation.



Waveguides project the immersive mixed reality expereince into your eyes.

HUD displaying the ETA of the first responders and general information.

Fig. 75: EVU – render 2

Fig. 76: EVU – render 3

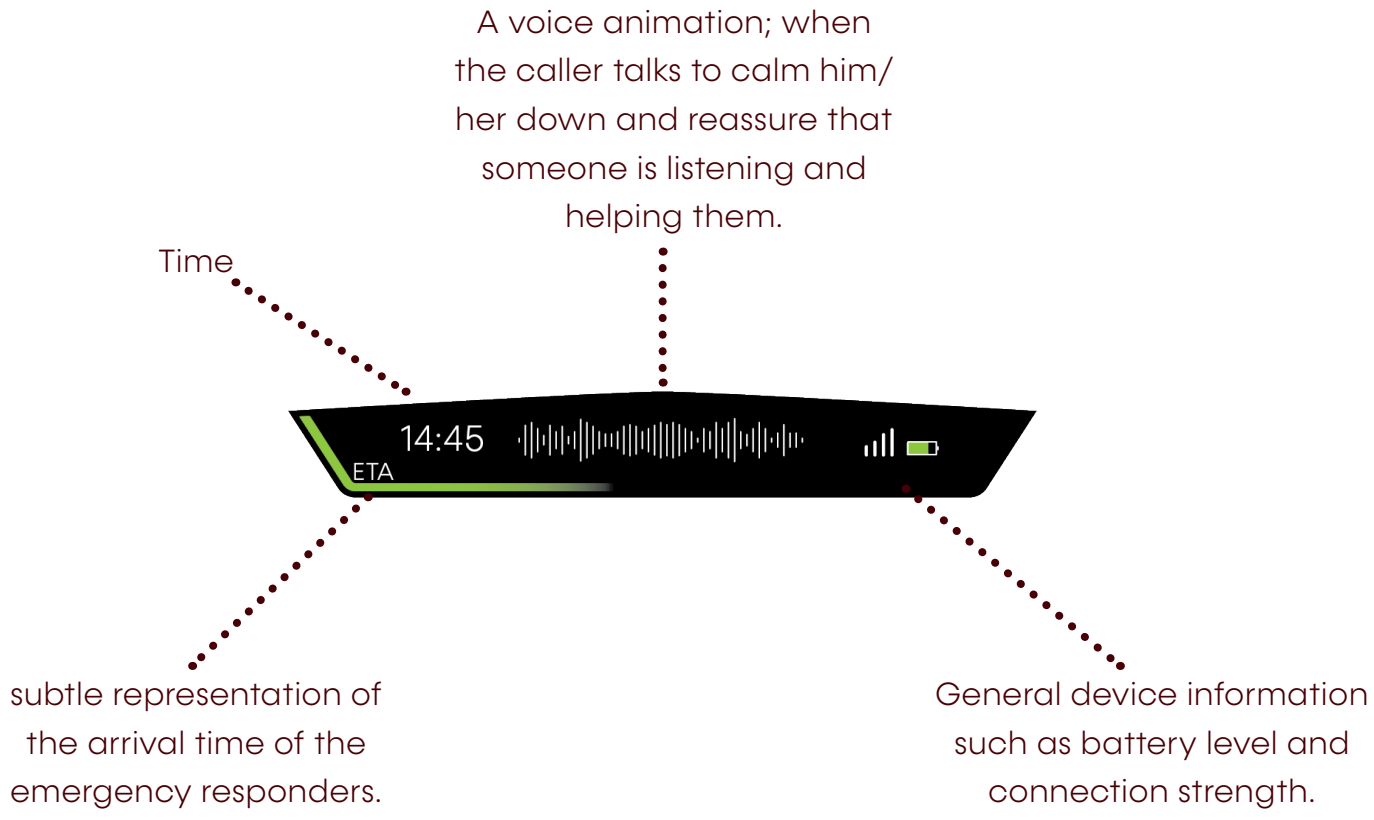


Fig. 77: EVU – Final HUD

Fig. 78: EVU – Final MR experiences

Fig. 79: Colour variations

Fig. 80: EVU docking station

The choice was made to integrate the mixed reality headset into a helmet. A helmet is a recognizable product to almost everyone. Since the product has to give confidence and can be used by anyone without any prior training this was an important aspect.

In addition, a helmet also acts as a landmark for bystanders and arriving emergency responders.

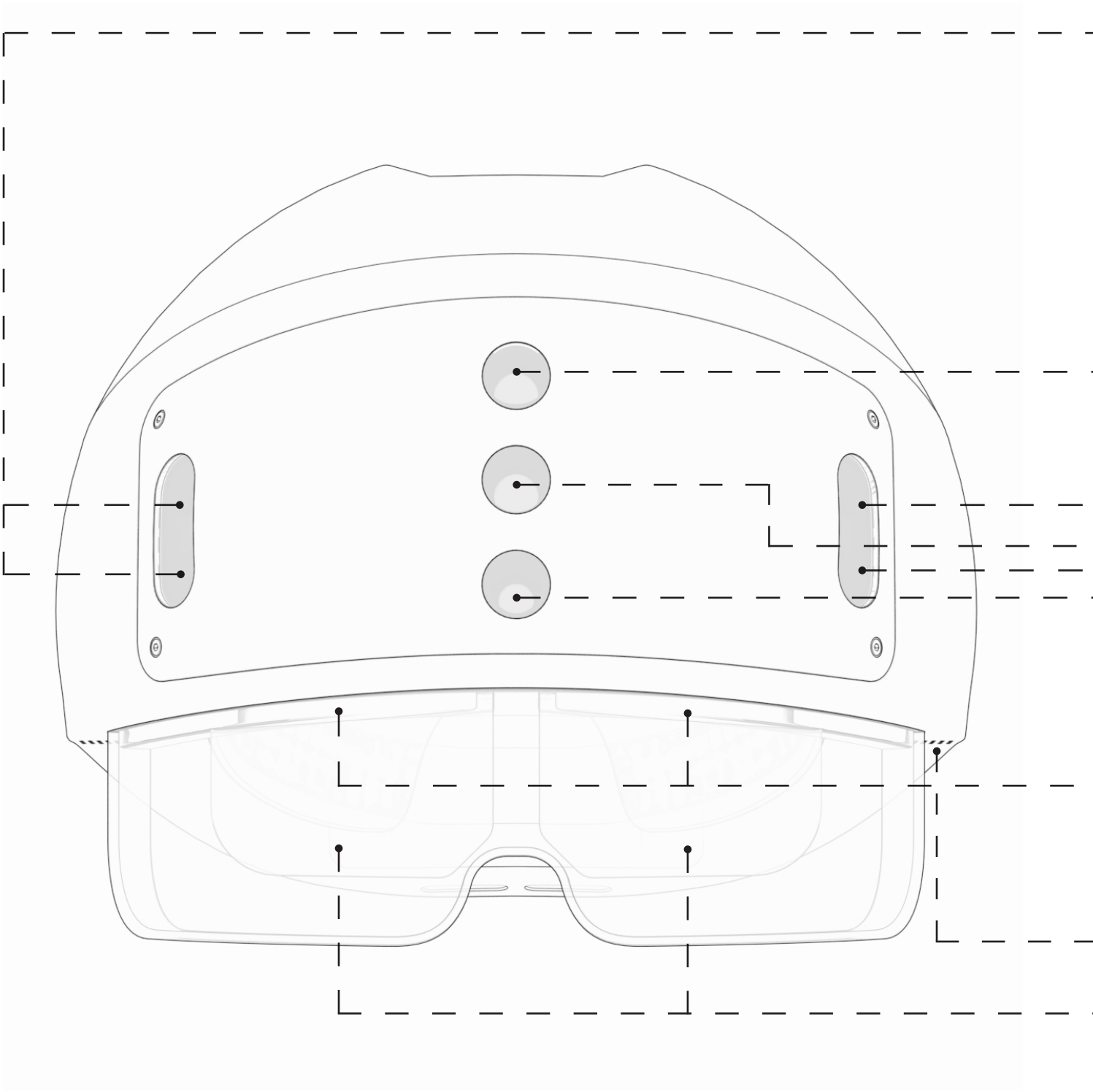
The colour chosen is red, as is often found on emergency equipment, but another colour such as green for a medical emergency or orange, which is often used for safety gear, can also be chosen.

EVU has its own docking station, which can also house other emergency equipment. The reason for this is to avoid loss of time and to get the full potential of EVU when fighting an emergency.

Fig. 81: EVU – side view

Sensors and technical components

Fig. 82: EVU –technical sketch 1



LIDAR:

LIDAR or Light Detection and ranging sensors: It is a remote sensing technology that shoots laser pulses to collect measurements. It calculates how long a laser beam takes to hit an object and come back. These measurements are processed and used to create a three-dimensional map of the environment and its object in front.

4 Head Tracking Cameras: Stereo and periphery + IMU

- 4 visible light cameras
- Inertial measurement unit (IMU): Magnetometer, gyroscope, accelerometer

The IMU is responsible for tracking the orientation when wearing the headset (Where we are looking at).

To track the position to the external environment the IMU is used in combination with the four light cameras to compensate for the drift position error from the IMU (also known as inside-out positional tracking in VR-headsets). The grey-scale or visible light cameras also help with the map building of the holograms.

RGB Camera and ambient light sensor:
Enables to record and share what the users sees.

Thermal camera:
To measure and map thermal images of the environment but also to screen elevated skin temperatures.

Depth camera:
Near and far range:
This camera operates in 2 modes, high frequency near-depth sensor to determine the hand tracking and a low frequency far-depth mode to used for spatial mapping.

2x inwards IR cameras for eye-tracking:
Near-infrared light is pointed towards the pupils of the user's eyes. These directed light rays cause reflections in the cornea and pupil. The vector between those reflections determines the position of your eyes and your point of gaze.

Microphone array and speaker:
Multichannel microphone and built-in spatial sound. The microphone array allows the distinction between speech and ambient sound.

Wave-guides:
See through holographic lenses. They are transparent screens invisibly lighted from the top side. They guide the light, magnify it and angle it into the user's eyes.

Removable front panel:
Front panel cover the main PCB and it's sensors. It allows easy access for maintenances an repairs.

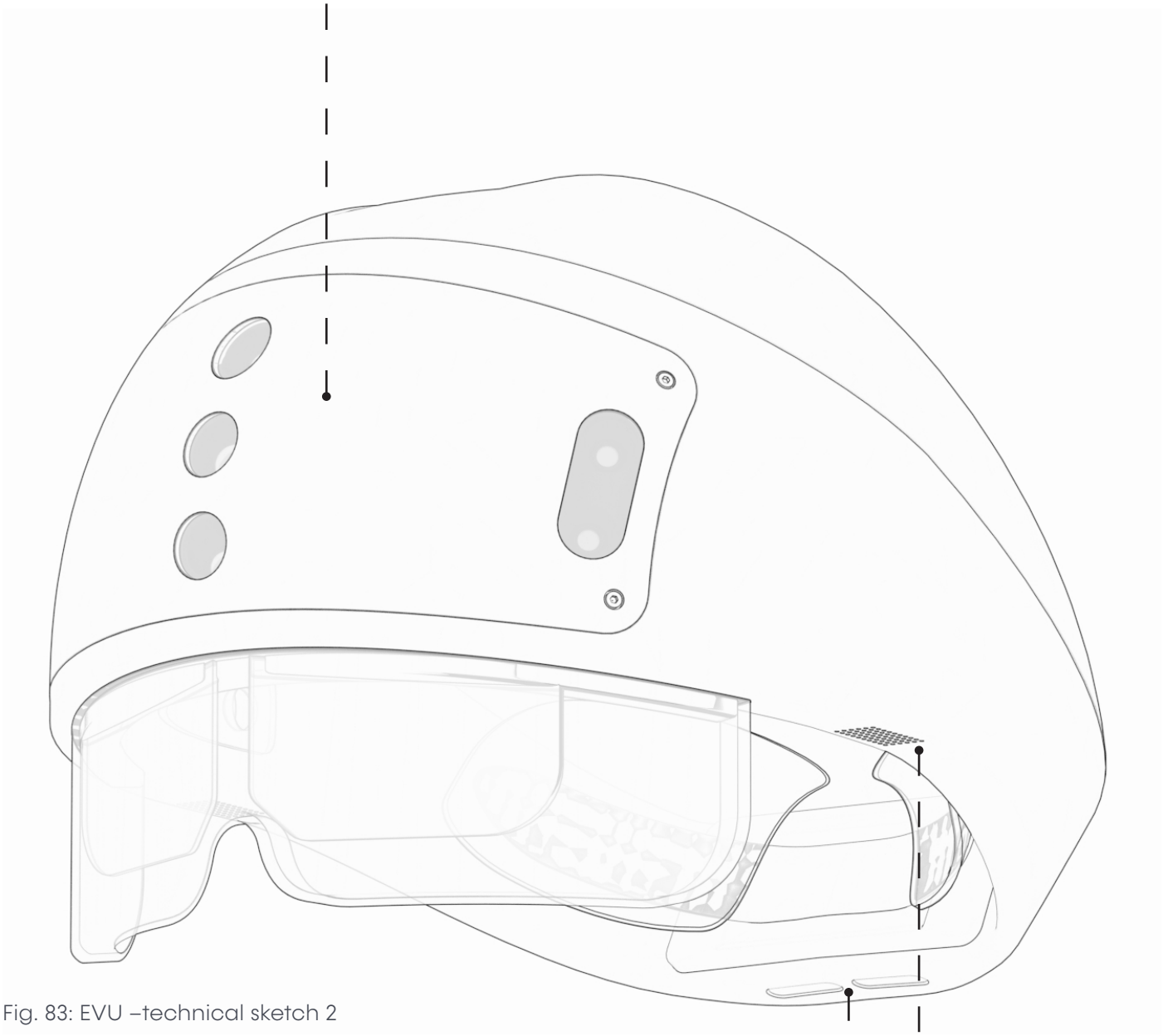


Fig. 83: EVU –technical sketch 2

Charging port connection.
The device charges while docked in it's station. Inside the device powers on Lithium batteries that provide 2-3 hours active use. If the charging station loses power the device should hold 2 weeks of charge on standby.

Speakers positioned above the ears, so the user is still aware of its surroundings

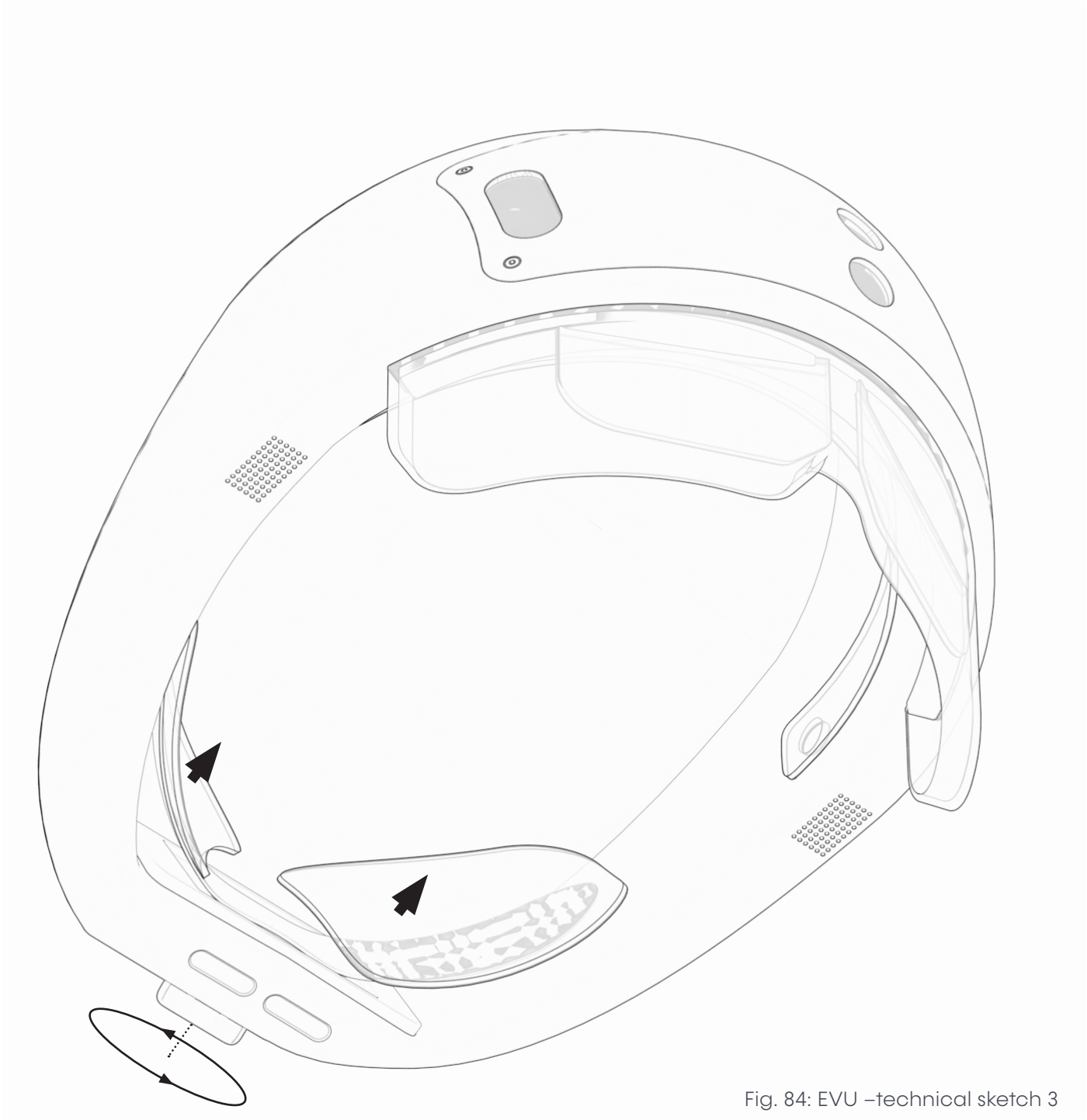


Fig. 84: EVU –technical sketch 3

Adjusting the wheel on the back of the helm moves the head pads. This physical knob allows a fast and easy adjustment to make the fit more comfortable.

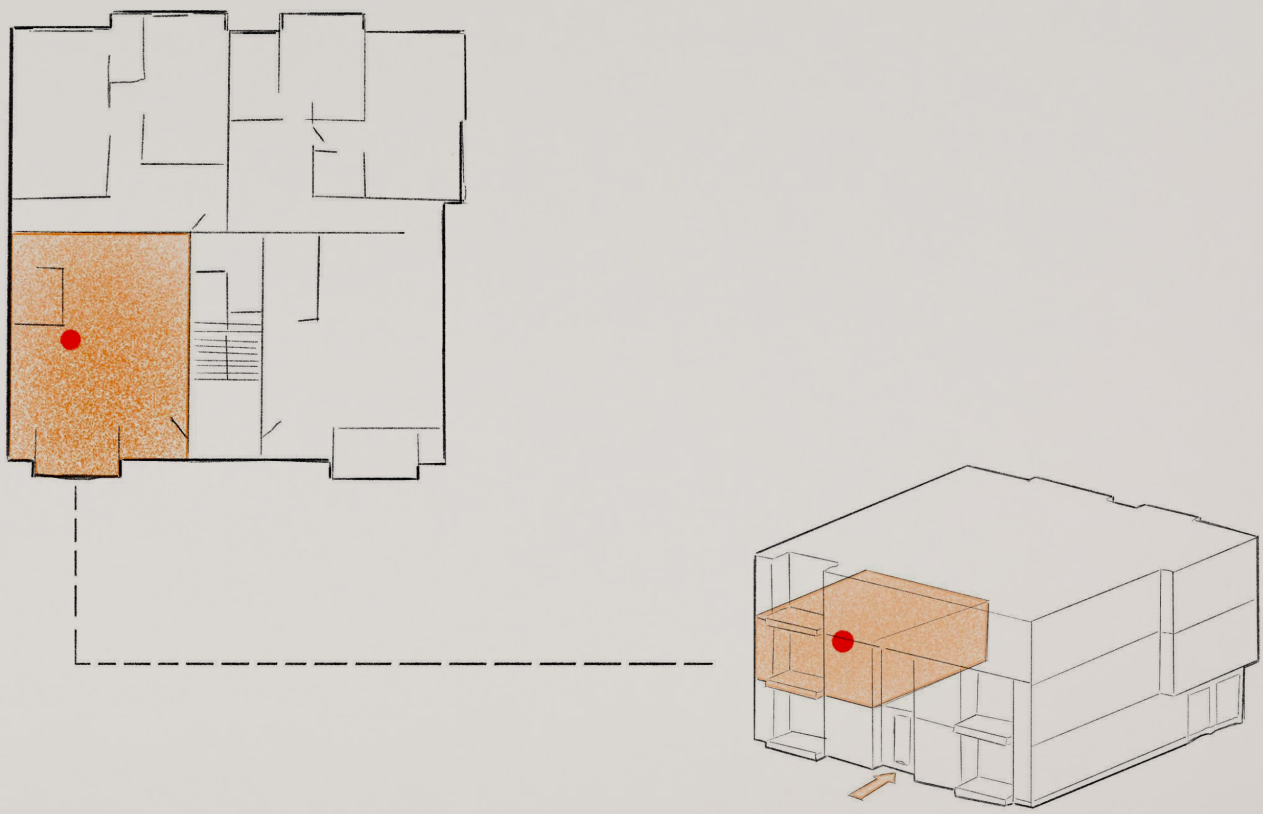
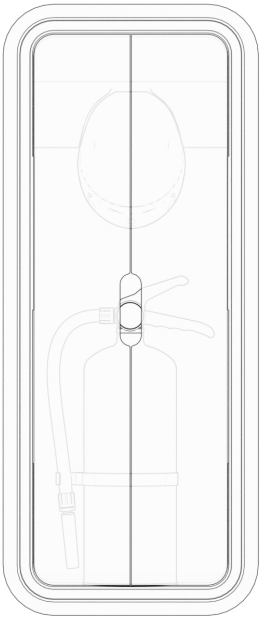


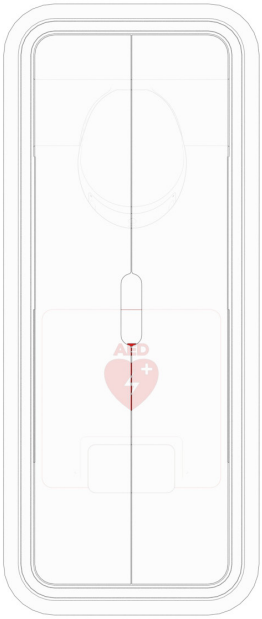
Fig. 85: EVU – Location sharing

The emergency response helmet is envisioned as a combination with current emergency devices such as a fire extinguisher, defibrillator or first aid kit. These safety tools are already strategically placed and mapped out on fire and safety plans.

This knowledge gives the opportunity to also digitally share the in-building location from the docking station to the emergency call centre.


FIRE EXTINGUISHER
INSTRUCTIONS

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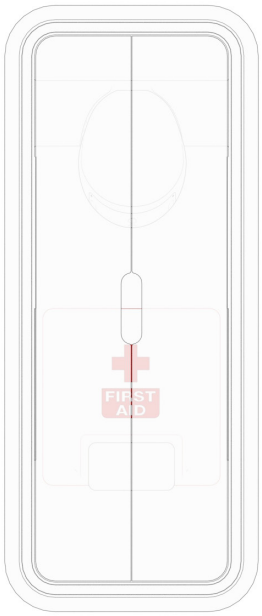
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6 Evaluate


FIRE EXTINGUISHER
INSTRUCTIONS

6.1 Augmented Reality test

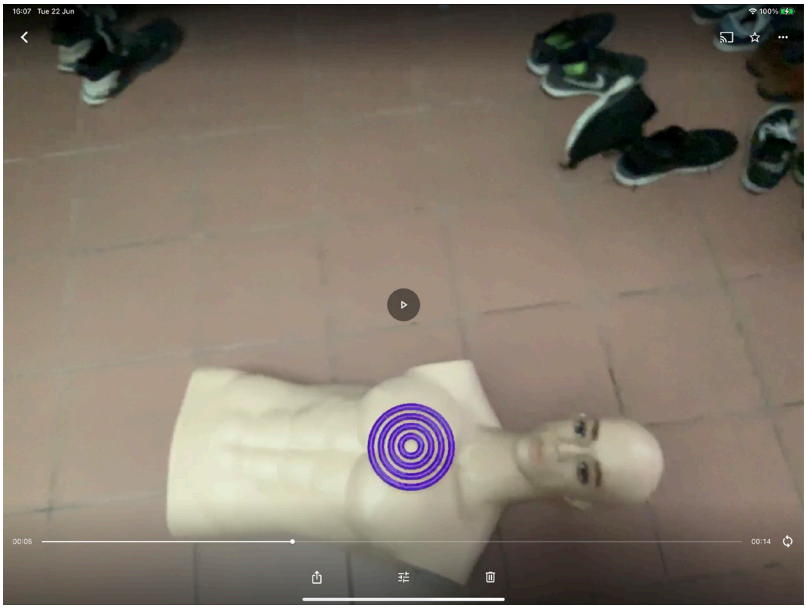
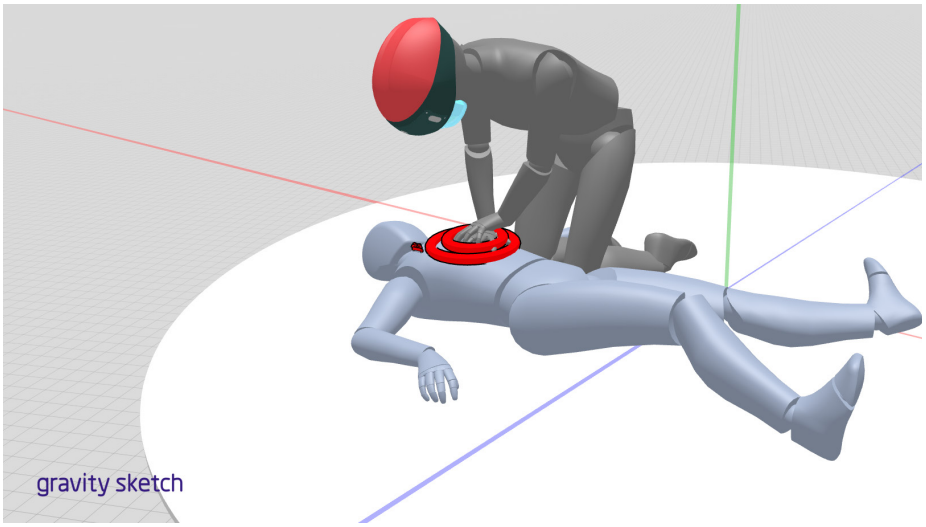


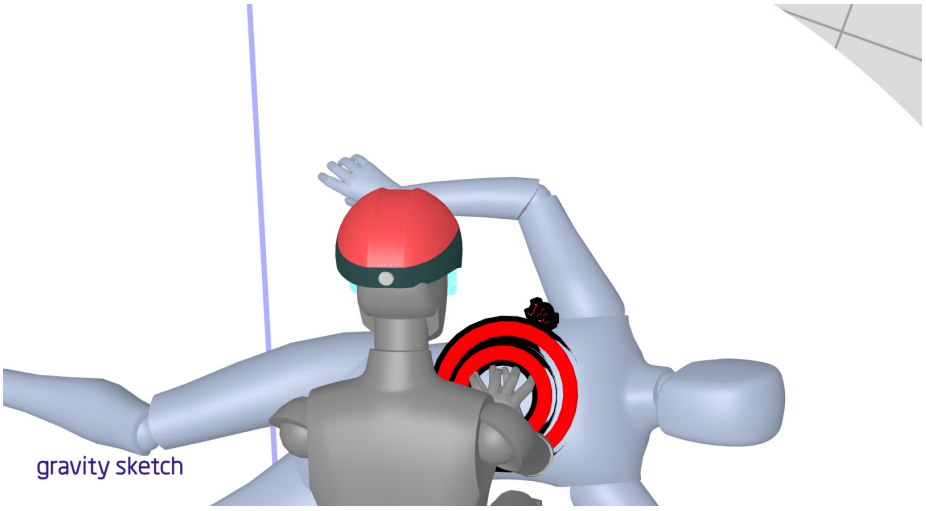
Fig. 87: AR – test screenshots

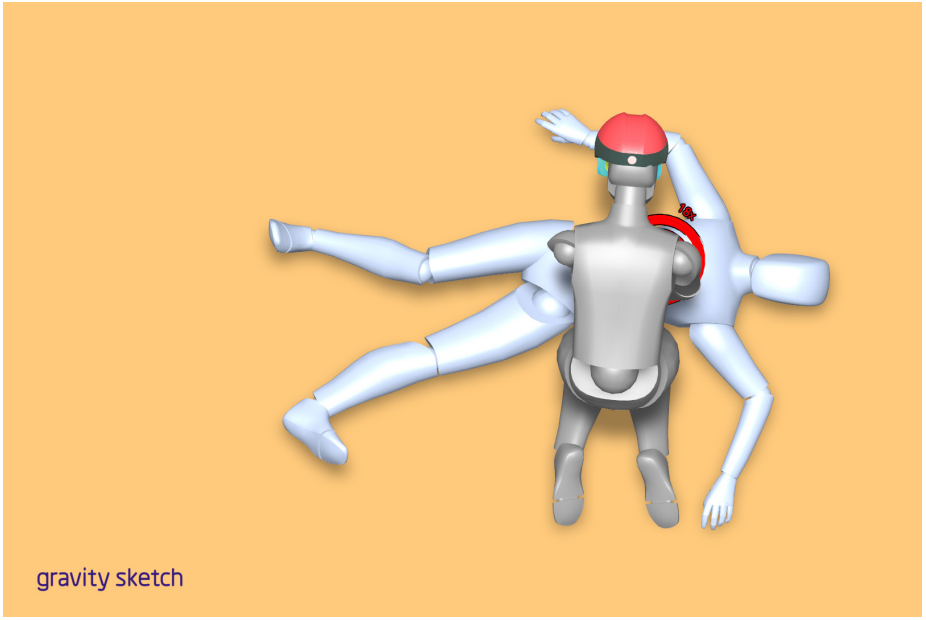
Due to the current situation that everything happens online and the available resources to test this concept two techniques were chosen. The first is an augmented reality test to see how the objects react with the environment and these are clearly understood.

In addition, a test setup was created in virtual reality since creativity has unlimited access here. Apart from playing with these test setups ourselves, there was, unfortunately, no time to test them with different audiences and age groups.

6.2 Virtual Reality test





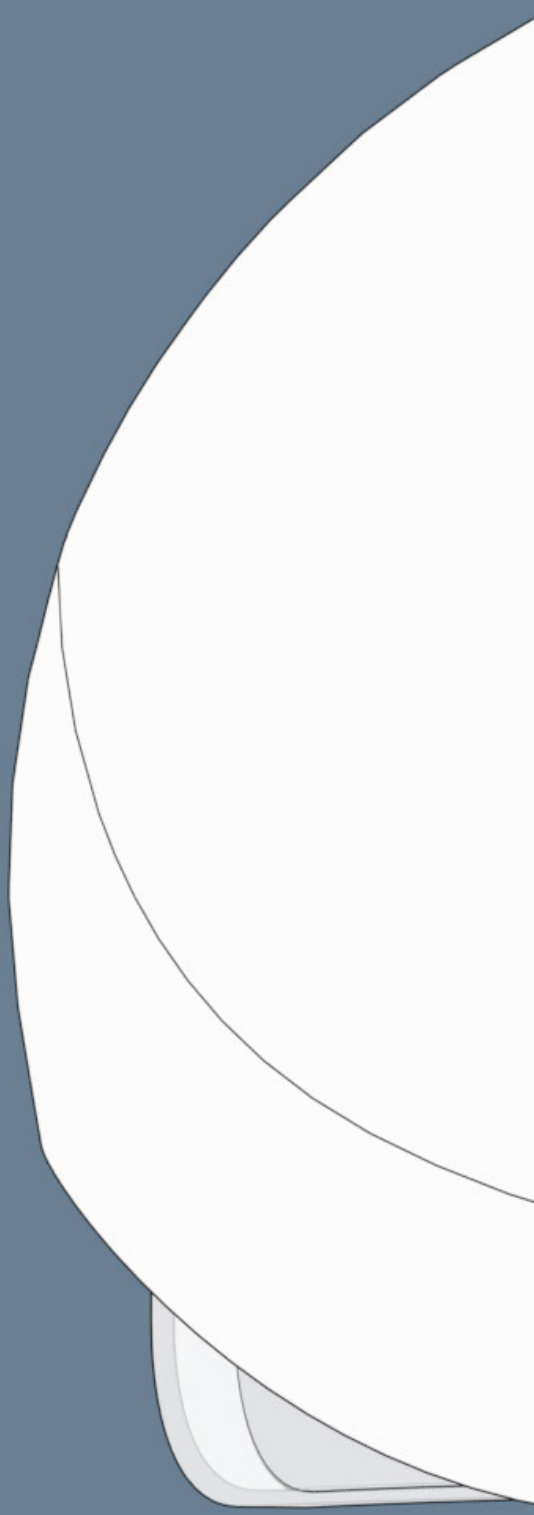


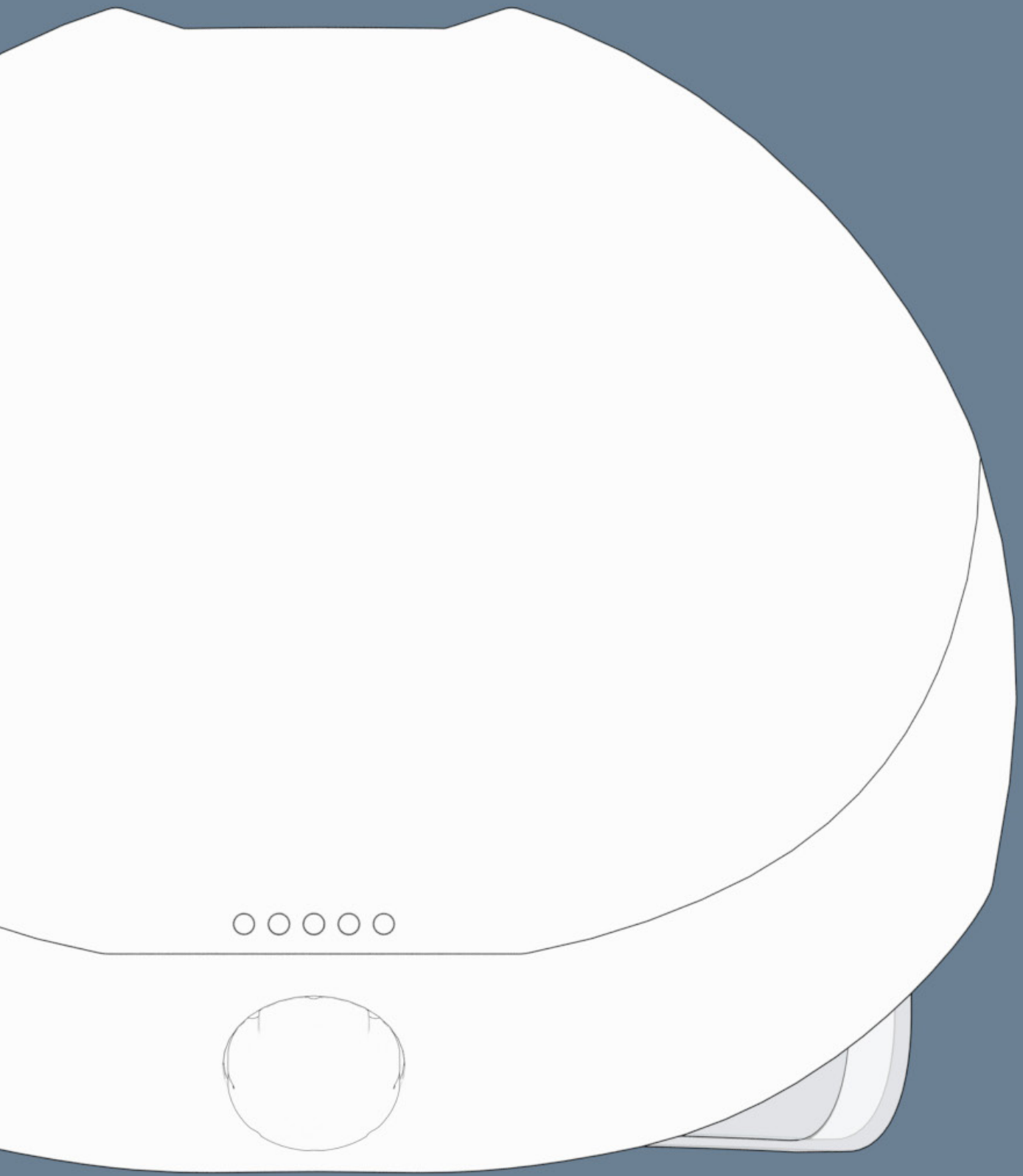
What the test teaches us: One must be careful to adjust the software so that there is dept between the objects. Objects that appear in the foreground despite being behind an object bring confusion to the test person.

The choice of colours and transparency of the objects has a certain influence on the clarity of the mixed reality elements. More attention should be paid to this in the future.

Fig. 88: VR – test screenshots

7 Recommendations?





7.1 What's next?

This thesis was an exploratory study resulting in a conceptual design. Many interesting points were raised and discussed. But due to the format and limited time, not all were explored in depth.

The next steps that should happen to take this project further is a deep dive into the electronic embodiment of all the components. Also, a further elaboration of all interactions and possible instructions that are relevant in emergency response.

However, I hope that this thesis can form the basis of new studies or at least inspire people. Based on my findings and results, I would recommend the following studies.

Interaction for mixed reality is still in baby shoes. A lot of research can still be done on this, it is not just curating flat images in a 3D environment.

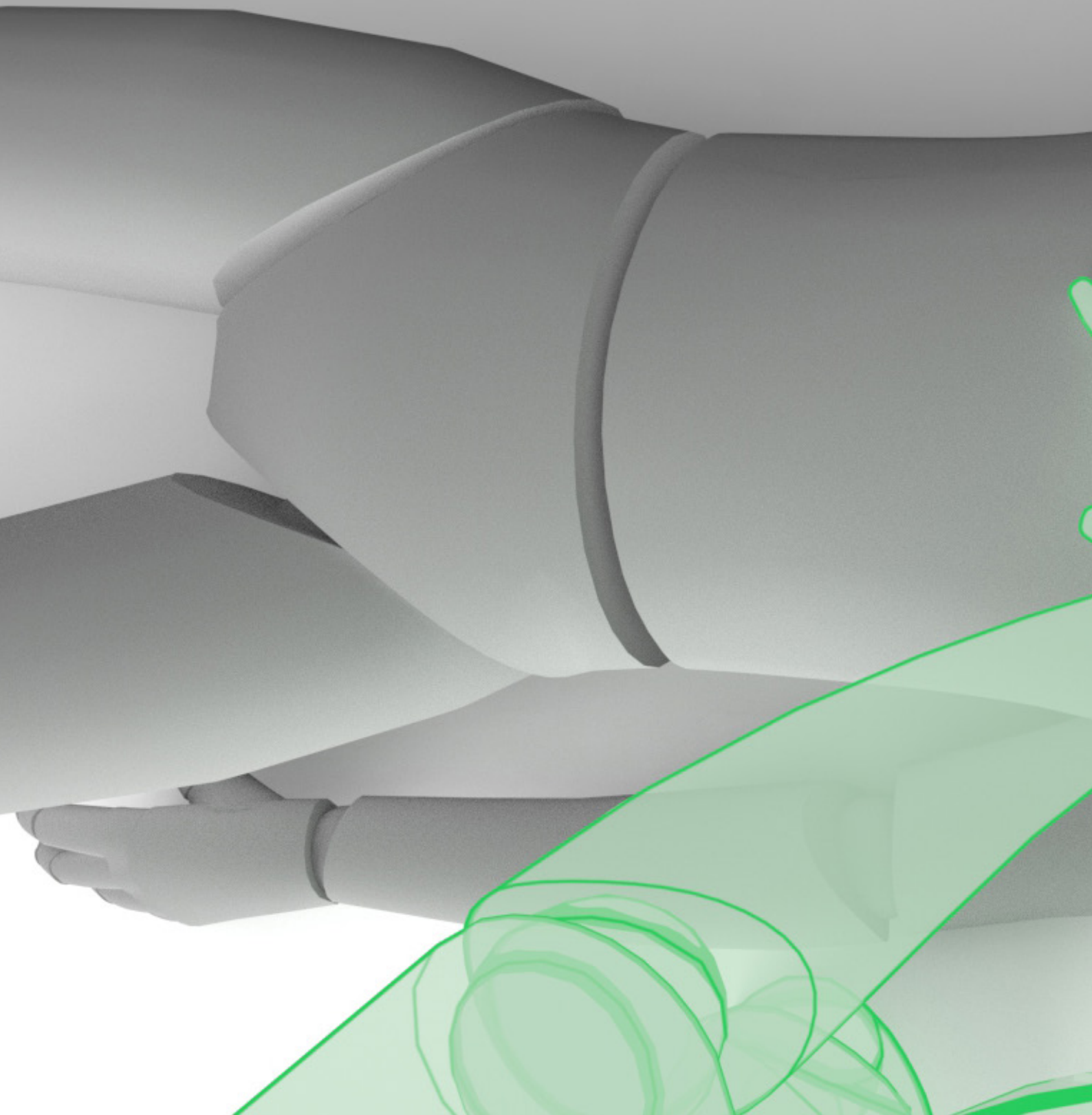
My design remained at a concept level, unfortunately, there was not the time to make an interactive model and test it with people in the field. The embodiment of the helmet, as well as the whole experience still, have the potential to raise several levels on the TRL. The technology is available today but is quite complex, most progress is made in companies with the largest research and development budgets.

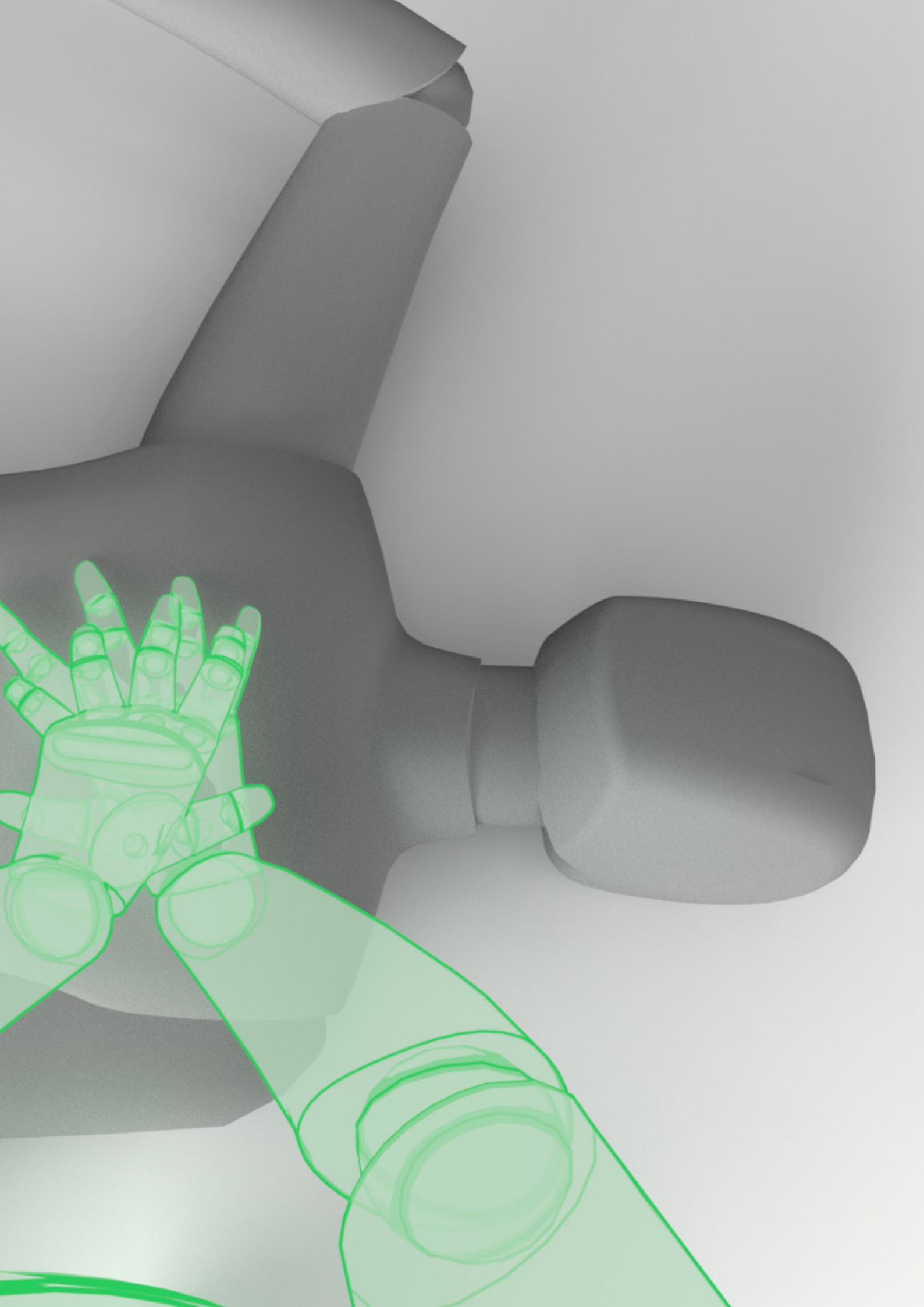
Low fidelity testing of mixed reality setups, for application design there are many kits and courses, for MR these are unexplored waters.

In third world countries, the framework of emergency care does not exist. People there rely on cabs and the goodwill of bystanders to be helped. A mobile version of my concept or another concept could potentially save many lives in those areas.

Fig. 89: EVU render with integrated logo

8 References





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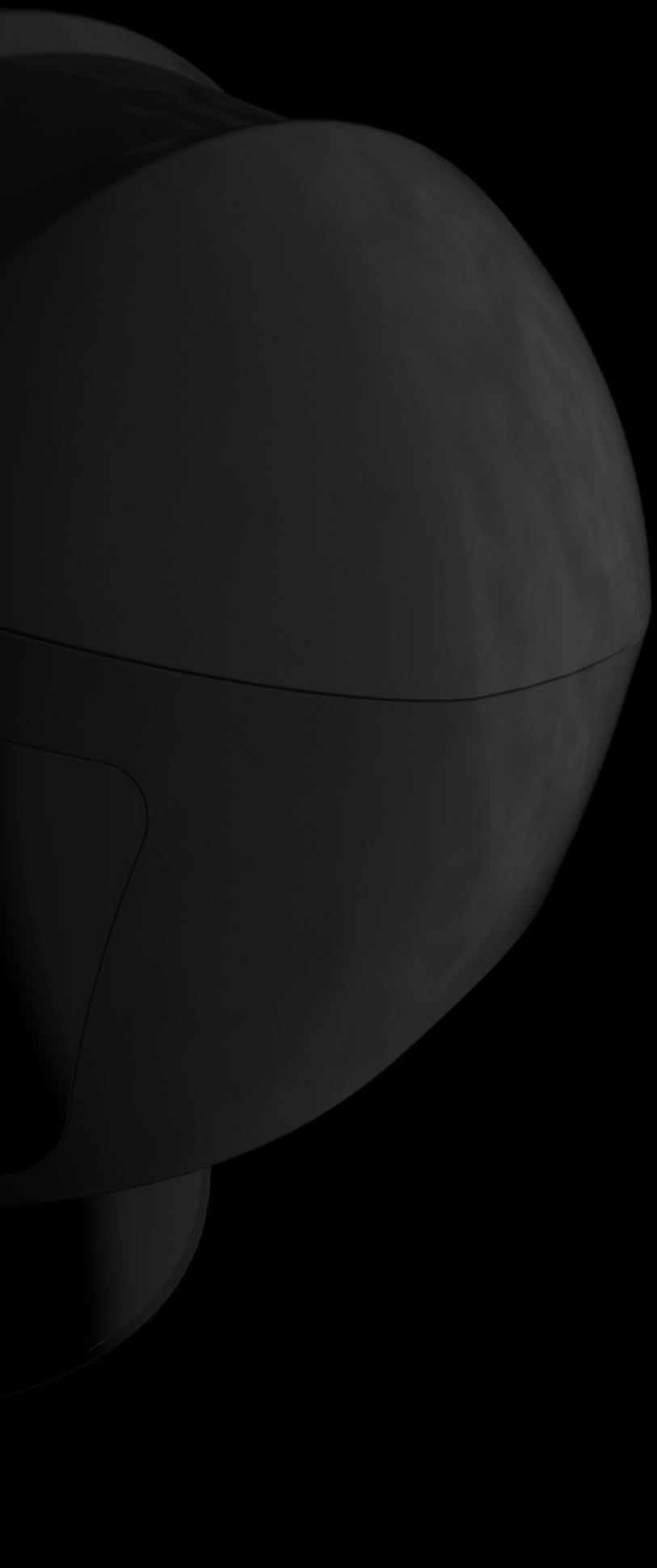
9 Appendices



DESIGN FOR our future

9.1 Project Brief

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT
Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name
initials
student number
street & no.
zipcode & city
country
phone
email

Your master programme (only select the options that apply to you):

IDE master(s): ★ IPD ○ DfI ○ SPD

2nd non-IDE master: _____

individual programme: __-__-____ (give date of approval)

honours programme: ○ Honours Programme Master

specialisation / annotation: ○ Medisign
○ Tech. in Sustainable Design
○ Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair _____
** mentor _____
2nd mentor _____
_____
_____

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

comments (optional)

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair. The study progress will be checked for a 2nd time just before the green light meeting.

i

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **. Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: ★ APPROVED ○ NOT APPROVED

Procedure: ★ APPROVED ○ NOT APPROVED

comments

Mixed reality: the next step in critical emergency calls? project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 08 - 02 - 2021 03 - 07 - 2021 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

My graduation idea started from personal experience, before studying design, I studied Nautical science to become a merchant marine officer. During that education, I had a lot of safety courses such as fire fighting, crowd control and medical emergencies. However, during practice drills, a considerable amount of students and professionals failed some simple tasks due to the stressful situation. This reoccurring realisation started my thought process. If trained people have difficulty to use a fire extinguisher or first aid kit in a stressful situation, how do we expect untrained people to handle right in such an event?

This graduation project focuses on exploring the technological possibilities of upgrading the auditory communication during critical emergency calls with an extra visual layer of information to achieve guided professional support from the start of an emergency (call).

The main stakeholders in this project are the caller and the professionals.

Bystanders of an emergency; call for help and are transferred to a physical dispatcher. The dispatcher will initiate the emergency care and will instruct the bystander until a professional support provider arrives at the scene. (See Figure 1 for an overview of the current context and the main stakeholders involved in emergency care, based on the WHO Emergency Care System Framework.) The bystander (or caller) is the stakeholder that initiates the whole process. He/she is the eyes, ears and hands of the emergency service until professional support arrives at the scene. On top of providing the right information, they will have to perform first aid or support the victim.

The dispatcher receives the call and handles to it according to predefined protocols. They filter and transfer the right information to the professional support agencies while instructing the (stressed) caller.

The professional support prepares themselves on the situation according to the received information and will take over the care when arriving on the scene.

Main problems in the current situation? (Assumptions, for now)
- Lots of shared auditory communication
- Critical situation
- Information is shared as it is perceived by the bystander
- People are handling under stress
- Saving time saves lives
- Every situation is unique

Augmented Reality is a rapidly developing technology which is currently applied in a different range of products. The viability of the technology is not a limitation. However, the application can be coding, data and software heavy, which is not my expertise or goal. So, I will attempt to tackle this design challenge by applying a human-centred approach that allows evolution in critical emergency calls.

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introduction (continued): space for images

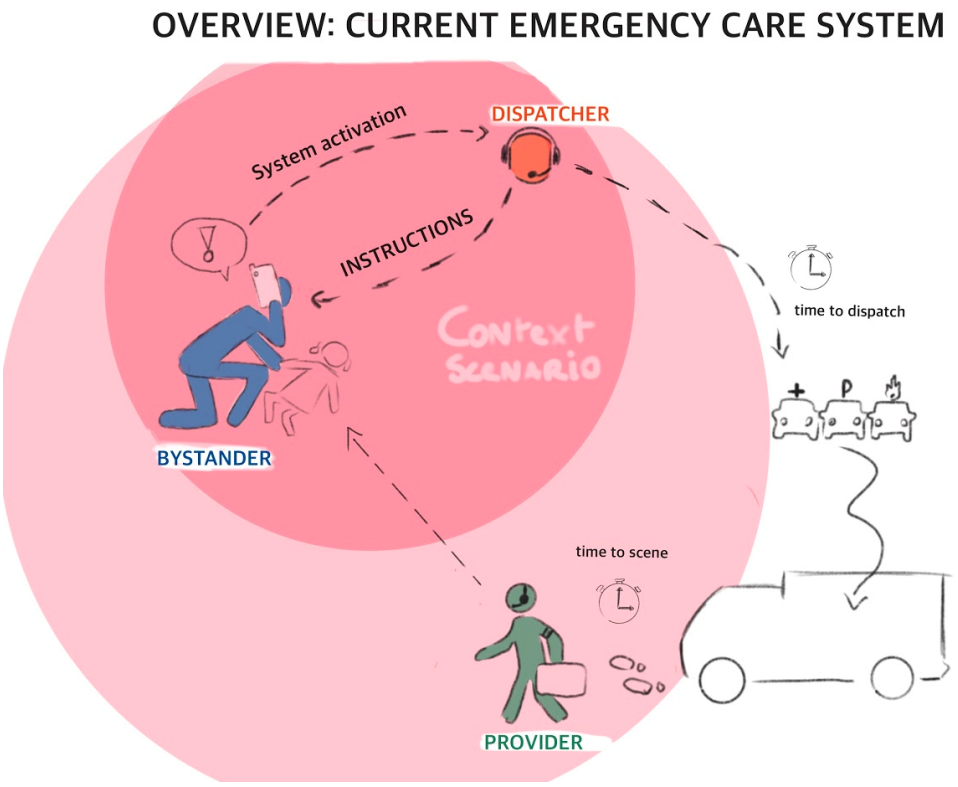


image / figure 1: overview of the current context and the main stakeholders involved

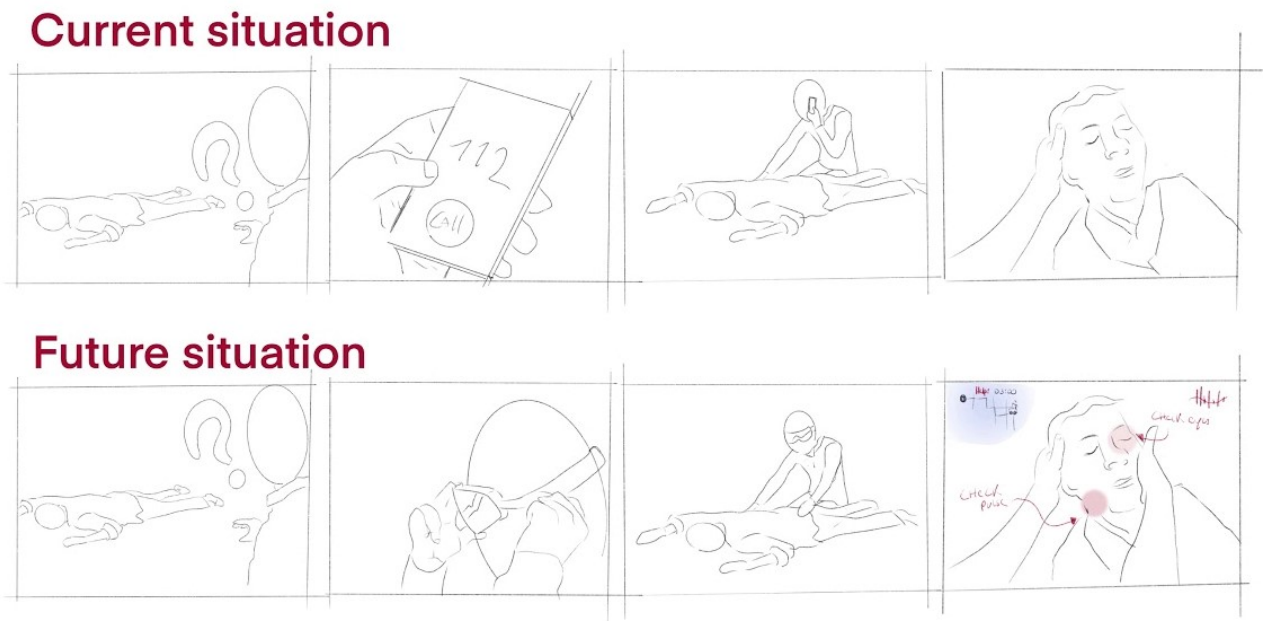


image / figure 2: Possible future scenario?

Initials & Name EDJ De Jonghe 4725 Student number 5157064

Title of Project Mixed reality: the next step in critical emergency calls?

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

In case of an emergency, a lot happens in a short time. The situation is stressful while there is a threat to a person's health, security, property or environment. However, currently, we still communicate about an emergency using only auditory communication, such as a phone call.

The main problem is that it is a limited medium for a large amount of shared information. For this reason, I want to apply Augmented Reality to upgrade the current means of communication.

The current issues include (more research is planned):
-The bystander/caller does not know how to handle in case of emergency.
-The caller can be in stress (is not an expert) this affects the information given to the dispatch.
-Time saves lives.

The final goal is to:
-Improve the overall guidance during an emergency call and treatment of the provider.
-Improve the preparedness of professional support when they arrive on the scene.
-Provide guided professional support until the professionals arrive on the scene.

What will be the difficult parts for me/the project to deal with?
- Due to the current Covid situation, all communication happens online. This can potentially lead to longer response times when reaching out to people.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

This project will identify mixed reality solutions that are suited to improve the way we perform (critical) emergency calls. The focus is to identify the current problems, and explore what added layer of digital information is required and how this information will be mapped out plus the physical package of mixed reality in a product.

RESEARCH GOAL:

I'm planning to research the context of (critical) emergency calls: Who is involved? What are their tasks, responsibilities and challenges? How do they experience the process, etc. But also how to visually communicate critical information and in which format. Next to research on context and interaction level, I will also deep-dive into the technology mixed reality and its possibilities and limitations.

DESIGN GOAL:

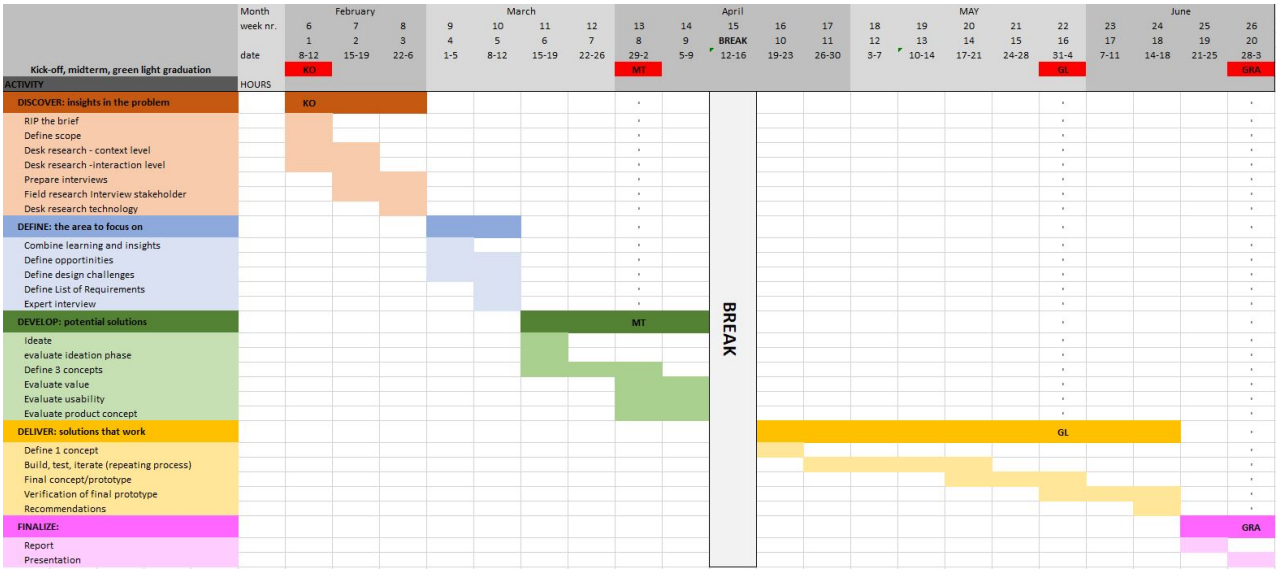
Following an iterative design process, I am planning to create a prototype to showcase the digital side of this project. (an UX/UI showcase in a digital format. For the physical side, I will make a looks-like-real prototype.
To communicate my ideas and progress with the different stakeholders, low budget/mock-ups will be made during the process of this project.

(At this moment I think a looks-like-real-works-like-real prototype is out of scope. However, a cinematic prototyping to showcase the interaction flow is within the current scope).

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 8 - 2 - 2021 3 - 7 - 2021 end date



To tackle this project, I will be using the double diamond design process.
According to its 4 phases (Discover, Define, Develop, Deliver), I mapped out my planning.
However, I added an extra stage to finalize the end deliverables.

In the middle of the process, I planned a one-week break. To recharge me with fresh energy and prevent a possible burnout.

From the start on, I'm planning to create low cost (ux) prototypes to test the ideas and functions with the stakeholders. This will make it possible to continuously adapt it to the feedback. A tangible prototype will make it easier to interact with the stakeholders and will bring continuing feedback in my iterating design process.

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

As explained in the introduction, my graduation idea started from personal experience and motivation to bring change in these critical emergency situations.

Personal (learning) objectives:

- Augmented reality is currently gaining popularity. It has the potential to become a prominent technology in everyday life. During this project, I aim to obtain depth knowledge about AR and implement it in my design.

- Broadening my knowledge about usability, IoT, consumer products and human-centered design by doing an in-depth project with a prevalent technology. How this will all come together will depend on the the outcome of the research phase.

- Combine all my previous knowledge and skills to cover the whole design process in this graduation project.

- Improve my planning and management skills with this solo project.

- Have fun during the process!

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

9.2 Miro Overview

Mail: Emilio De Jonghe

TU Delft